UNIX® Shells by Example, Third Edition

By Ellie Quigley

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Five UNIX shells, three essential utilities, one indispensable resource!

- Learn UNIX shell programming the easy way, using hands−on examples
- Covers all five leading UNIX shells−C, Bourne, Korn, bash, and tcsh
- By best−selling author Ellie Quigley, Silicon Valley's top UNIX instructor

The best−selling UNIX Shells by Example continues to be the only book you need to learn UNIX shell programming. UNIX Shells by Example, Third Edition adds thorough coverage of the new bash and tcsh shells to the full explanations in Quigley's famous treatment of the C, Bourne, and Korn shells and the awk, sed, and grep utilities, making this the most complete UNIX shell programming book available anywhere. Using proven techniques drawn from her acclaimed Silicon Valley UNIX classes, Quigley transforms you into an expert−level shell programmer. You'll learn what the shells are, what they do, and how to program them, as well as how and when to use awk, sed, and grep. Code examples, completely revised and classroom−tested for this edition, explain concepts first−hand and can serve as the basis for your own projects.

Explains the C, Bourne, Korn, bash, and tcsh shells in one cohesive way−you'll understand which shell to use and why Details the essential awk, sed, and grep programming utilities Offers proven teaching methods from a top UNIX shell instructor Provides source code and data files for all examples on the CD−ROM, so you can experiment with them on your own system UNIX system administrators, application developers, and power users will turn to this book again and again, both as a vital classroom learning tool and as a favorite reference manual.

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Dedication

This book is dedicated to my papa, Archibald MacNichol Main, Jr., the best father in the world.

Preface

Playing the "shell" game is a lot of fun. This book was written to make your learning experience both fun and profitable. Since the first edition was published, I have heard from many of you who have been helped by my book to realize that shell programming doesn't need to be difficult at all! Learning by example makes it easy and fun. In fact, due to such positive feedback, I have been asked by Prentice Hall to produce this new, updated version to include two additional and popular shells, the Bash and TC shells. Although often associated with Linux systems, the Bash and TC shells are freely available to anyone using UNIX as well. In fact, today many UNIX users prefer these shells to the traditional UNIX shells because they offer an enhanced and flexible interactive environment, as well as improved programming capabilities.

Writing *UNIX Shells by Example* is the culmination of 19 years of teaching and developing classes for the various shells and those UNIX utilities most heavily used by shell programmers. The course notes I developed for teaching classes have been used by the University of California Santa Cruz and University of California Davis UNIX programs, Sun Microsystems Education, Apple Computer, DeAnza College, and numerous vendors throughout the world. Depending on the requirements of my client, I normally teach one shell at a time rather than all of them. To accommodate the needs of so many clients, I developed separate materials for each of the respective UNIX shells and tools.

Whether I am teaching "Grep, Sed, and Awk," "Bourne Shell for the System Administrator," or "The Interactive Korn Shell," one student always asks, "What book can I get that covers all the shells and the important utilities such as grep, sed, and awk? Should I get the awk book, or should I get a book on grep and sed? Is there one book that really covers it all? I don't want to buy three or four books in order to become a shell programmer."

In response, I can recommend a number of excellent books covering these topics separately, and some UNIX books that attempt to do it all, but the students want one book with everything and not just a quick survey. They want the UNIX tools, regular expressions, all three shells, quoting rules, a comparison of the shells, exercises, and so forth, all in one book. This is that book. As I wrote it, I thought about how I teach the classes and organized the chapters in the same format. In the shell programming classes, the first topic is always an introduction to what the shell is and how it works. Then we talk about the UNIX utilities such as grep, sed, and awk, the most important tools in the shell programmer's toolbox. When learning about the shell, it is presented first as an interactive program where everything can be accomplished at the command line, and then as a programming language where the programming constructs are described and demonstrated in shell scripts. (Since the C and TC shells are almost identical as programming languages, there are separate chapters describing interactive use, but only one chapter discussing programming constructs.) When shell programming classes are over, whether they last two days or a week or even a semester, the students are proficient and excited about writing scripts. They have learned how to play the shell game. This book will teach how to play the same game whether you take a class or just play by yourself.

Having always found that simple examples are easier for quick comprehension, each concept is captured in a small example followed by the output and an explanation of each line of the program. This method has proven to be very popular with those who learned Perl programming from my first book, *Perl by Example*, and *UNIX Shells by Example* now has been well−received for those who needed to write, read, and maintain shell programs.

The five shells are presented in parallel so that if, for example, you want to know how redirection is performed in one shell, there is a parallel discussion of that topic in each of the other shell chapters. For a quick comparison chart, see Appendix B of this book.

It is a nuisance to have to go to another book or the UNIX man pages when all you want is enough information about a particular command to jog your memory on how the command works. To save you time, Appendix A contains a list of useful commands, their syntax and definitions. Examples and explanations are provided for the more robust and often−used commands.

The comparison chart in Appendix B will help you keep the different shells straight, especially when you port scripts from one shell to another, and serve as a quick syntax check when all you need is a reminder of how the construct works.

One of the biggest hurdles for shell programmers is using quotes properly. The section on quoting rules in Appendix C presents a step−by−step process for successful quoting in some of the most complex command lines. This procedure has dramatically reduced the amount of time programmers waste when debugging scripts with futile attempts at matching quotes properly.

I think you'll find this book a valuable tutorial and reference. The objective is to explain through example and keep things simple so that you have fun learning and save time. Since the book replicates what I say in my classes, I am confident that you will be a productive shell programmer in a short amount of time. Everything you need is right here at your fingertips. Playing the shell game is fun. You'll see!

Ellie Quigley (ellieq@ellieq.com)

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Mark Taub, my acquisitions editor, and Vanessa Moore, my production editor at Prentice Hall; Beth Gerra, Roberta Harvey, and Gary Wilson for reviewing the original material; Steve Hansen for hardware and software support. Finally, I would like to thank all my students at UC Santa Cruz, UC Davis, and Sun Microsystems for their feedback.

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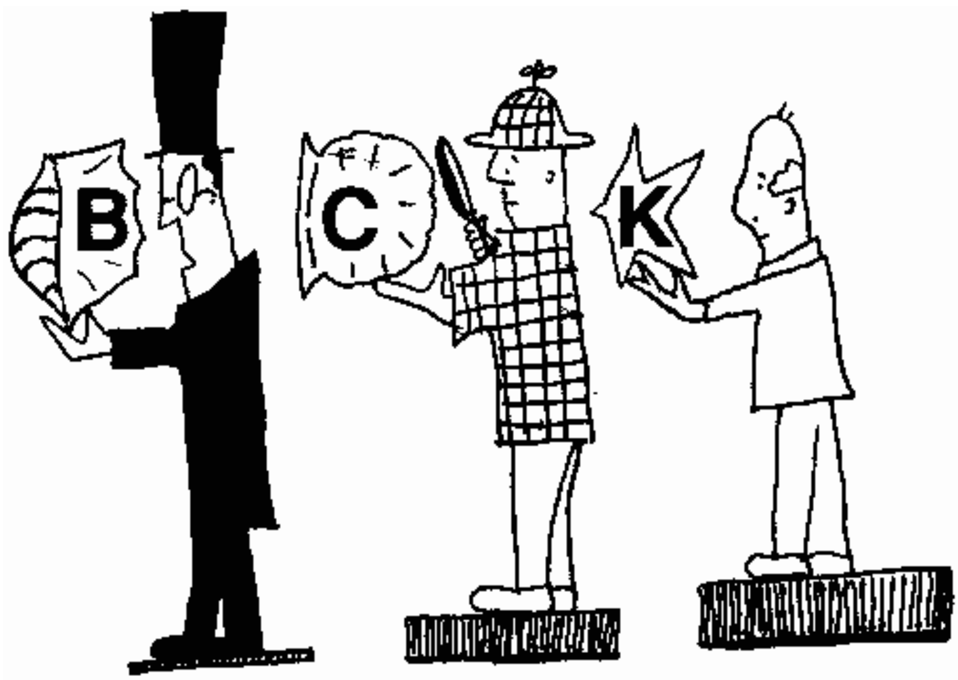
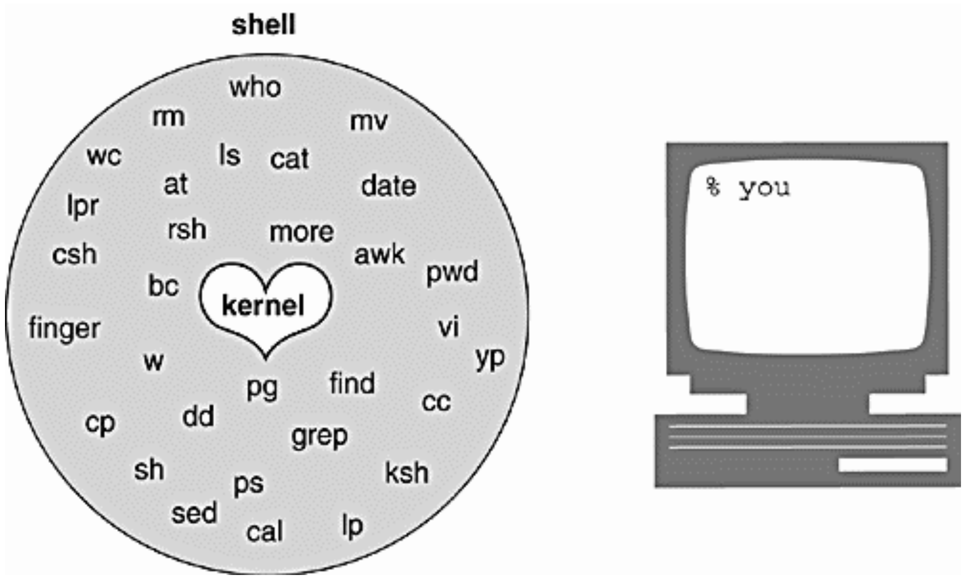
Chapter 1. Introduction to UNIX Shells



1.1 Definition and Function

The shell is a special program used as an interface between the user and the heart of the UNIX operating system, a program called the kernel, as shown in Figure 1.1. The kernel is loaded into memory at boot−up time and manages the system until shutdown. It creates and controls processes, and manages memory, file systems, communications, and so forth. All other programs, including shell programs, reside out on the disk. The kernel loads those programs into memory, executes them, and cleans up the system when they terminate. The shell is a utility program that starts up when you log on. It allows users to interact with the kernel by interpreting commands that are typed either at the command line or in a script file.

Figure 1.1. The kernel, the shell, and you.



When you log on, an interactive shell starts up and prompts you for input. After you type a command, it is the responsibility of the shell to (a) parse the command line; (b) handle wildcards, redirection, pipes, and job control; and (c) search for the command, and if found, execute that command. When you first learn UNIX, you spend most of your time executing commands from the prompt. You use the shell interactively.

If you type the same set of commands on a regular basis, you may want to automate those tasks. This can be done by putting the commands in a file, called a script file, and then executing the file. A shell script is much like a batch file: It is a list of UNIX commands typed into a file, and then the file is executed. More sophisticated scripts contain programming constructs for making decisions, looping, file testing, and so forth. Writing scripts not only requires learning programming constructs and techniques, but assumes that you have a good understanding of UNIX utilities and how they work. There are some utilities, such as grep, sed, and awk, that are extremely powerful tools used in scripts for the manipulation of command output and files. After you have become familiar with these tools and the programming constructs for your particular shell, you will be ready to start writing useful scripts. When executing commands from within a script, you are using the shell as a programming language.

1.1.1 The Three Major UNIX Shells

The three prominent and supported shells on most UNIX systems are the Bourne shell (AT&T shell), the C shell (Berkeley shell), and the Korn shell (superset of the Bourne shell). All three of these behave pretty much the same way when running interactively, but have some differences in syntax and efficiency when used as scripting languages.

The Bourne shell is the standard UNIX shell, and is used to administer the system. Most of the system administration scripts, such as the rc start and stop scripts and shutdown are Bourne shell scripts, and when in single user mode, this is the shell commonly used by the administrator when running as root. This shell was written at AT&T and is known for being concise, compact, and fast. The default Bourne shell prompt is the dollar sign ($).

The C shell was developed at Berkeley and added a number of features, such as command line history, aliasing, built−in arithmetic, filename completion, and job control. The C shell has been favored over the Bourne shell by users running the shell interactively, but administrators prefer the Bourne shell for scripting, because Bourne shell scripts are simpler and faster than the same scripts written in C shell. The default C shell prompt is the percent sign (%).

The Korn shell is a superset of the Bourne shell written by David Korn at AT&T. A number of features were added to this shell above and beyond the enhancements of the C shell. Korn shell features include an editable history, aliases, functions, regular expression wildcards, built−in arithmetic, job control, coprocessing, and special debugging features. The Bourne shell is almost completely upward−compatible with the Korn shell, so older Bourne shell programs will run fine in this shell. The default Korn shell prompt is the dollar sign ($).

1.1.2 The Linux Shells

Although often called "Linux" shells, Bash and TC shells are freely available and can be compiled on any UNIX system; in fact, the shells are now bundled with Solaris 8 and Sun's UNIX operating system. But when you install Linux, you will have access to the GNU shells and tools, and not the standard UNIX shells and tools. Although Linux supports a number of shells, the Bourne Again shell (bash) and the TC shell (tcsh) are by far the most popular. The Z shell is another Linux shell that incorporates a number of features from the Bourne Again shell, the TC shell, and the Korn shell. The Public Domain Korn shell (pdksh) a Korn shell clone, is also available, and for a fee you can get AT&T's Korn shell, not to mention a host of other unknown smaller shells.

To see what shells are available under your version of Linux, look in the file, /etc/shell.

To change to one of the shells listed in /etc/shell, type the chsh command and the name of the shell. For example, to change permanently to the TC shell, use the chsh command. At the prompt, type:

```
chsh /bin/tcsh
```

1.1.3 History of the Shell

The first significant, standard UNIX shell was introduced in V7 (seventh edition of AT&T) UNIX in late 1979, and was named after its creator, Stephen Bourne. The Bourne shell as a programming language is based on a language called Algol, and was primarily used to automate system administration tasks. Although popular for its simplicity and speed, it lacks many of the features for interactive use, such as history, aliasing, and job control. Enter bash, the Bourne Again shell, which was developed by Brian Fox of the Free Software Foundation under the GNU copyright license and is the default shell for the very popular Linux operating system. It was intended to conform to the IEEE POSIX P1003.2/ISO 9945.2 Shell and Tools standard. Bash also offers a number of new features (both at the interactive and programming level) missing in the original Bourne shell (yet Bourne shell scripts will still run unmodified). It also incorporates the most useful features of both the C shell and Korn shell. It's big. The improvements over Bourne shell are: command line history and editing, directory stacks, job control, functions, aliases, arrays, integer arithmetic (in any base from 2 to 64), and Korn shell features, such as extended metacharacters, select loops for creating menus, the let command, etc.

The C shell, developed at the University of California at Berkeley in the late 1970s, was released as part of 2BSD UNIX. The shell, written primarily by Bill Joy, offered a number of additional features not provided in the standard Bourne shell. The C shell is based on the C programming language, and when used as a programming language, it shares a similar syntax. It also offers enhancements for interactive use, such as command line history, aliases, and job control. Because the shell was designed on a large machine and a number of additional features were added, the C shell has a tendency to be slow on small machines and sluggish even on large machines when compared to the Bourne shell.

The TC shell is an expanded version of the C shell. Some of the new features are: command line editing (emacs and vi), scrolling the history list, advanced filename, variable, and command completion, spelling correction, scheduling jobs, automatic locking and logout, time stamps in the history list, etc. It's also big.

With both the Bourne shell and the C shell available, the UNIX user now had a choice, and conflicts arose over which was the better shell. David Korn, from AT&T, invented the Korn shell in the mid−1980s. It was released in 1986 and officially became part of the SVR4 distribution of UNIX in 1988. The Korn shell, really a superset of the Bourne shell, runs not only on UNIX systems, but also on OS/2, VMS, and DOS. It provides upward−compatibility with the Bourne shell, adds many of the popular features of the C shell, and is fast and efficient. The Korn shell has gone through a number of revisions. The most widely used version of the Korn shell is the 1988 version, although the 1993 version is gaining popularity. Linux users may find they are running the free version of the Korn shell, called The Public Domain Korn shell, or simply pdksh, a clone of David Korn's 1988 shell. It is free and portable and currently work is underway to make it fully compatible with its namesake, Korn shell, and to make it POSIX compliant. Also available is the Z shell (zsh), another Korn shell clone with TC shell features, written by Paul Falsted, and freely available at a number of Web sites.

1.1.4 Uses of the Shell

One of the major functions of a shell is to interpret commands entered at the command line prompt when running interactively. The shell parses the command line, breaking it into words (called tokens), separated by whitespace, which consists of tabs, spaces, or a newline. If the words contain special metacharacters, the shell evaluates them. The shell handles file I/O and background processing. After the command line has been processed, the shell searches for the command and starts its execution.

Another important function of the shell is to customize the user's environment, normally done in shell initialization files. These files contain definitions for setting terminal keys and window characteristics; setting variables that define the search path, permissions, prompts, and the terminal type; and setting variables that are required for specific applications such as windows, text−processing programs, and libraries for programming languages. The Korn shell and C shell also provide further customization with the addition of history and aliases, built−in variables set to protect the user from clobbering files or inadvertently logging out, and to notify the user when a job has completed.

The shell can also be used as an interpreted programming language. Shell programs, also called scripts, consist of commands listed in a file. The programs are created in an editor (although on−line scripting is permitted). They consist of UNIX commands interspersed with fundamental programming constructs such as variable assignment, conditional tests, and loops. You do not have to compile shell scripts. The shell interprets each line of the script as if it had been entered from the keyboard. Because the shell is responsible for interpreting commands, it is necessary for the user to have an understanding of what those commands are. See Appendix A for a list of useful commands.

1.1.5 Responsibilities of the Shell

The shell is ultimately responsible for making sure that any commands typed at the prompt get properly executed. Included in those responsibilities are:

1. Reading input and parsing the command line.
2. Evaluating special characters.
3. Setting up pipes, redirection, and background processing.
4. Handling signals.
5. Setting up programs for execution.

Each of these topics is discussed in detail as it pertains to a particular shell.

1.2 System Startup and the Login Shell

When you start up your system, the first process is called init. Each process has a process identification number associated with it, called the PID. Since init is the first process, its PID is 1. The init process initializes the system and then starts another process to open terminal lines and set up the standard input (stdin), standard output (stdout), and standard error (stderr), which are all associated with the terminal. The standard input normally comes from the keyboard; the standard output and standard error go to the screen. At this point, a login prompt would appear on your terminal.

After you type your login name, you will be prompted for a password. The /bin/login program then verifies your identity by checking the first field in the passwd file. If your username is there, the next step is to run the password you typed through an encryption program to determine if it is indeed the correct password. Once your password is verified, the login program sets up an initial environment consisting of variables that define the working environment that will be passed on to the shell. The HOME, SHELL, USER, and LOGNAME variables are assigned values extracted from information in the passwd file. The HOME variable is assigned your home directory; the SHELL variable is assigned the name of the login shell, which is the last entry in the passwd file. The USER and/or LOGNAME variables are assigned your login name. A search path variable is set so that commonly used utilities may be found in specified directories. When login has finished, it will execute the program found in the last entry of the passwd file. Normally, this program is a shell. If the last entry in the passwd file is /bin/csh, the C shell program is executed. If the last entry in the passwd file is /bin/sh or is null, the Bourne shell starts up. If the last entry is /bin/ksh, the Korn shell is executed. This shell is called the login shell.

After the shell starts up, it checks for any systemwide initialization files set up by the system administrator and then checks your home directory to see if there are any shell−specific initialization files there. If any of these files exist, they are executed. The initialization files are used to further customize the user environment. After the commands in those files have been executed, a prompt appears on the screen. The shell is now waiting for your input.

1.2.1 Parsing the Command Line

When you type a command at the prompt, the shell reads a line of input and parses the command line, breaking the line into words, called tokens. Tokens are separated by spaces and tabs and the command line is terminated by a newline.[1] The shell then checks to see whether the first word is a built−in command or an executable program located somewhere out on disk. If it is built−in, the shell will execute the command internally. Otherwise, the shell will search the directories listed in the path variable to find out where the program resides. If the command is found, the shell will fork a new process and then execute the program. The shell will sleep (or wait) until the program finishes execution and then, if necessary, will report the status of the exiting program. A prompt will appear and the whole process will start again. The order of processing the command line is as follows:

1. History substitution is performed (if applicable).
2. Command line is broken up into tokens, or words.
3. History is updated (if applicable).
4. Quotes are processed.
5. Alias substitution and functions are defined (if applicable).
6. Redirection, background, and pipes are set up.
7. Variable substitution ($user, $name, etc.) is performed.

8. Command substitution (echo for today is 'date') is performed.
9. Filename substitution, called globbing (cat abc.??, rm *.c, etc.) is performed.
10. Program execution.

1.2.2 Types of Commands

When a command is executed, it is an alias, a function, a built−in command, or an executable program on disk. Aliases are abbreviations (nicknames) for existing commands and apply to the C, TC, Bash, and Korn shells. Functions apply to the Bourne (introduced with AT&T System V, Release 2.0), Bash, and Korn shells. They are groups of commands organized as separate routines. Aliases and functions are defined within the shell's memory. Built−in commands are internal routines in the shell, and executable programs reside on disk. The shell uses the path variable to locate the executable programs on disk and forks a child process before the command can be executed. This takes time. When the shell is ready to execute the command, it evaluates command types in the following order:[2]

1. Aliases
2. Keywords
3. Functions (bash)
4. Built−in commands
5. Executable programs

If, for example, the command is xyz the shell will check to see if xyz is an alias. If not, is it a built−in command or a function? If neither of those, it must be an executable command residing on the disk. The shell then must search the path for the command.

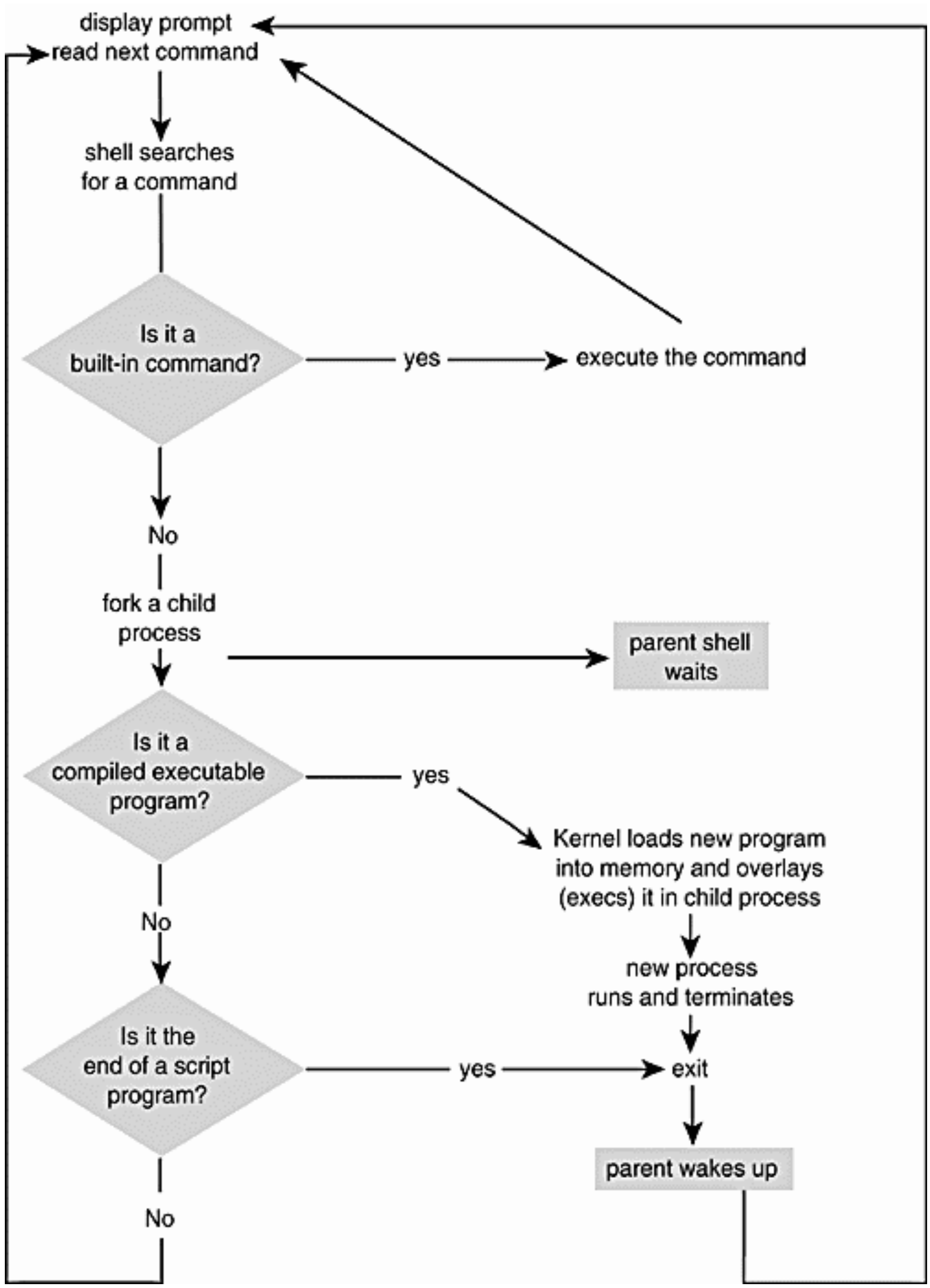
1.3 Processes and the Shell

A process is a program in execution and can be identified by its unique PID (process identification) number. The kernel controls and manages processes. A process consists of the executable program, its data and stack, program and stack pointer, registers, and all the information needed for the program to run. When you start the shell, it is a process. The shell belongs to a process group identified by the group's PID. Only one process group has control of the terminal at a time and is said to be running in the foreground. When you log on, your shell is in control of the terminal and waits for you to type a command at the prompt.

The shell can spawn other processes. In fact, when you enter a command at the prompt or from a shell script, the shell has the responsibility of finding the command either in its internal code (built−in) or out on the disk and then arranging for the command to be executed. This is done with calls to the kernel, called system calls. A system call is a request for kernel services and is the only way a process can access the system's hardware. There are a number of system calls that allow processes to be created, executed, and terminated. (The shell provides other services from the kernel when it performs redirection and piping, command substitution, and the execution of user commands.)

The system calls used by the shell to cause new processes to run are discussed in the following sections. See Figure 1.2.

Figure 1.2. The shell and command execution.



1.3.1 What Processes Are Running?

The ps Command. The ps command with its many options displays a list of the processes currently running in a number of formats. Example 1.1 shows all processes that are running by users on a Linux system. (See Appendix A for ps and its options.)

Example 1.1

```
$ ps au  (BSD/Linux ps)  (use ps −ef for SVR4)
USER   PID %CPU %MEM  SIZE   RSS TTY STAT START  TIME COMMAND
ellie  456  0.0  1.3  1268   840   1 S    13:23  0:00 −bash
ellie  476  0.0  1.0  1200   648   1 S    13:23  0:00 sh /usr/X11R6/bin/sta
ellie  478  0.0  1.0  2028   676   1 S    13:23  0:00 xinit /home/ellie/.xi
```

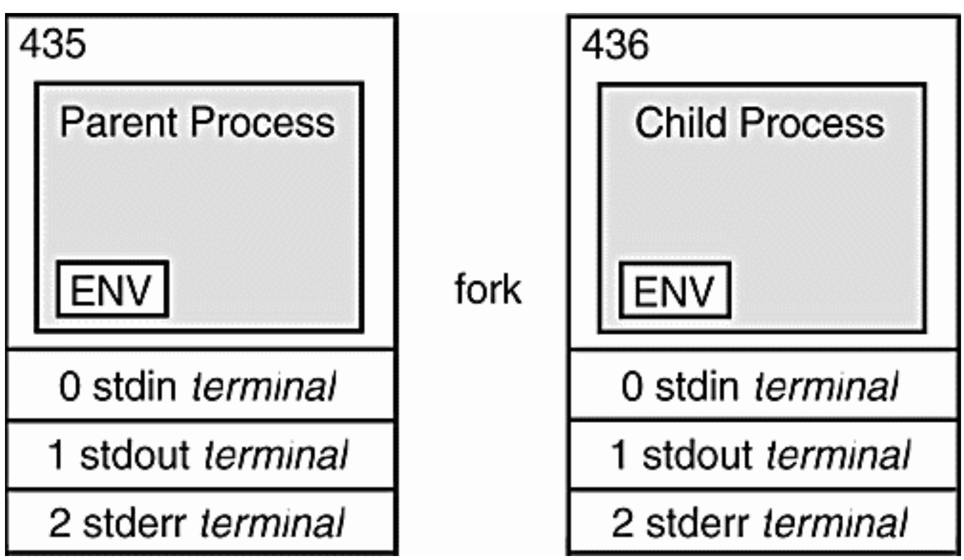
```
ellie   480  0.0  1.6  1852  1068   1 S    13:23  0:00 fvwm2
ellie   483  0.0  1.3  1660   856   1 S    13:23  0:00 /usr/X11R6/lib/X11/fv
ellie   484  0.0  1.3  1696   868   1 S    13:23  0:00 /usr/X11R6/lib/X11/fv
ellie   487  0.0  2.0  2348  1304   1 S    13:23  0:00 xclock −bg #c0c0c0 −p
ellie   488  0.0  1.1  1620   724   1 S    13:23  0:00 /usr/X11R6/lib/X11/fv
ellie   489  0.0  2.0  2364  1344   1 S    13:23  0:00 xload −nolabel −bg gr
ellie   495  0.0  1.3  1272   848  p0 S    13:24  0:00 −bash
ellie   797  0.0  0.7   852   484  p0 R    14:03  0:00 ps au
root    457  0.0  0.4   724   296   2 S    13:23  0:00 /sbin/mingetty tty2
root    458  0.0  0.4   724   296   3 S    13:23  0:00 /sbin/mingetty tty3
root    459  0.0  0.4   724   296   4 S    13:23  0:00 /sbin/mingetty tty4
root    460  0.0  0.4   724   296   5 S    13:23  0:00 /sbin/mingetty tty5
root    461  0.0  0.4   724   296   6 S    13:23  0:00 /sbin/mingetty tty6
root    479  0.0  4.5 12092  2896   1 S    13:23  0:01 X :0
root    494  0.0  2.5  2768  1632   1 S    13:24  0:00 nxterm −ls −sb −fn
```

1.3.2 Creating Processes

The fork System Call. A process is created in UNIX with the fork system call. The fork system call creates a duplicate of the calling process. The new process is called the child and the process that created it is called the parent. The child process starts running right after the call to fork, and both processes initially share the CPU. The child process has a copy of the parent's environment, open files, real and user identifications, umask, current working directory, and signals.

When you type a command, the shell parses the command line and determines whether the first word is a built−in command or an executable command that resides out on the disk. If the command is built−in, the shell handles it, but if on the disk, the shell invokes the fork system call to make a copy of itself (Figure 1.3). Its child will search the path to find the command, as well as set up the file descriptors for redirection, pipes, command substitution, and background processing. While the child shell works, the parent normally sleeps. (See wait, below.)

Figure 1.3. The fork system call.



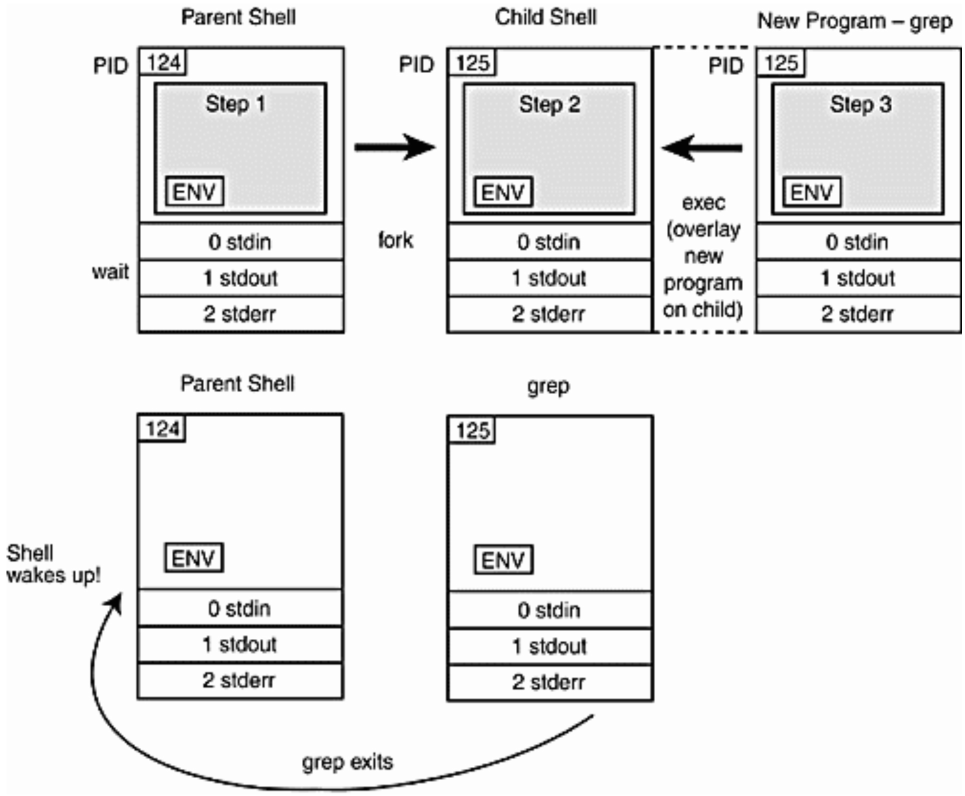
The wait System Call. The parent shell is programmed to go to sleep (wait) while the child takes care of details such as handling redirection, pipes, and background processing. The wait system call causes the parent process to suspend until one of its children terminates. If wait is successful, it returns the PID of the child that died and the child's exit status. If the parent does not wait and the child exits, the child is put in a zombie state (suspended animation) and will stay in that state until either the parent calls wait or the parent dies.[3] If the parent dies before the child, the init process adopts any orphaned zombie process. The wait system call, then, is not just used to put a parent to sleep, but also to ensure that the process terminates properly.

The exec System Call. After you enter a command at the terminal, the shell normally forks off a new shell process: the child process. As mentioned earlier, the child shell is responsible for causing the command you typed to be executed. It does this by calling the exec system call. Remember, the user command is really just an executable program. The shell searches the path for the new program. If it is found, the shell calls the exec system call with the name of the command as its argument. The kernel loads this new program into memory in place of the shell that called it. The child shell, then, is overlaid with the new program. The new program becomes the child process and starts executing. Although the new process has its own local variables, all environment variables, open files, signals, and the current working directory are passed to the new process. This process exits when it has finished, and the parent shell wakes up.

The exit System Call. A new program can terminate at any time by executing the exit call. When a child process terminates, it sends a signal (sigchild) and waits for the parent to accept its exit status. The exit status is a number between 0 and 255. An exit status of zero indicates that the program executed successfully, and a nonzero exit status means that the program failed in some way.

For example, if the command ls had been typed at the command line, the parent shell would fork a child process and go to sleep. The child shell would then exec (overlay) the ls program in its place. The ls program would run in place of the child, inheriting all the environment variables, open files, user information, and state information. When the new process finished execution, it would exit and the parent shell would wake up. A prompt would appear on the screen, and the shell would wait for another command. If you are interested in knowing how a command exited, each shell has a special built−in variable that contains the exit status of the last command that terminated. (All of this will be explained in detail in the individual shell chapters.) See Figure 1.4 for an example of process creation and termination.

Figure 1.4. The fork, exec, wait, and exit system calls.



EXPLANATION

1. The parent shell creates a copy of itself with the fork system call. The copy is called the child shell.
2. The child shell has a new PID and is a copy of its parent. It will share the CPU with the parent.
3. The kernel loads the grep program into memory and executes (exec) it in place of the child shell. The grep program inherits the open files and environment from the child.
4. The grep program exits, the kernel cleans up, and the parent is awakened.

Example 1.2

```
(C Shell)
1   % cp filex filey
    % echo $status
    0
2   % cp xyz
    Usage: cp [-ip] f1 f2; or: cp [-ipr] f1 ... fn d2
    % echo $status
    1

(Bourne and Korn Shells)
3   $ cp filex filey
    $ echo $?
    0
    $ cp xyz
    Usage: cp [-ip] f1 f2; or: cp [-ipr] f1 ... fn d2
    $ echo $?
    1
```

EXPLANATION

1. The cp (copy) command is entered at the C shell command line prompt. After the command has made a copy of filex called filey, the program exits and the prompt appears. The csh status variable contains the exit status of the last command that was executed. If the status is zero, the cp program exited with success. If the exit status is nonzero, the cp program failed in some way.
2. When entering the cp command, the user failed to provide two filenames: the source and destination files. The cp program sent an error message to the screen and exited with a status of one. That number is stored in the csh status variable. Any number other than zero indicates that the program failed.
3. The Bourne and Korn shells process the cp command as the C shell did in the first two examples. The only difference is that the Bourne and Korn shells store the exit status in the ? variable, rather than the status variable.

1.4 The Environment and Inheritance

When you log on, the shell starts up and inherits a number of variables, I/O streams, and process characteristics from the /bin/login program that started it. In turn, if another shell is spawned (forked) from the login or parent shell, that child shell (subshell) will inherit certain characteristics from its parent. A subshell may be started for a number of reasons: for handling background processing, for handling groups of commands, or for executing scripts. The child shell inherits an environment from its parent. The environment consists of process permissions (who owns the process), the working directory, the file creation mask, special variables, open files, and signals.

1.4.1 Ownership

When you log on, the shell is given an identity. It has a real user identification (UID), one or more real group identifications (GID), and an effective user identification and effective group identification (EUID and EGID). The EUID and EGID are initially the same as the real UID and GID. These ID numbers are found in the passwd file and are used by the system to identify users and groups. The EUID and EGID determine what permissions a process has access to when reading, writing, or executing files. If the EUID of a process and the real UID of the owner of the file are the same, the process has the owner's access permissions for the file. If the EGID and real GID of a process are the same, the process has the owner's group privileges.

The real UID, from the /etc/passwd file, is a positive integer associated with your login name. The real UID is the third field in the password file. When you log on, the login shell is assigned the real UID and all processes spawned from the login shell inherit its permissions. Any process running with a UID of zero belongs to root (the superuser) and has root privileges. The real group identification, the GID, associates a group with your login name. It is found in the fourth field of the password file.

The EUID and EGID can be changed to numbers assigned to a different owner. By changing the EUID (or EGID[4]) to another owner, you can become the owner of a process that belongs to someone else. Programs that change the EUID or EGID to another owner are called setuid or setgid programs. The /bin/passwd program is an example of a setuid program that gives the user root privileges. Setuid programs are often sources for security holes. The shell allows you to create setuid scripts, and the shell itself may be a setuid program.

1.4.2 The File Creation Mask

When a file is created, it is given a set of default permissions. These permissions are determined by the program creating the file. Child processes inherit a default mask from their parents. The user can change the mask for the shell by issuing the umask command at the prompt or by setting it in the shell's initialization files. The umask command is used to remove permissions from the existing mask.

Initially, the umask is 000, giving a directory 777 (rwxrwxrwx) permissions and a file 666 (rw–rw–rw–) permissions as the default. On most systems, the umask is assigned a value of 022 by the /bin/login program or the /etc/profile initialization file.

The umask value is subtracted from the default settings for both the directory and file permissions as follows:

```
 777 (Directory)       666 (File)
-022 (umask value)    -022 (umask value)
-------               ---------
 755                   644

Result: drwxr-xr-x    -rw-r--r--
```

After the umask is set, all directories and files created by this process are assigned the new default permissions. In this example, directories will be given read, write, and execute for the owner; read and execute for the group; and read and execute for the rest of the world (others). Any files created will be assigned read and write for the owner, and read for the group and others. To change permissions on individual directories and permissions, the chmod command is used.

1.4.3 Changing Permissions with chmod

There is one owner for every UNIX file. Only the owner or the superuser can change the permissions on a file or directory by issuing the chmod command. The following example illustrates the permissions modes. A group may have a number of members, and the owner of the file may change the group permissions on a file so that the group can enjoy special privileges.

The chown command changes the owner and group on files and directories. Only the owner or superuser can invoke it. On BSD versions of UNIX, only the superuser, root, can change ownership.

Every UNIX file has a set of permissions associated with it to control who can read, write, or execute the file. A total of nine bits constitutes the permissions on a file. The first set of three bits controls the permissions of the owner of the file, the second set controls the permissions of the group, and the last set controls the permissions of everyone else. The permissions are stored in the mode field of the file's inode.

The chmod command changes permissions on files and directories. The user must own the files to change permissions on them.[5]

Table 1.1 illustrates the eight possible combinations of numbers used for changing permissions.

Table 1.1. Permission Modes

Decimal	**Octal**	**Permissions**
0	000	none
1	001	– –x
2	010	–w–
3	011	–wx
4	100	r– –
5	101	r–x
6	110	rw–
7	111	rwx

The symbolic notation for chmod is as follows:

r = read; w = write; x = execute; u = user; g = group; o = others; a = all.

Example 1.3

```
1   $ chmod 755 file
    $ ls −l file
    −rwxr−xr−x 1 ellie 0 Mar   7 12:52 file
2   $ chmod g+w file
    $ ls −l file
    −rwxrwxr−x  1 ellie 0 Mar  7 12:54 file
3   $ chmod go−rx file
    $ ls −l file
    −rwx−w−−−− 1 ellie 0 Mar  7 12:56 file
4   $ chmod a=r file
    $ ls −l file
    −r−−r−−r−− 1 ellie 0 Mar  7 12:59 file
```

EXPLANATION

1. The first argument is the octal value 755. It turns on rwx for the user, and r and x for the group and others for file.
2. In the symbolic form of chmod, write permission is added to the group.
3. In the symbolic form of chmod, read and execute permission are subtracted from the group and others.
4. In the symbolic form of chmod, all are given only read permission. The = sign causes all permissions to be reset to the new value.

Example 1.4

```
(The Command Line)
1   $ chown steve filex
2   $ ls −l

(The Output)
−rwxrwxr−x 1 steve groupa 170 Jul 28:20 filex
```

EXPLANATION

1. The ownership of filex is changed to steve.
2. The ls –l command displays the owner steve in column 3.

1.4.4 Changing Ownership with the chown Command

The Working Directory. When you log in, you are given a working directory within the file system, called the home directory. The working directory is inherited by processes spawned from this shell. Any child process of this shell can change its own working directory, but the change will have no effect on the parent shell.

The cd command, used to change the working directory, is a shell built−in command. Each shell has its own copy of cd. A built−in command is executed directly by the shell as part of the shell's code; the shell does not perform the fork and exec system calls when executing built−in commands. If another shell (script) is forked from the parent shell, and the cd command is issued in the child shell, the directory will be changed in the child shell. When the child exits, the parent shell will be in the same directory it was in before the child started.

Example 1.5

```
1   % cd /

2   % pwd
    /

3   % sh

4   $ cd /home

5   $ pwd
    /home

6   $ exit

7   % pwd
    /

    %
```

EXPLANATION

1. The prompt is a C shell prompt. The cd command changes directory to /. The cd command is built into the shell's internal code.
2. The pwd command displays the present working directory, /.
3. The Bourne shell is started.
4. The cd command changes directories to /home.
5. The pwd command displays the present working directory, /home.
6. The Bourne shell is exited, returning back to the C shell.
7. In the C shell, the present working directory is still /. Each shell has its own copy of cd.

Variables. The shell can define two types of variables: local and environment. The variables contain information used for customizing the shell, and information required by other processes so that they will function properly. Local variables are private to the shell in which they are created and not passed on to any processes spawned from that shell. Environment variables, on the other hand, are passed from parent to child process, from child to grandchild, and so on. Some of the environment variables are inherited by the login shell from the /bin/login program. Others are created in the user initialization files, in scripts, or at the command line. If an environment variable is set in the child shell, it is not passed back to the parent.

File Descriptors. All I/O, including files, pipes, and sockets, are handled by the kernel via a mechanism called the file descriptor. A file descriptor is a small unsigned integer, an index into a file−descriptor table maintained by the kernel and used by the kernel to reference open files and I/O streams. Each process inherits its own file−descriptor table from its parent. The first three file descriptors, 0, 1, and 2, are assigned to your terminal. File descriptor 0 is standard input (stdin), 1 is standard output (stdout), and 2 is standard error (stderr). When you open a file, the next available descriptor is 3, and it will be assigned to the new file. If all the available file descriptors are in use,[6] a new file cannot be opened.

Redirection. When a file descriptor is assigned to something other than a terminal, it is called I/O redirection. The shell performs redirection of output to a file by closing the standard output file descriptor, 1 (the terminal), and then assigning that descriptor to the file (Figure 1.5).When redirecting standard input, the shell closes file descriptor 0 (the terminal) and assigns that descriptor to a file (Figure 1.6). The Bourne and Korn shells handle errors by assigning a file to file descriptor 2 (Figure 1.7). The C shell, on the other hand, goes through a more complicated process to do the same thing (Figure 1.8)

Figure 1.5. Redirection of standard output.

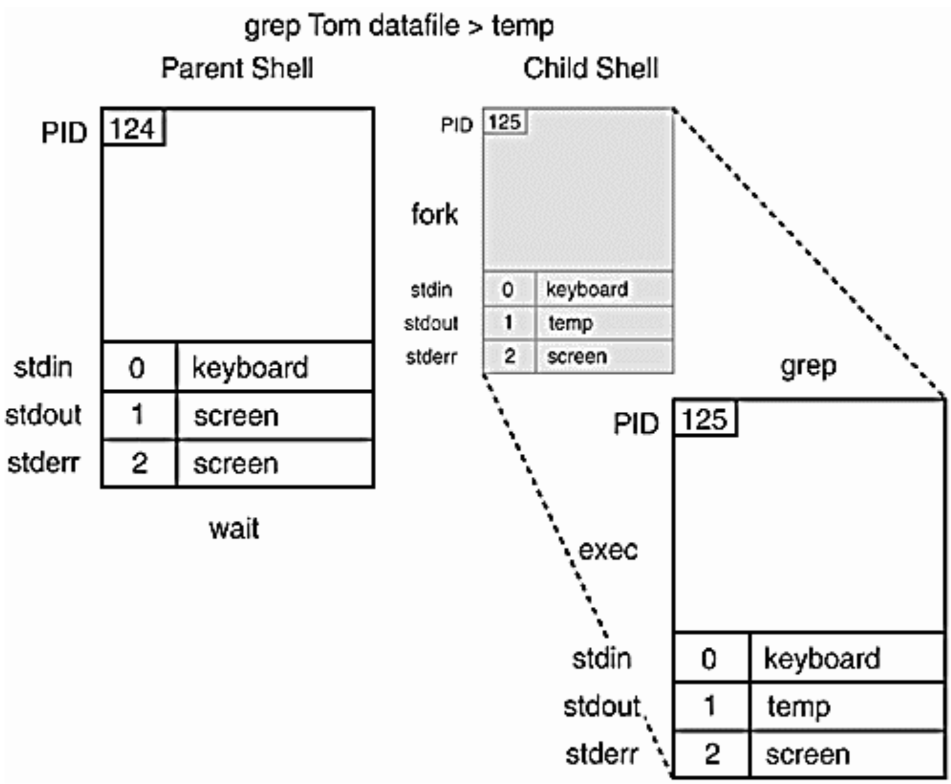


Figure 1.6. Redirection of standard input.

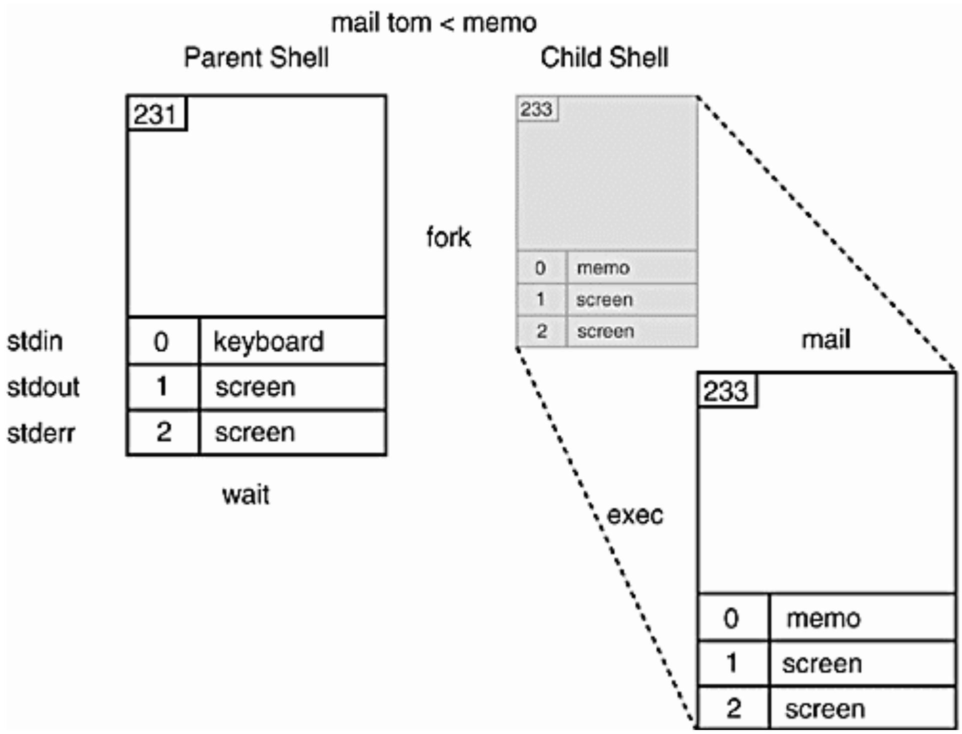


Figure 1.7. Redirection of standard error (Bourne and Korn shells).

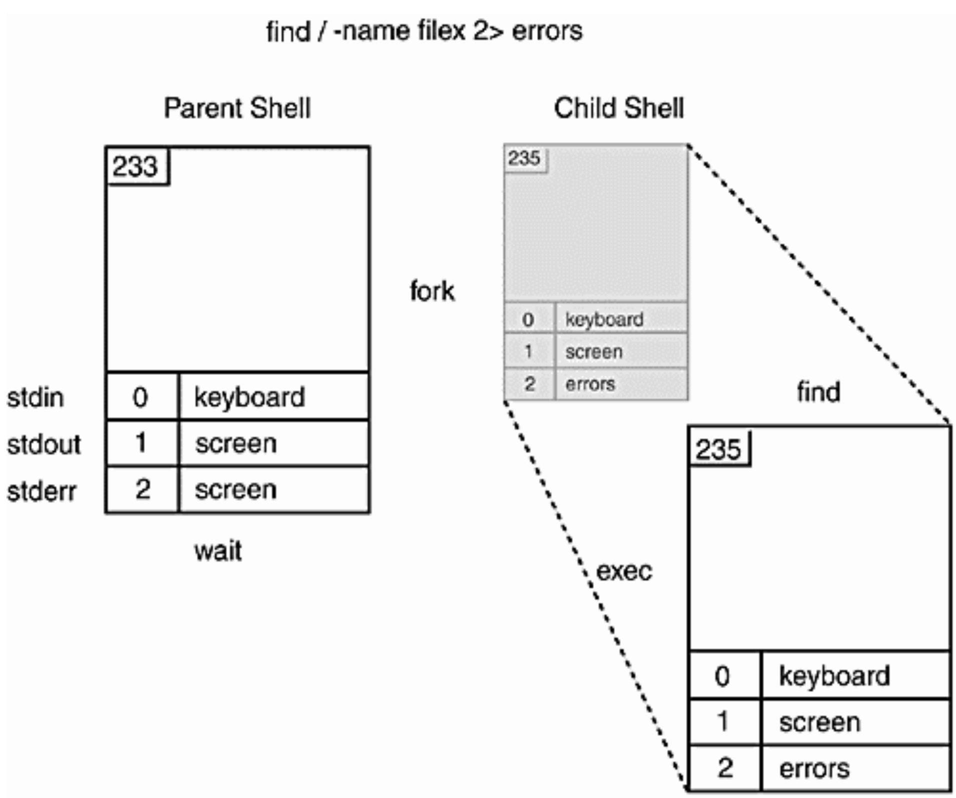
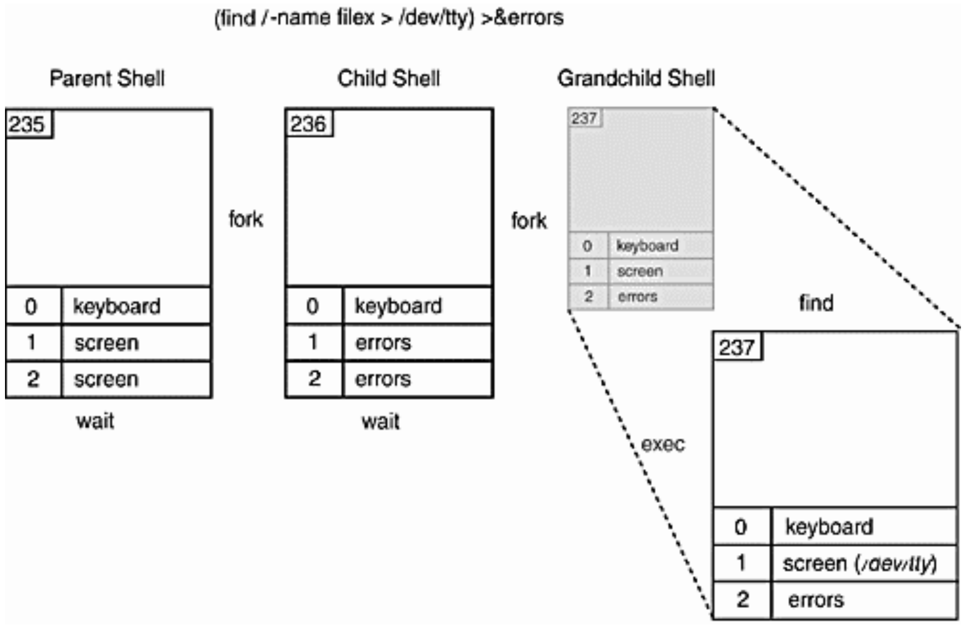


Figure 1.8. Redirection of standard error (C shell).



Example 1.6

```
1   % who > file
2   % cat file1 file2 >> file3
3   % mail tom < file
4   % find / −name file −print 2> errors
5   % ( find / −name file −print > /dev/tty) >& errors
```

EXPLANATION

1. The output of the who command is redirected from the terminal to file. (All shells redirect output in this way.)
2. The output from the cat command (concatenate file1 and file2) is appended to file3. (All shells redirect and append output in this way.)
3. The input of file is redirected to the mail program; that is, user tom will be sent the contents of file. (All shells redirect input in this way.)
4. Any errors from the find command are redirected to errors. Output goes to the terminal. (The Bourne and Korn shells redirect errors this way.)
5. Any errors from the find command are redirected to errors. Output is sent to the terminal. (The C shell redirects errors this way.)

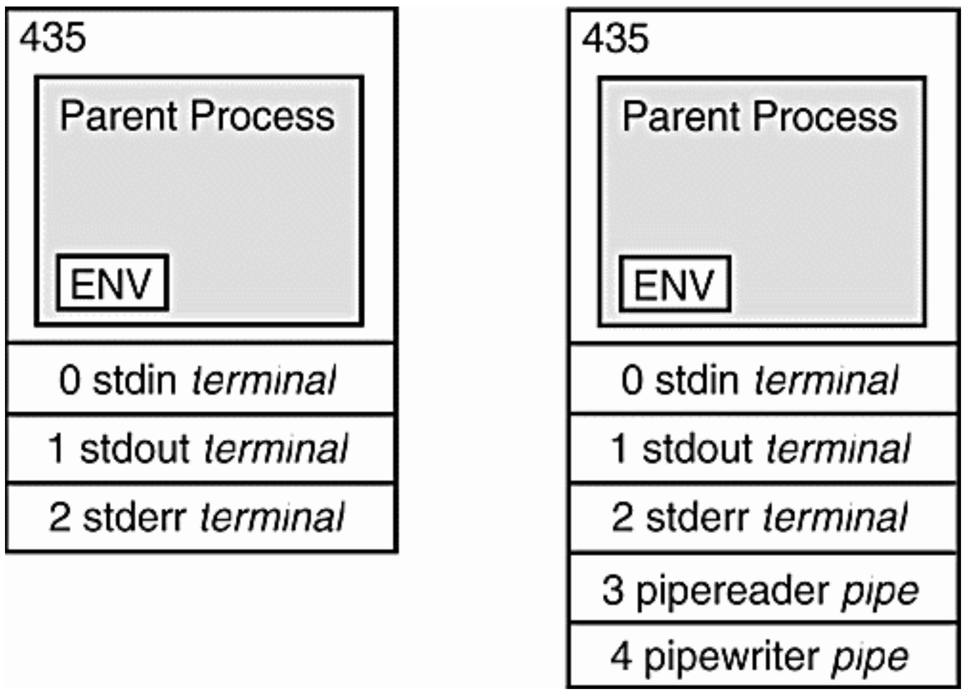
Pipes. Pipes allow the output of one command to be sent to the input of another command. The shell implements pipes by closing and opening file descriptors; however, instead of assigning the descriptors to a file, it assigns them to a pipe descriptor created with the pipe system call. After the parent creates the pipe file descriptors, it forks a child process for each command in the pipeline. By having each process manipulate the pipe descriptors, one will write to the pipe and the other will read from it. The pipe is merely a kernel buffer from which both processes can share data, thus eliminating the need for intermediate temporary files. After the descriptors are set up, the commands are exec'ed concurrently. The output of one command is sent to the buffer, and when the buffer is full or the command has terminated, the command on the right−hand side of the pipe reads from the buffer. The kernel synchronizes the activities so that one process waits while the other reads from or writes from the buffer.

The syntax of the pipe command is

```
who | wc
```

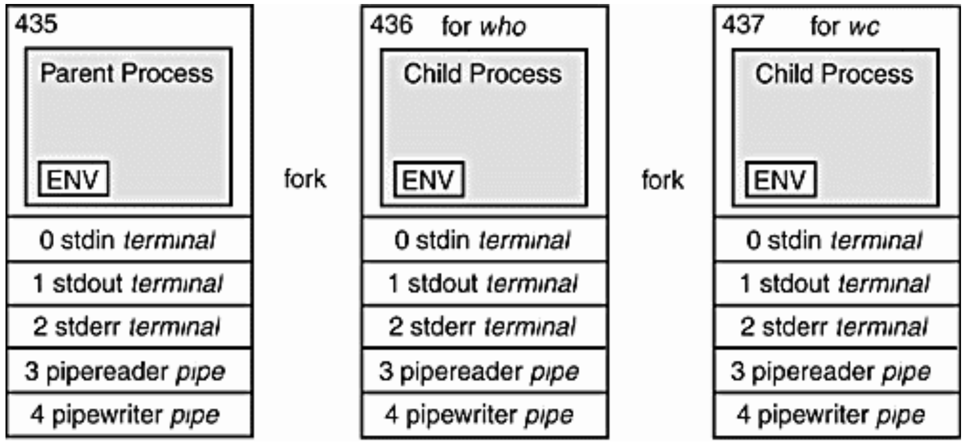
The shell sends the output of the who command as input to the wc command. This is accomplished with the pipe system call. The parent shell calls the pipe system call, which creates two pipe descriptors, one for reading from the pipe and one for writing to it. The files associated with the pipe descriptors are kernel−managed I/O buffers used to temporarily store data, thus saving you the trouble of creating temporary files. Figures 1.9 through 1.13 illustrate the steps for implementing the pipe.

Figure 1.9. The parent calls the pipe system call for setting up a pipeline.



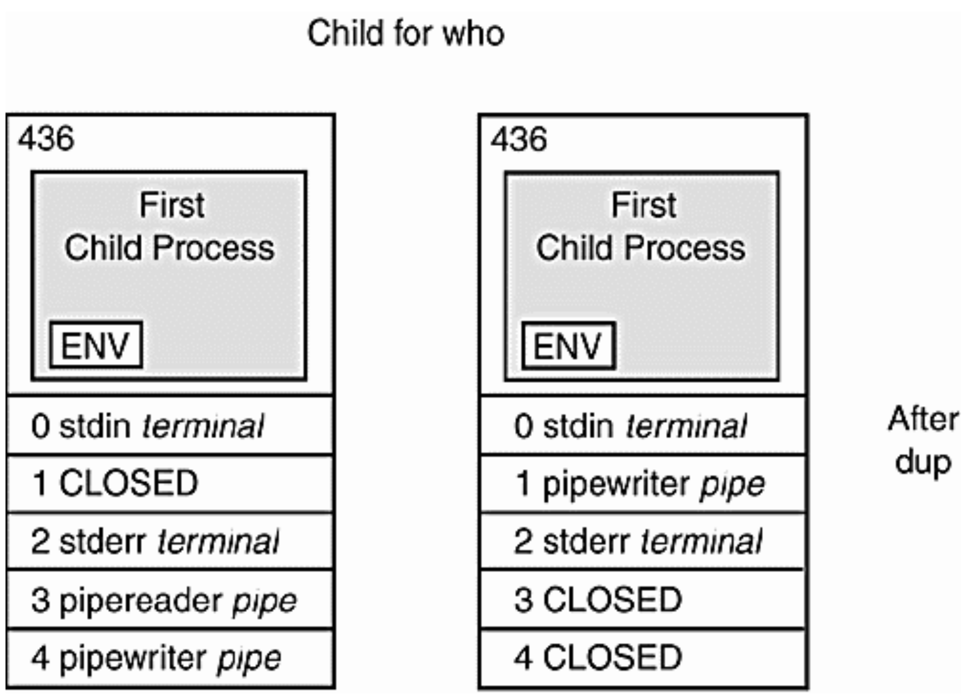
1. The parent shell calls the pipe system call. Two file descriptors are returned: one for reading from the pipe and one for writing to the pipe. The file descriptors assigned are the next available descriptors in the file−descriptor (fd) table, fd 3 and fd 4. See Figure 1.9.
2. For each command, who and wc, the parent forks a child process. Both child processes get a copy of the parent's open file descriptors. See Figure 1.10.

Figure 1.10. The parent forks two child processes, one for each command in the pipeline.



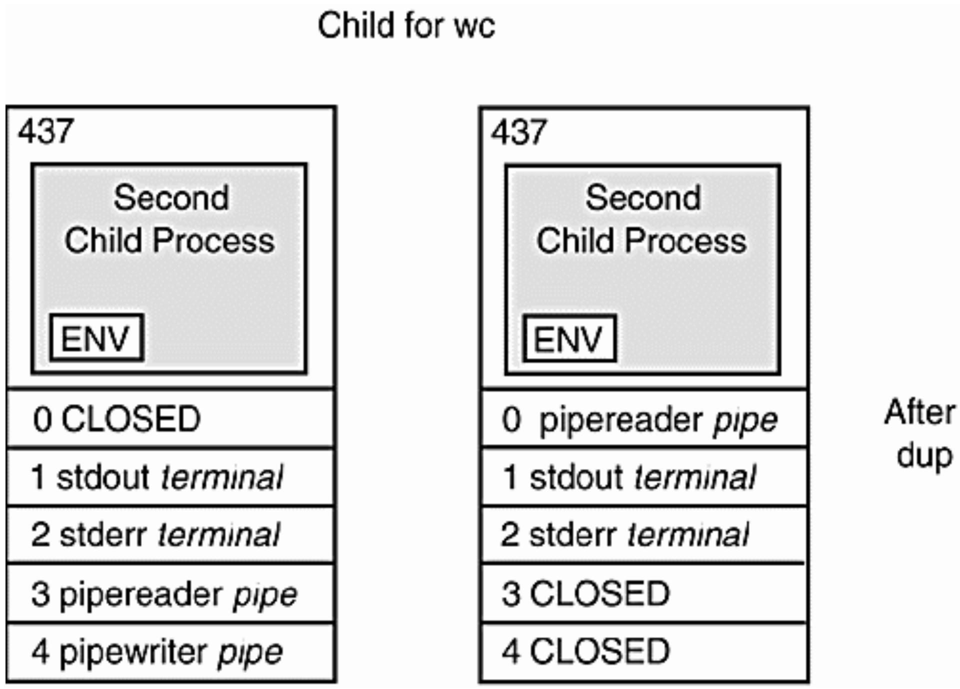
3. The first child closes its standard output. It then duplicates (the dup system call) file descriptor 4, the one associated with writing to the pipe. The dup system call copies fd 4 and assigns the copy to the lowest available descriptor in the table, fd 1. After it makes the copy, the dup call closes fd 4. The child will now close fd 3 because it does not need it. This child wants its standard output to go to the pipe. See Figure 1.11.

Figure 1.11. The first child is prepared to write to the pipe.



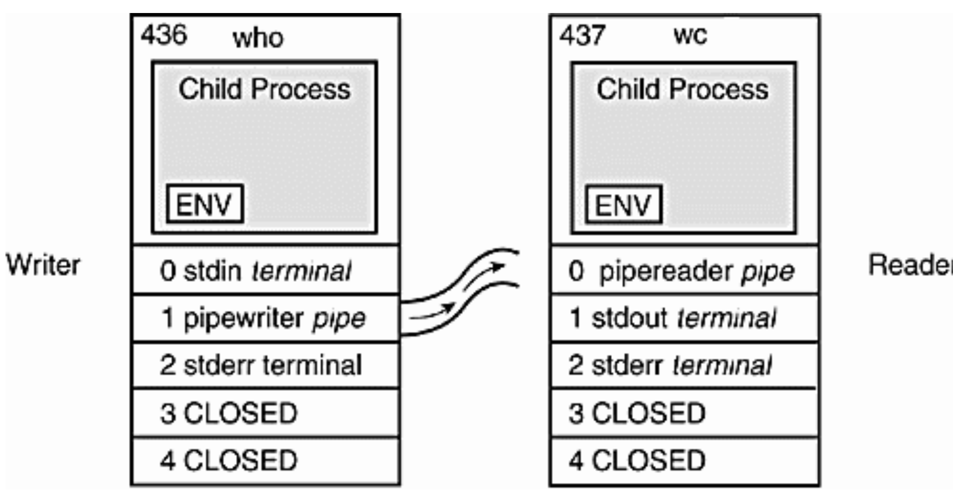
4. Child 2 closes its standard input. It then duplicates (dups) fd 3, which is associated with reading from the pipe. By using dup, a copy of fd 3 is created and assigned to the lowest available descriptor. Since fd 0 was closed, it is the lowest available descriptor. Dup closes fd 3. The child closes fd 4. Its standard input will come from the pipe. See Figure 1.12.

Figure 1.12. The second child is prepared to read input from the pipe.



5. The who command is executed in place of Child 1 and the wc command is executed to replace Child 2. The output of the who command goes into the pipe and is read by the wc command from the other end of the pipe. See Figure 1.13.

Figure 1.13. The output of who is sent to the input of wc.



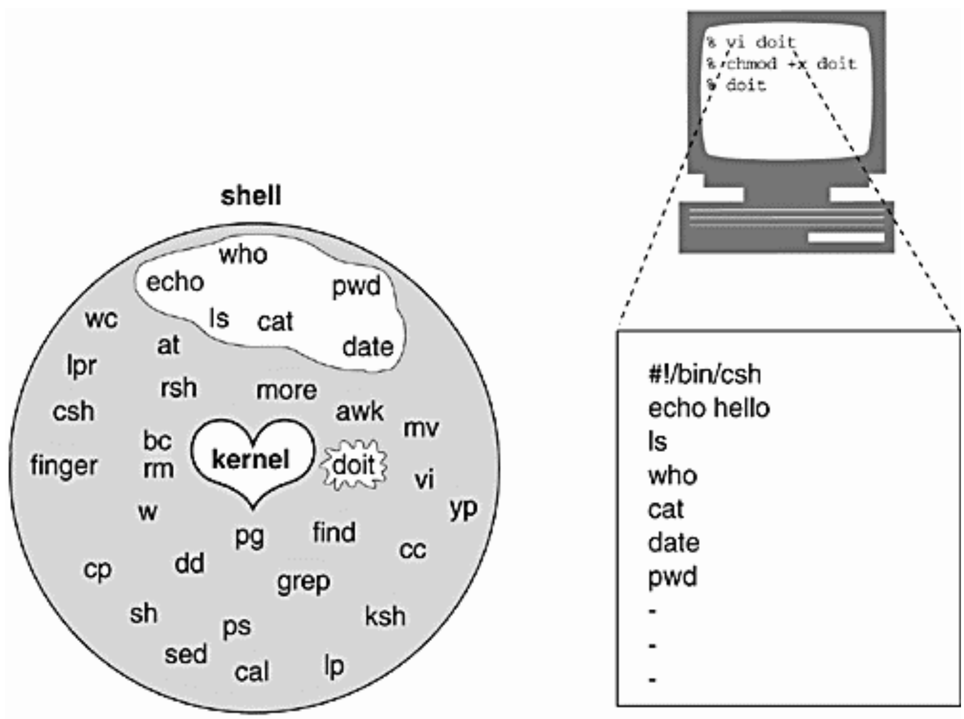
1.4.5 The Shell and Signals

A signal sends a message to a process and normally causes the process to terminate, usually owing to some unexpected event such as a segmentation violation, bus error, or power failure. You can send signals to a process by pressing the Break, Delete, Quit, or Stop keys, and all processes sharing the terminal are affected by the signal sent. You can kill a process with the kill command. By default, most signals terminate the program. The shells allow you to handle signals coming into your program, either by ignoring them or by specifying some action to be taken when a specified signal arrives. The C shell is limited to handling ^C (Control−C).

1.5 Executing Commands from Scripts

When the shell is used as a programming language, commands and shell control constructs are typed in an editor and saved to a file, called a script. The lines from the file are read and executed one at a time by the shell. These programs are interpreted, not compiled. Compiled programs are converted into machine language before they are executed. Therefore, shell programs are usually slower than binary executables, but they are easier to write and are used mainly for automating simple tasks. Shell programs can also be written interactively at the command line, and for very simple tasks, this is the quickest way. However, for more complex scripting, it is easier to write scripts in an editor (unless you are a really great typist). The following script can be executed by any shell to output the same results. Figure 1.14 illustrates the creation of a script called doit and how it fits in with already existing UNIX programs/utilities/commands.

Figure 1.14. Creating a generic shell script.



EXPLANATION
1. Go into your favorite editor and type in a set of UNIX commands, one per line. Indicate what shell you want by placing the pathname of the shell after the #! on the first line. This program is being executed by the C shell and it is named doit. 2. Save your file and turn on the execute permissions so that you can run it. 3. Execute your program just as you would any other UNIX command.

1.5.1 Sample Scripts: Comparing Three Shells

At first glance, the following three programs look very similar. They are. And they all do the same thing. The main difference is the syntax. After you have worked with all three shells for some time, you will quickly adapt to the differences and start formulating your own opinions about which shell is your favorite. A detailed comparison of differences among the C, Bourne, and Korn shells is found in Appendix B.

The following scripts send a mail message to a list of users, inviting each of them to a party. The place and time of the party are set in variables. The people to be invited are selected from a file called guests. A list of foods is stored in a word list, and each person is asked to bring one of the foods from the list. If there are more users than food items, the list is reset so that each user is asked to bring a different food. The only user who is not invited is the user root.

1.5.2 The C Shell Script

Example 1.7

```
1   #!/bin/csh –f
2   # The Party Program––Invitations to friends from the "guest" file
3   set guestfile = ~/shell/guests
4   if ( ! –e "$guestfile" ) then
        echo "$guestfile:t non–existent"
        exit 1
    endif
5   setenv PLACE "Sarotini's"
    @ Time = 'date +%H' + 1
    set food = ( cheese crackers shrimp drinks "hot dogs" sandwiches )
6   foreach person ( 'cat $guestfile' )
       if ( $person =~ root ) continue

7       mail –v –s "Party" $person << FINIS   # Start of here document
        Hi ${person}! Please join me at $PLACE for a party!
        Meet me at    $Time o'clock.
        I'll bring the ice cream. Would you please bring $food[1] and
        anything else you would like to eat? Let me know if you can't
        make it. Hope to see you soon.
             Your pal,
             ellie@'hostname'       # or 'uname –n'
    FINIS
8       shift food
        if ( $#food ==  0 ) then
             set food = ( cheese crackers shrimp drinks "hot dogs"
                          sandwiches )
        endif
9    end

    echo "Bye..."
```

EXPLANATION

1. This line lets the kernel know that you are running a C shell script. The –f option is a fast startup. It says, "Do not execute the .cshrc file," an initialization file that is automatically executed every time a new csh program is started.
2. This is a comment. It is ignored by the shell, but important for anyone trying to understand what the script is doing.
3. The variable guestfile is set to the full pathname of a file called guests.
4. This line reads: If the file guests does not exist, then print to the screen "guests nonexistent" and exit from the script with an exit status of 1 to indicate that something went wrong in the program.
5. Set variables are assigned the values for the place, time, and list of foods to bring. The PLACE variable is an environment variable. The Time variable is a local variable. The @ symbol tells the C shell to perform its built−in arithmetic; that is, add 1 to the Time

variable after extracting the hour from the date command. The Time variable is spelled with an uppercase T to prevent the C shell from confusing it with one of its reserved words, time.

6. For each person on the guest list, except the user root, a mail message will be created inviting the person to a party at a given place and time, and asking him or her to bring one of the foods on the list.
7. The mail message is created in what is called a here document. All text from the user−defined word FINIS to the final FINIS will be sent to the mail program. The foreach loop shifts through the list of names, performing all of the instructions from the foreach to the keyword end.
8. After a message has been sent, the food list is shifted so that the next person will get the next food item on the list. If there are more people than food items, the food list will be reset to ensure that each person is instructed to bring a food item.
9. This marks the end of the looping statements.

1.5.3 The Bourne Shell Script

Example 1.8

```
1   #!/bin/sh
2   # The Party Program−−Invitations to friends from the "guest" file
3   guestfile=/home/jody/ellie/shell/guests
4   if [ ! −f "$guestfile" ]
    then
        echo "'basename $guestfile' non−existent"
        exit 1
    fi
5   PLACE="Sarotini's"
    export PLACE
    Time='date +%H'
    Time='expr $Time + 1'
    set cheese crackers shrimp drinks "hot dogs" sandwiches
6   for person in 'cat $guestfile'
    do
        if [ $person =~ root ]
        then
             continue
        else
7            mail −v −s "Party" $person <<− FINIS
             Hi ${person}! Please join me at $PLACE for a party!
             Meet me at $Time o'clock.
             I'll bring the ice cream. Would you please bring $1 and
             anything else you would like to eat? Let me know if you
             can't make it. Hope to see you soon.
                 Your pal,
                 ellie@'hostname'
             FINIS
8            shift
             if [ $# −eq 0 ]
             then
                set cheese crackers shrimp drinks "hot dogs" sandwiches
             fi
        fi
9   done
    echo "Bye..."
```

EXPLANATION

1. This line lets the kernel know that you are running a Bourne shell script.
2. This is a comment. It is ignored by the shell, but important for anyone trying to understand what the script is doing.
3. The variable guestfile is set to the full pathname of a file called guests.
4. This line reads: If the file guests does not exist, then print to the screen "guests nonexistent" and exit from the script.
5. Variables are assigned the values for the place and time. The list of foods to bring is assigned to special variables (positional parameters) with the set command.
6. For each person on the guest list, except the user root, a mail message will be created inviting each person to a party at a given place and time, and asking each to bring a food from the list.
7. The mail message is sent when this line is uncommented. It is not a good idea to uncomment this line until the program has been thoroughly debugged, otherwise the e−mail will be sent to the same people every time the script is tested. The next statement, using the cat command with the here document, allows the script to be tested by sending output to the screen that would normally be sent through the mail when line 7 is uncommented.
8. After a message has been sent, the food list is shifted so that the next person will get the next food on the list. If there are more people than foods, the food list will be reset, insuring that each person is assigned a food.
9. This marks the end of the looping statements.

1.5.4 The Korn Shell Script

Example 1.9

```
1   #!/bin/ksh
2   # The Party Program−−Invitations to friends from the "guest" file
3   guestfile=~/shell/guests
4   if [[ ! −a "$guestfile" ]]
    then
        print "${guestfile##*/} non−existent"
        exit 1
    fi
5   export PLACE="Sarotini's"
    (( Time=$(date +%H) + 1 ))
    set cheese crackers shrimp drinks "hot dogs" sandwiches
6   for person in $(< $guestfile)
    do
        if  [[ $person = root ]]
        then
             continue
        else

             # Start of here document
7            mail −v −s "Party" $person <<− FINIS
             Hi ${person}! Please join me at $PLACE for a party!
             Meet me at $Time o'clock.
             I'll bring the ice cream. Would you please bring $1
             and anything else you would like to eat? Let me know
             if you can't make it.
                    Hope to see you soon.
                            Your pal,
```

```
                              ellie@'hostname'
             FINIS
8            shift
             if (( $# ==  0 ))
             then
               set cheese crackers shrimp drinks "hot dogs" sandwiches
             fi
         fi
9   done
    print "Bye..."
```

EXPLANATION

1. This line lets the kernel know that you are running a Korn shell script.
2. This is a comment. It is ignored by the shell, but important for anyone trying to understand what the script is doing.
3. The variable guestfile is set to the full pathname of a file called guests.
4. This line reads: If the file guests does not exist, then print to the screen "guests nonexistent" and exit from the script.
5. Variables are assigned the values for the place and time. The list of foods to bring is assigned to special variables (positional parameters) with the set command.
6. For each person on the guest list, except the user root, a mail message will be created inviting the person to a party at a given place and time, and assigning a food from the list to bring.
7. The mail message is sent. The body of the message is contained in a here document.
8. After a message has been sent, the food list is shifted so that the next person will get the next food on the list. If there are more people than foods, the food list will be reset, insuring that each person is assigned a food.
9. This marks the end of the looping statements.

[1] The process of breaking the line up into tokens is called lexical analysis.

[2] Numbers 3 and 4 are reversed for Bourne and Korn(88) shells. Number 3 does not apply for C and TC shells.

[3] To remove zombie processes, the system must be rebooted.

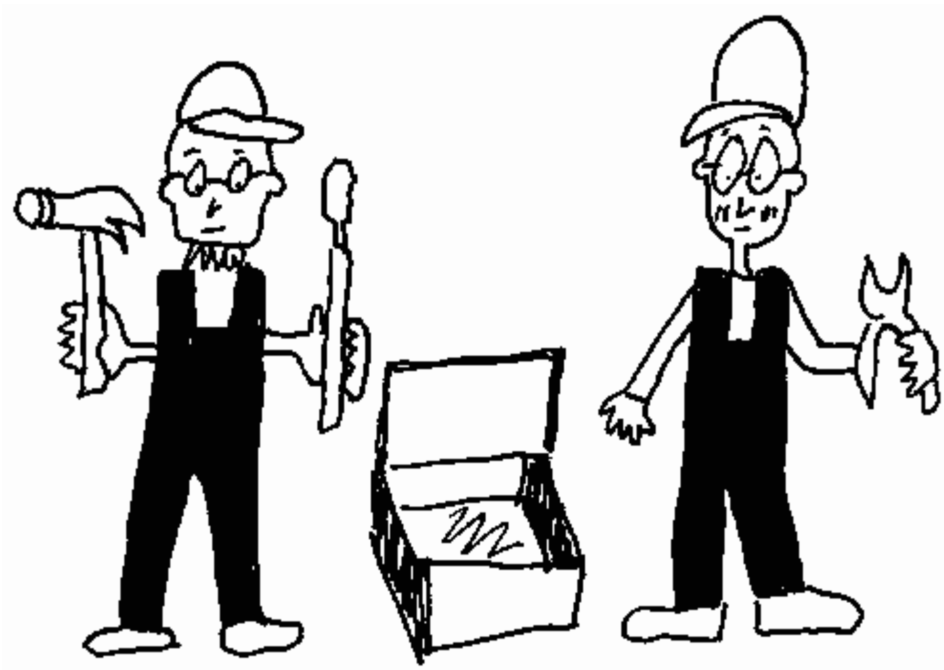
[4] The setgid permission is system−dependent in its use. On some systems, a setgid on a directory may cause files created in that directory to belong to the same group that is owned by the directory. On others, the EGID of the process determines the group that can use the file.

[5] The caller's EUID must match the owner's UID of the file, or the owner must be superuser.

[6] See built−in commands, limit and ulimit.

CONTENTS

Chapter 2. The UNIX Toolbox



There are hundreds of UNIX utilities available, and many of them are everyday commands such as ls, pwd, who, and vi. Just as there are essential tools that a carpenter uses, there are also essential tools the shell programmer needs to write meaningful and efficient scripts. The three major utilities that will be discussed in detail here are grep, sed, and awk. These programs are the most important UNIX tools available for manipulating text, output from a pipe, or standard input. In fact, sed and awk are often used as scripting languages by themselves. Before you fully appreciate the power of grep, sed, and awk, you must have a good foundation on the use of regular expressions and regular expression metacharacters. A complete list of useful UNIX utilities is found in Appendix A of this book.

2.1 Regular Expressions

2.1.1 Definition and Example

For users already familiar with the concept of regular expression metacharacters, this section may be bypassed. However, this preliminary material is crucial to understanding the variety of ways in which grep, sed, and awk are used to display and manipulate data.

What is a regular expression? A regular expression[1] is just a pattern of characters used to match the same characters in a search. In most programs, a regular expression is enclosed in forward slashes; for example, /love/ is a regular expression delimited by forward slashes, and the pattern love will be matched any time the same pattern is found in the line being searched. What makes regular expressions interesting is that they can be controlled by special metacharacters. If you are new to the idea of regular expressions, let us look at an example that will help you understand what this whole concept is about. Suppose that you are working in the vi editor on an e−mail message to your friend. It looks like this:

```
% vi letter
-------------------------------------------------------------------
Hi tom,
I think I failed my anatomy test yesterday. I had a terrible
stomach ache. I ate too many fried green tomatoes.
Anyway, Tom, I need your help. I'd like to make the test up
tomorrow, but don't know where to begin studying. Do you
think you could help me? After work, about 7 PM, come to
my place and I'll treat you to pizza in return for your help. Thanks.
                                      Your pal,
                                      guy@phantom

~
~
~
~
-------------------------------------------------------------------
```

Now, suppose you find out that Tom never took the test either, but David did. You also notice that in the greeting, you spelled Tom with a lowercase t. So you decide to make a global substitution to replace all occurrences of tom with David, as follows:

```
% vi letter
-------------------------------------------------------------------
Hi David,
I think I failed my anaDavidy test yeserday. I had a terrible
sDavidachache. I think I ate too many fried green Davidatoes.
Anyway, Tom, I need your help. I'd like to make the test up
Davidorrow, but don't know where to begin studying. Do you
think you could help me? After work, about 7 PM, come to
my place and I'll treat you to pizza in return for your help. Thanks.
                                      Your pal,
                                      guy@phanDavid

~
~
~


--> :1,$s/tom/David/g
-------------------------------------------------------------------
```

The regular expression in the search string is tom. The replacement string is David. The vi command reads "for lines 1 to the end of the file ($), substitute tom everywhere it is found on each line and replace it with David." Hardly what you want! And one of the occurrences of Tom was untouched because you only asked for tom, not Tom, to be replaced with David. So what to do?

Regular expression metacharacters are special characters that allow you to delimit a pattern in some way so that you can control what substitutions will take place. There are metacharacters to anchor a word to the beginning or end of a line. There are metacharacters that allow you to specify any characters, or some number of characters, to find both upper− and lowercase characters, digits only, and so forth. For example, to change the name tom or Tom to David, the following vi command would have done the job:

```
:1,$s/\<[Tt]om\>/David/g
```

This command reads, "From the first line to the last line of the file (1,$), substitute (s) the word Tom or tom with David," and the g flag says to do this globally (i.e., make the substitution if it occurs more than once on the same line). The regular expression metacharacters are \< and \> for beginning and end of a word, and the pair of brackets, [Tt], match for one of the characters enclosed within them (in this case, for either T or t). There are five basic metacharacters that all UNIX pattern−matching utilities recognize, and then an extended set of metacharacters that vary from program to program.

2.1.2 Regular Expression Metacharacters

Table 2.1 presents regular expression metacharacters that can be used in all versions of vi, ex, grep, egrep, sed, and awk. Additional metacharacters are described for each of the utilities where applicable.

Table 2.1. Regular Expression Metacharacters

Metacharacter Function ExampleWhat It Matches^Beginning−of−line anchor/^love/Matches all lines beginning with love.$End−of−line anchor/love$/Matches all lines ending with love..Matches one character/l..e/Matches lines containing an l, followed by two characters, followed by an e.*Matches zero or more of the preceding characters/ *love/Match lines with zero or more spaces, followed by the pattern love.[ ]Matches one in the set/[Ll]ove/Matches lines containing love or Love.[x–y]Matches one character within a range in the set/[A–Z]ove/Matches letters from A through Z followed by ove.[^]Matches one character not in the set/[^A–Z]/Matches any character not in the range between A and Z.\Used to escape a metacharacter/love\./Matches lines containing love, followed by a literal period. Normally the period matches one of any character. Additional metacharacters are supported by many UNIX programs that use RE metacharacters:\<Beginning−of−word anchor/\<love/Matches lines containing a word that begins with love (supported by vi and grep).\>End−of−word anchor/love\>/Matches lines containing a word that ends with love (supported by vi and grep).\(..\)Tags match characters to be used later /\(love\)able \1er/May use up to nine tags, starting with the first tag at the left−most part of the pattern. For example, the pattern love is saved as tag 1, to be referenced later as \1; in this example, the search pattern consists of lovable followed by lover (supported by sed, vi, and grep).x{m\}or x{m,\}or x{m,n\}Repetition of character x, m times, at least m times, at least m and not more than n times[a]o{5,10\}Matches if line contains between 5 and 10 consecutive occurrences of the letter o (supported by vi and grep).

[a] Not dependable on all versions of UNIX or all pattern−matching utilities; usually works with vi and grep.

Assuming that you know how the vi editor works, each metacharacter is described in terms of the vi search string. In the following examples, characters are highlighted to demonstrate what vi will find in its search.

Example 2.1

```
(A Simple Regular Expression Search)
% vi picnic
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
I had a lovely time on our little picnic.
Lovers were all around us. It is springtime. Oh
love, how much I adore you. Do you know
the extent of my love? Oh, by the way, I think
I lost my gloves somewhere out in that field of
clover. Did you see them? I can only hope love
is forever. I live for you. It's hard to get back in the
groove.


~
~
```

```
~
/love/
----------------------------------------------------------------
```

EXPLANATION

The regular expression is love. The pattern love is found by itself and as part of other words, such as lovely, gloves, and clover.

Example 2.2

```
(The Beginning−of−Line Anchor (^))
% vi picnic
----------------------------------------------------------------
I had a lovely time on our little picnic.
Lovers were all around us. It is springtime. Oh
love, how much I adore you. Do you know
the extent of my love? Oh, by the way, I think
I lost my gloves somewhere out in that field of
clover. Did you see them? I can only hope love
is forever. I live for you. It's hard to get back in the
groove.
~
~
~
/^love/
----------------------------------------------------------------
```

EXPLANATION

The caret (^) is called the beginning−of−line anchor. Vi will find only those lines where the regular expression love is matched at the beginning of the line, i.e., love is the first set of characters on the line; it cannot be preceded by even one space.

Example 2.3

```
(The End−of−Line Anchor ($))
% vi picnic
----------------------------------------------------------------
I had a lovely time on our little picnic.
Lovers were all around us. It is springtime. Oh
love, how much I adore you. Do you know
the extent of my love? Oh, by the way, I think
I lost my gloves somewhere out in that field of
clover. Did you see them? I can only hope love
is forever. I live for you. It's hard to get back in the
groove.

~
~
~
/love$/
----------------------------------------------------------------
```

EXPLANATION

The dollar sign ($) is called the end−of−line anchor. Vi will find only those lines where the regular expression love is matched at the end of the line, i.e., love is the last set of characters on the line and is directly followed by a newline.

Example 2.4

```
(Any Single Character (.))
% vi picnic
----------------------------------------------------------------
I had a lovely time on our little picnic.
Lovers were all around us. It is springtime. Oh
love, how much I adore you. Do you know
the extent of my love? Oh, by the way, I think
I lost my gloves somewhere out in that field of
clover. Did you see them? I can only hope love
is forever. I live for you. It's hard to get back in the
groove.

~
~
~
/l.ve/
-----------------------------------------------------------------
```

EXPLANATION

The dot (.) matches any one character, except the newline. Vi will find those lines where the regular expression consists of an l, followed by any single character, followed by a v and an e. It finds combinations of love and live.

Example 2.5

```
(Zero or More of the Preceding Character (*))
% vi picnic
----------------------------------------------------------------
I had a lovely time on our little picnic.
Lovers were all around us. It is springtime. Oh
love, how much I adore you. Do you know
the extent of my love? Oh, by the way, I think
I lost my gloves somewhere out in that field of
clover. Did you see them? I can only hope love
is forever. I live for you. It's hard to get back in the
groove.

~
~
~
/o*ve/
-----------------------------------------------------------------
```

EXPLANATION

The asterisk (*) matches zero or more of the preceding character.[2] It is as though the asterisk were glued to the character directly before it and controls only that character. In this case, the asterisk is glued to the letter o. It matches for only the letter o and as many consecutive occurrences of the letter o as there are in the pattern, even no occurrences of o at all. Vi searches for zero or more occurrences of the letter o followed by a v and an e, finding love, loooove, lve, and so forth.

Example 2.6

```
(A Set of Characters ([]))
% vi picnic
----------------------------------------------------------------
I had a lovely time on our little picnic.
Lovers were all around us. It is springtime. Oh
love, how much I adore you. Do you know
the extent of my love? Oh, by the way, I think
I lost my gloves somewhere out in that field of
clover. Did you see them? I can only hope love
is forever. I live for you. It's hard to get back in the
groove.

~
~
~
/[Ll]ove/
----------------------------------------------------------------
```

EXPLANATION

The square brackets match for one of a set of characters. Vi will search for the regular expression containing either an uppercase or lowercase l followed by an o, v, and e.

Example 2.7

```
(A Range of Characters ( [ - ] ))
% vi picnic
----------------------------------------------------------------
I had a lovely time on our little picnic.
Lovers were all around us. It is springtime. Oh
love, how much I adore you. Do you know
the extent of my love? Oh, by the way, I think
I lost my gloves somewhere out in that field of
clover. Did you see them? I can only hope love
is forever. I live for you. It's hard to get back in the
groove.

~
~
~
/ove[a-z]/
-----------------------------------------------------------------
```

EXPLANATION

The dash between characters enclosed in square brackets matches one character in a range of characters. Vi will search for the regular expression containing an o, v, and e, followed by any character in the ASCII range between a and z. Since this is an ASCII range, the range cannot be represented as [z–a].

Example 2.8

```
(Not One of the Characters in the Set ([^]))
% vi picnic
----------------------------------------------------------------
I had a lovely time on our little picnic.
Lovers were all around us. It is springtime. Oh
love, how much I adore you. Do you know
the extent of my love? Oh, by the way, I think
I lost my gloves somewhere out in that field of
clover. Did you see them? I can only hope love
is forever. I live for you. It's hard to get back in the
groove.

~
~
~/ove[^a-zA-Z0-9]/
----------------------------------------------------------------
```

EXPLANATION

The caret inside square brackets is a negation metacharacter. Vi will search for the regular expression containing an o, v, and e, followed by any character not in the ASCII range between a and z, not in the range between A and Z, and not a digit between 0 and 9. For example, it will find ove followed by a comma, a space, a period, and so on, because those characters are not in the set.

2.2 Combining Regular Expression Metacharacters

Now that basic regular expression metacharacters have been explained, they can be combined into more complex expressions. Each of the regular expression examples enclosed in forward slashes is the search string and is matched against each line in the text file.

Example 2.9

```
Note: The line numbers are NOT part of the text file. The vertical
bars mark the left and right margins.
   ---------------------------------------------------------------
1  |Christian Scott lives here and will put on a Christmas party.|
2  |There are around 30 to 35 people invited.                   |
3  |They are:                                                    |
4  |                                                          Tom|
5  |Dan                                                          |
6  |   Rhonda Savage                                             |
7  |Nicky and Kimberly.                                          |
8  |Steve, Suzanne, Ginger and Larry.                            |
   ---------------------------------------------------------------
```

EXPLANATION

a. /^[A–Z]..$/

   Will find all lines beginning with a capital letter, followed by two of any character, followed by a newline. Will find Dan on line 5.

b. /^[A–Z][a–z]*3[0–5]/

   Will find all lines beginning with an uppercase letter, followed by zero or more lowercase letters or spaces, followed by the number 3 and another number between 0 and 5. Will find line 2.

c. /[a–z]*\./

   Will find lines containing zero or more lowercase letters, followed by a literal period. Will find lines 1, 2, 7, and 8.

d. /^ *[A–Z][a–z][a–z]$/

   Will find a line that begins with zero or more spaces (tabs do not count as spaces), followed by an uppercase letter, two lowercase letters, and a newline. Will find Tom on line 4 and Dan on line 5.

e. /^[A–Za–z]*[^,][A–Za–z]*$/

   Will find a line that begins with zero or more uppercase and/or lowercase letters, followed by a noncomma, followed by zero or more upper− or lowercase letters and a newline. Will find line 5.

2.2.1 More Regular Expression Metacharacters

The following metacharacters are not necessarily portable across all utilities using regular expressions, but can be used in the vi editor and some versions of sed and grep. There is an extended set of metacharacters available with egrep and awk, which will be discussed in later sections.

Example 2.10

```
    (Beginning−of−Word (\<) and End−of−Word (\>) Anchors)
    % vi textfile
    −−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
    Unusual occurrences happened at the fair.
−−> Patty won fourth place in the 50 yard dash square and fair.
    Occurrences like this are rare.
    The winning ticket is 55222.
    The ticket I got is 54333 and Dee got 55544.
    Guy fell down while running around the south bend in his last
    event.
    ~
    ~
    ~
    /\<fourth\>/
    −−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
```

EXPLANATION

Will find the word fourth on each line. The \< is the beginning−of−word anchor and the \> is the end−of−word anchor. A word can be separated by spaces, end in punctuation, start at the beginning of a line, end at the end of a line, and so forth.

Example 2.11

```
    % vi textfile
    ------------------------------------------------------------
    Unusual occurrences happened at the fair.
--> Patty won fourth place in the 50 yard dash square and fair.
    Occurrences like this are rare.
    The winning ticket is 55222.
    The ticket I got is 54333 and Dee got 55544.
--> Guy fell down while running around the south bend in his last
    event.
    ~
    ~
    ~
    /\<f.*th\>/
    ------------------------------------------------------------
```

EXPLANATION

Will find any word (or group of words) beginning with an f, followed by zero or more of any character (.*), and a string ending with th.

Example 2.12

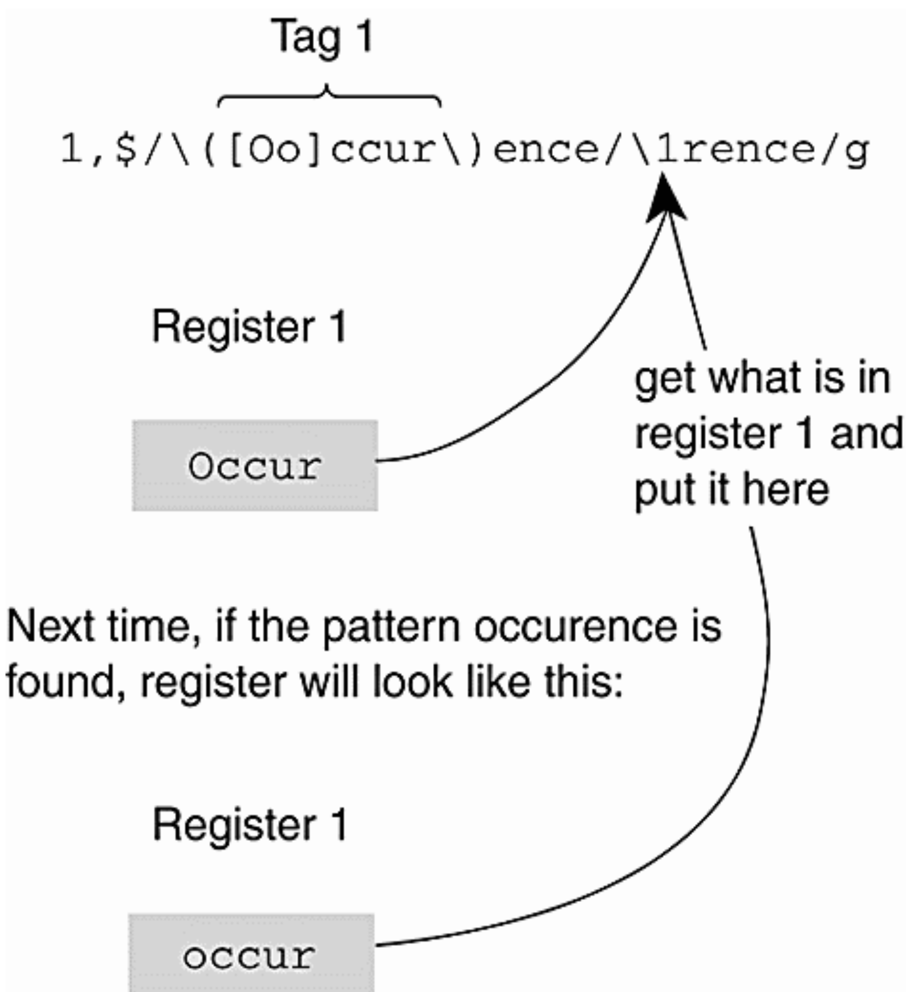
```
(Remembered Patterns \( and \))
    % vi textfile (Before Substitution)
    ------------------------------------------------------------
    Unusual occurences happened at the fair.
    Patty won fourth place in the 50 yard dash square and fair.
    Occurences like this are rare.
    The winning ticket is 55222.
    The ticket I got is 54333 and Dee got 55544.
    Guy fell down while running around the south bend in his last
    event.
    ~
    ~
    ~
1   :1,$s/\([0o]ccur\)ence/\1rence/
    ------------------------------------------------------------
    % vi textfile (After Substitution)
    ------------------------------------------------
--> Unusual occurrences happened at the fair.
    Patty won fourth place in the 50 yard dash square and fair.
--> Occurrences like this are rare.
    The winning ticket is 55222.
    The ticket I got is 54333 and Dee got 55544.
    Guy fell down while running around the south bend in his last
    event.
    ~
    ~
```

```
~
------------------------------------------------------------
```

EXPLANATION

1. The editor searches for the entire string occurence or Occurrence (note: the words are misspelled), and if found, the pattern portion enclosed in parentheses is tagged (i.e., either occur or Occur is tagged). Since this is the first pattern tagged, it is called tag 1. The pattern is stored in a memory register called register 1. On the replacement side, the contents of the register are replaced for \1 and the rest of the word, rence, is appended to it. We started with occurence and ended up with occurrence.

Figure 2.1. Remembered patterns and tags.



Example 2.13

```
% vi textfile (Before Substitution)
  ------------------------------------------------------------
  Unusual occurrences happened at the fair.
  Patty won fourth place in the 50 yard dash square and fair.
  Occurrences like this are rare.
  The winning ticket is 55222.
```

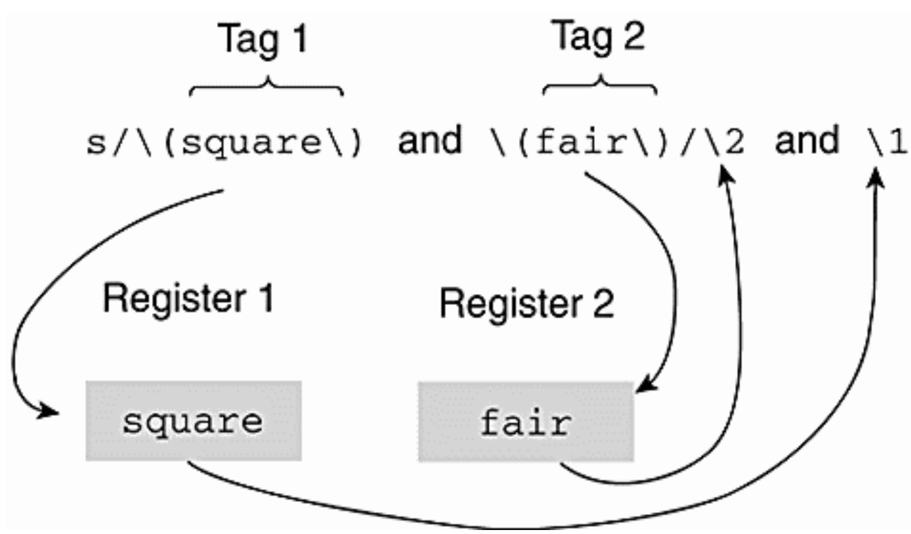
```
    The ticket I got is 54333 and Dee got 55544.
    Guy fell down while running around the south bend in his last
    event.
    ~
    ~
    ~
1   :s/\(square\) and \(fair\)/\2 and \1/
    -------------------------------------------------------------

    % vi textfile (After Substitution)
    -------------------------------------------------------------
    Unusual occurrences happened at the fair.
--> Patty won fourth place in the 50 yard dash fair and square.
    Occurrences like this are rare.
    The winning ticket is 55222.
    The ticket I got is 54333 and Dee got 55544.
    Guy fell down while running around the south bend in his last
    event.
    ~
    ~
    ~
    -------------------------------------------------------------
```

EXPLANATION

1. The editor searches for the regular expression square and fair, and tags square as 1 and fair as 2. On the replacement side, the contents of register 2 are substituted for \2 and the contents of register 1 are substituted for \1. See Figure 2.2.

Figure 2.2. Using more than one tag.



Example 2.14

```
(Repetition of Patterns ( \{n\} ))
    % vi textfile
    -------------------------------------------
    Unusual occurrences happened at the fair.
    Patty won fourth place in the 50 yard dash square and fair.
    Occurrences like this are rare.
--> The winning ticket is 55222.
```

```
    The ticket I got is 54333 and Dee got 55544.
    Guy fell down while running around the south bend in his last
    event.
    ~
    ~
    ~
    ~
1   /5\{2\}2\{3\}\./
    -------------------------------------------------------------
```

EXPLANATION

1. Searches for lines containing two occurrences of the number 5, followed by three occurrences of the number 2, followed by a literal period.

[1] If you receive an error message that contains the string RE, there is a problem with the regular expression you are using in the program.

[2] Do not confuse this metacharacter with the shell wildcard (*). They are totally different. The shell asterisk matches for zero or more of any character, whereas the regular expression asterisk matches for zero or more of the preceding character.

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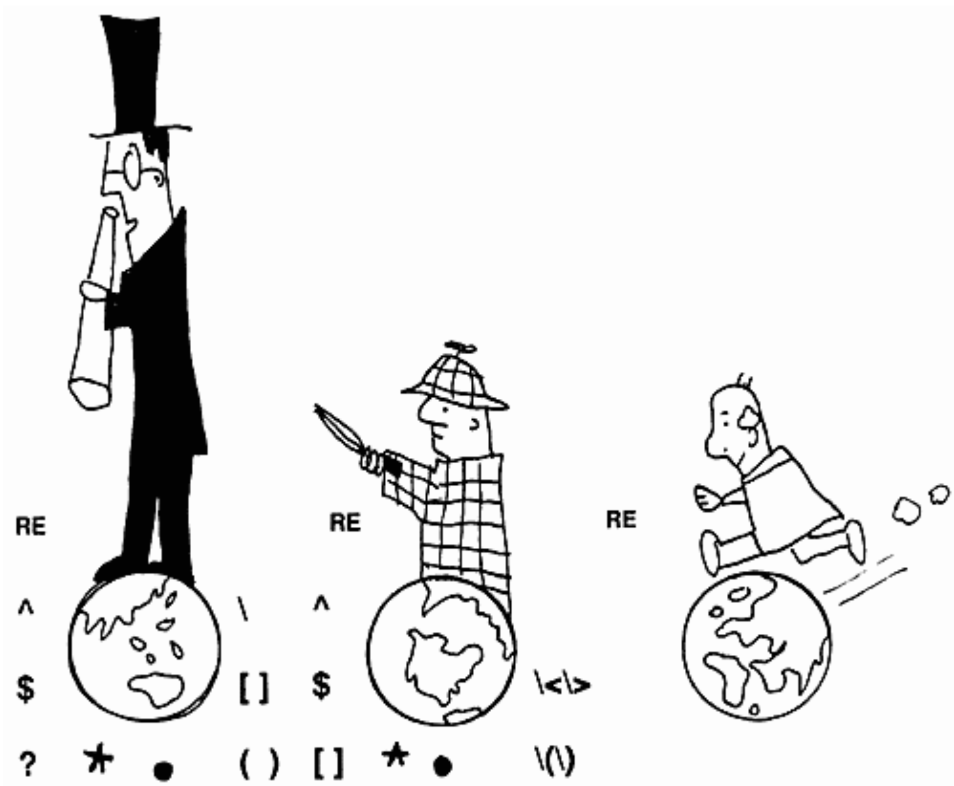
Chapter 3. The grep Family



The grep family consists of the commands grep, egrep, and fgrep. The grep command globally searches for regular expressions in files and prints all lines that contain the expression. The egrep and fgrep commands are simply variants of grep. The egrep command is an extended grep, supporting more regular expression metacharacters. The fgrep command, called fixed grep, and sometimes fast grep, treats all characters as literals; that is, regular expression metacharacters aren't special—they match themselves. The Free Software Foundation provides a free version of grep, called GNU grep. These versions of grep are the ones used on Linux systems, and can be found in /usr/xpg4/bin on Sun's Solaris OS. The GNU version of grep has extended the basic regular expression metacharacter set, added POSIX compliancy, and included a number of new command line options. They also provide a recursive grep called rgrep for descending entire directory trees.

3.1 The grep Command

3.1.1 The Meaning of grep

The name grep can be traced back to the ex editor. If you invoked that editor and wanted to search for a string, you would type at the ex prompt:

```
: /pattern/p
```

The first line containing the string pattern would be printed as "p" by the print command. If you wanted all the lines that contained pattern to be printed, you would type:

```
: g/pattern/p
```

When g precedes pattern, it means "all lines in the file," or "perform a global substitution."

Because the search pattern is called a regular expression, we can substitute RE for pattern and the command reads:

```
: g/RE/p
```

And there you have it: the meaning of grep and the origin of its name. It means "globally search for the regular expression (RE) and print out the line." The nice part of using grep is that you do −−not have to invoke an editor to perform a search, and you do not need to enclose the regular expression in forward slashes. It is much faster than using ex or vi.

3.1.2 How grep Works

The grep command searches for a pattern of characters in a file or multiple files. If the pattern contains whitespace, it must be quoted. The pattern is either a quoted string or a single word[1], and all other words following it are treated as filenames. Grep sends its output to the screen and does not change or affect the input file in any way.

FORMAT

```
grep word filename filename
```

Example 3.1

```
grep Tom /etc/passwd
```

EXPLANATION

Grep will search for the pattern Tom in a file called /etc/passwd. If successful, the line from the file will appear on the screen; if the pattern is not found, there will be no output at all; and if the file is not a legitimate file, an error will be sent to the screen. If the pattern is found, grep returns an exit status of 0, indicating success; if the pattern is not found, the exit status returned is 1; and if the file is not found, the exit status is 2.

The grep program can get its input from a standard input or a pipe, as well as from files. If you forget to name a file, grep will assume it is getting input from standard input, the keyboard, and will stop until you type something. If coming from a pipe, the output of a command will be piped as input to the grep command, and if a desired pattern is matched, grep will print the output to the screen.

Example 3.2

```
% ps –ef | grep root
```

EXPLANATION

The output of the ps command (ps –ef displays all processes running on this system) is sent to grep and all lines containing root are printed.

The grep command supports a number of regular expression metacharacters (see Table 3.1) to help further define the search pattern. It also provides a number of options (see Table 3.2) to modify the way it does its search or displays lines. For example, you can provide options to turn off case sensitivity, display line numbers, display errors only, and so on.

Example 3.3

```
% grep −n  '^jack:' /etc/passwd
```

EXPLANATION

Grep searches the /etc/passwd file for jack; if jack is at the beginning of a line, grep prints out the number of the line on which jack was found and where in the line jack was found.

Table 3.1. grep's Regular Expression Metacharacters

Metacharacter	Function	Example	What It Matches
^	Beginning−of−line anchor	'^love'	Matches all lines beginning with love.
$	End−of−line anchor	'love$'	Matches all lines ending with love.
.	Matches one character	'l..e'	Matches lines containing an l, followed by two characters, followed by an e.
*	Matches zero or more characters	' *love'	Matches lines with zero or more spaces, followed by the pattern love.
[ ]	Matches one character in the set	'[Ll]ove'	Matches lines containing love or Love.
[^]	Matches one character not in the set	'[^A–K]ove'	Matches lines not containing a character in the range A through K, followed by ove.
\<	Beginning−of−word anchor	'\<love'	Matches lines containing a word that begins with love.
\>	End−of−word anchor	'love\>'	Matches lines containing a word that ends with love.
\(..\)	Tags matched characters	'\(love\)ing'	Tags marked portion in a register to be remembered later as number 1. To reference later, use \1 to repeat the pattern. May use up to nine tags, starting with the first tag at the left−most part of the pattern. For example, the pattern love is saved in register 1 to be referenced later as \1.
x\{m\} x\{m,\} x\{m,n\}[a]	Repetition of character x: m times, at least m times, or between m and n times	'o\{5\}' 'o\{5,\}' 'o\{5,10\}'	Matches if line has 5 occurences of o, at least 5 occurences of o, or between 5 and 10 occurrences of o.

[a] The \{ \} metacharacters are not supported on all versions of UNIX or all pattern−matching utilities; they usually work with vi and grep.

Table 3.2. grep's Options

OptionWhat It Does–bPrecedes each line by the block number on which it was found. This is sometimes useful in locating disk block numbers by context.–cDisplays a count of matching lines rather than displaying the lines that match.–hDoes not display filenames.–iIgnores the case of letters in making comparisons (i.e., upper−− and lowercase are considered identical).–lLists only the names of files with matching lines (once), separated by newline characters.–nPrecedes each line by its relative line number in the file.–sWorks silently, that is, displays nothing except error messages. This is useful for checking the exit status.–vInverts the search to display only lines that do not match.–wSearches for the expression as a word, as if surrounded by \< and \>. This applies to grep only. (Not all versions of grep support this feature; e.g., SCO UNIX does not.)

3.1.3 grep and Exit Status

The grep command is very useful in shell scripts, because it always returns an exit status to indicate whether it was able to locate the pattern or the file you were looking for. If the pattern is found, grep returns an exit status of 0, indicating success; if grep cannot find the pattern, it returns 1 as its exit status; and if the file cannot be found, grep returns an exit status of 2. (Other UNIX utilities that search for patterns, such as sed and awk, do not use the exit status to indicate the success or failure of locating a pattern; they report failure only if there is a syntax error in a command.)

In the following example, john is not found in the /etc/passwd file.

Example 3.4

```
1   % grep 'john' /etc/passwd
2   % echo $status (csh)
    1

    or

    $ echo $?  (sh, ksh)
    1
```

EXPLANATION

1. Grep searches for john in the /etc/passwd file, and if successful, grep exits with a status of 0. If john is not found in the file, grep exits with 1. If the file is not found, an exit status of 2 is returned.
2. The C shell variable, status, and the Bourne/Korn shell variable, ?, are assigned the exit status of the last command that was executed.

3.2 grep Examples with Regular Expressions

The file being used for these examples is called datafile.

```
% cat datafile
northwest          NW   Charles Main       3.0    .98    3     34
western            WE   Sharon Gray        5.3    .97    5     23
southwest          SW   Lewis Dalsass      2.7    .8     2     18
southern           SO   Suan Chin          5.1    .95    4     15
southeast          SE   Patricia Hemenway  4.0    .7     4     17
eastern            EA   TB Savage          4.4    .84    5     20
northeast          NE   AM Main Jr.        5.1    .94    3     13
```

```
north               NO   Margot Weber       4.5    .89    5      9
central             CT   Ann Stephens       5.7    .94    5     13
```

Example 3.5

```
grep NW datafile
northwest    NW    Charles Main    3.0   .98    3    34
```

EXPLANATION

Prints all lines containing the regular expression NW in a file called datafile.

Example 3.6

```
grep NW d*
datafile: northwest  NW   Charles Main   3.0  .98  3    34
db:northwest         NW   Joel Craig     30   40   5    123
```

EXPLANATION

Prints all lines containing the regular expression NW in all files starting with a d. The shell expands d* to all files that begin with a d, in this case the filenames are db and datafile.

Example 3.7

```
grep '^n' datafile
northwest        NW     Charles Main     3.0  .98   3   34
northeast        NE     AM Main Jr.      5.1  .94   3   13
north            NO     Margot Weber     4.5  .89   5    9
```

EXPLANATION

Prints all lines beginning with an n. The caret (^) is the beginning−of−line anchor.

Example 3.8

```
grep '4$' datafile
northwest        NW     Charles Main     3.0  .98   3   34
```

EXPLANATION

Prints all lines ending with a 4. The dollar sign ($) is the end of line anchor.

Example 3.9

```
grep TB Savage datafile
grep: Savage: No such file or directory
datafile:eastern   EA TB Savage          4.4  .84   5   20
```

EXPLANATION

Since the first argument is the pattern and all of the remaining arguments are filenames, grep will search for TB in a file called Savage and a file called datafile. To search for TB Savage, see the next example.

Example 3.10

```
grep 'TB Savage' datafile
eastern          EA     TB Savage         4.4  .84    5   20
```

EXPLANATION

Prints all lines containing the pattern TB Savage. Without quotes (in this example, either single or double quotes will do), the whitespace between TB and Savage would cause grep to search for TB in a file called Savage and a file called datafile, as in the previous example.

```
% cat datafile
northwest          NW    Charles Main       3.0    .98    3    34
western            WE    Sharon Gray        53     .97    5    23
southwest          SW    Lewis Dalsass      2.7    .8     2    18
southern           SO    Suan Chin          5.1    .95    4    15
southeast          SE    Patricia Hemenway  4.0    .7     4    17
eastern            EA    TB Savage          4.4    .84    5    20
northeast          NE    AM Main Jr.        5.1    .94    3    13
north              NO    Margot Weber       4.5    .89    5     9
central            CT    Ann Stephens       5.7    .94    5    13
```

Example 3.11

```
grep '5\..' datafile
western          WE     Sharon Gray       5.3  .97   5   23
southern         SO     Suan Chin         5.1  .95   4   15
northeast        NE     AM Main Jr.       5.1  .94   3   13
central          CT     Ann Stephens      5.7  .94   5   13
```

EXPLANATION

Prints a line containing the number 5, followed by a literal period and any single character. The "dot" metacharacter represents a single character, unless it is escaped with a backslash. When escaped, the character is no longer a special metacharacter, but represents itself, a literal period.

Example 3.12

```
grep '\.5' datafile
north            NO     Margot Weber     4.5  .89   5   9
```

EXPLANATION

Prints any line containing the expression .5.

Example 3.13

```
grep '^[we]' datafile
western          WE     Sharon Gray     5.3  .97   5   23
eastern          EA     TB Savage       4.4  .84   5   20
```

EXPLANATION

Prints lines beginning with either a w or an e. The caret (^) is the beginning−of−line anchor, and either one of the characters in the brackets will be matched.

Example 3.14

```
grep '[^0−9]' datafile
northwest        NW    Charles Main          3.0  .98  3   34
western          WE    Sharon Gray           5.3  .97  5   23
southwest        SW    Lewis Dalsass         2.7  .8   2   18
southern         SO    Suan Chin             5.1  .95  4   15
southeast        SE    Patricia Hemenway     4.0  .7   4   17
eastern          EA    TB Savage             4.4  .84  5   20
northeast        NE    AM Main Jr.           5.1  .94  3   13
north            NO    Margot Weber          4.5  .89  5   9
central          CT    Ann Stephens          5.7  .94  5   13
```

EXPLANATION

Prints all lines containing one non−digit. Because all lines have at least one non−digit, all lines are printed. (See the –v option.)

Example 3.15

```
grep '[A−Z][A−Z] [A−Z]' datafile
eastern          EA     TB Savage       4.4  .84   5   20
northeast        NE     AM Main Jr.     5.1  .94   3   13
```

EXPLANATION

Prints all lines containing two capital letters followed by a space and a capital letter, e.g., TB Savage and AM Main.

Example 3.16

```
grep 'ss* ' datafile
northwest        NW     Charles Main     3.0  .98   3   34
southwest        SW     Lewis Dalsass    2.7  .8    2   18
```

EXPLANATION

Prints all lines containing an s followed by zero or more consecutive occurrences of the letter s and a space. Finds Charles and Dalsass.

```
% cat datafile
northwest          NW     Charles Main       3.0  .98  3    34
western            WE     Sharon Gray        53   .97  5    23
southwest          SW     Lewis Dalsass      2.7  .8   2    18
southern           SO     Suan Chin          5.1  .95  4    15
southeast          SE     Patricia Hemenway  4.0  .7   4    17
eastern            EA     TB Savage          4.4  .84  5    20
northeast          NE     AM Main Jr.        5.1  .94  3    13
north              NO     Margot Weber       4.5  .89  5     9
central            CT     Ann Stephens       5.7  .94  5    13
```

Example 3.17

```
grep '[a−z]\{9\}' datafile
northwest       NW    Charles Main      3.0  .98   3   34
southwest       SW    Lewis Dalsass     2.7  .8    2   18
southeast       SE    Patricia Hemenway 4.0  .7    4   17
northeast       NE    AM Main Jr.       5.1  .94   3   13
```

EXPLANATION

Prints all lines where there are at least nine consecutive lowercase letters, for example, northwest, southwest, southeast, and northeast.

Example 3.18

```
grep '\(3\)\.[0−9].*\1     *\1' datafile
northwest       NW      Charles Main     3.0  .98   3   34
```

EXPLANATION

Prints the line if it contains a 3 followed by a period and another number, followed by any number of characters (.*), another 3 (originally tagged), any number of tabs, and another 3. Since the 3 was enclosed in parentheses, \(3\), it can be later referenced with \1. \1 means that this was the first expression to be tagged with the \(\) pair.

Example 3.19

```
grep '\<north' datafile
northwest       NW     Charles Main     3.0  .98   3   34
northeast       NE     AM Main Jr.      5.1  .94   3   13
north           NO     Margot Weber     4.5  .89   5    9
```

EXPLANATION

Prints all lines containing a word starting with north. The \< is the beginning−of−word anchor.

Example 3.20

```
grep '\<north\>' datafile
north            NO     Margot Weber     4.5  .89   5   9
```

EXPLANATION

Prints the line if it contains the word north. The \< is the beginning−of−word anchor, and the \> is the end−of−word anchor.

Example 3.21

```
grep '\<[a−z].*n\>' datafile
northwest        NW     Charles Main    3.0  .98   3   34
western          WE     Sharon Gray     5.3  .97   5   23
southern         SO     Suan Chin       5.1  .95   4   15
eastern          EA     TB Savage       4.4  .84   5   20
northeast        NE     AM Main Jr.     5.1  .94   3   13
central          CT     Ann Stephens    5.7  .94   5   13
```

EXPLANATION

Prints all lines containing a word starting with a lowercase letter, followed by any number of characters, and a word ending in n. Watch the .* symbol. It means any character, including whitespace.

3.3 grep with Pipes

Instead of taking its input from a file, grep often gets its input from a pipe.

Example 3.22

```
% ls −l
drwxrwxrwx  2  ellie    2441 Jan 6 12:34    dir1
−rw−r−−r−−  1  ellie    1538 Jan 2 15:50    file1
−rw−r−−r−−  1  ellie    1539 Jan 3 13:36    file2
drwxrwxrwx  2  ellie    2341 Jan 6 12:34    grades

% ls −l | grep '^d'
drwxrwxrwx  2  ellie    2441 Jan 6 12:34    dir1
drwxrwxrwx  2  ellie    2341 Jan 6 12:34    grades
```

EXPLANATION

The output of the ls command is piped to grep. All lines of output that begin with a d are printed; that is, all directories are printed.

3.4 grep with Options

The grep command has a number of options that control its behavior. Not all versions of UNIX support exactly the same options, so be sure to check your man pages for a complete list.

```
% cat datafile
northwest          NW   Charles Main      3.0    .98    3    34
western            WE   Sharon Gray       53     .97    5    23
southwest          SW   Lewis Dalsass     2.7    .8     2    18
southern           SO   Suan Chin         5.1    .95    4    15
southeast          SE   Patricia Hemenway 4.0    .7     4    17
eastern            EA   TB Savage         4.4    .84    5    20
northeast          NE   AM Main Jr.       5.1    .94    3    13
north              NO   Margot Weber      4.5    .89    5     9
central            CT   Ann Stephens      5.7    .94    5    13
```

Example 3.23

```
grep –n '^south' datafile
3:southwest      SW     Lewis Dalsass       2.7   .8    2   18
4:southern       SO     Suan Chin           5.1   .95   4   15
5:southeast      SE     Patricia Hemenway   4.0   .7    4   17
```

EXPLANATION

The –n option precedes each line with the number of the line where the pattern was found, followed by the line.

Example 3.24

```
grep –i 'pat' datafile
southeast        SE     Patricia Hemenway    4.0   .7    4    17
```

EXPLANATION

The –i option turns off case sensitivity. It does not matter if the expression pat contains any combination of upper− or lowercase letters.

Example 3.25

```
grep –v 'Suan Chin' datafile
northwest        NW     Charles Main         3.0  .98  3  34
western          WE     Sharon Gray          5.3  .97  5  23
southwest        SW     Lewis Dalsass        2.7  .8   2  18
southeast        SE     Patricia Hemenway    4.0  .7   4  17
eastern          EA     TB Savage            4.4  .84  5  20
northeast        NE     AM Main Jr.          5.1  .94  3  13
north            NO     Margot Weber         4.5  .89  5  9
central          CT     Ann Stephens         5.7  .94  5  13
```

EXPLANATION

Here, the –v option prints all lines not containing the pattern Suan Chin. This option is used when deleting a specific entry from the input file. To really remove the entry, you would redirect the output of grep to a temporary file, and then change the name of the temporary file back to the name of the original file as shown here:

```
grep –v 'Suan Chin' datafile > temp
mv temp datafile
```

Remember that you must use a temporary file when redirecting the output from datafile. If you redirect from datafile to datafile, the shell will "clobber" the datafile. (See "Redirection" on page 16.)

```
% cat datafile
northwest          NW    Charles Main       3.0    .98    3    34
western            WE    Sharon Gray        53     .97    5    23
southwest          SW    Lewis Dalsass      2.7    .8     2    18
southern           SO    Suan Chin          5.1    .95    4    15
southeast          SE    Patricia Hemenway  4.0    .7     4    17
eastern            EA    TB Savage          4.4    .84    5    20
northeast          NE    AM Main Jr.        5.1    .94    3    13
north              NO    Margot Weber       4.5    .89    5     9
central            CT    Ann Stephens       5.7    .94    5    13
```

Example 3.26

```
grep –l 'SE'  *
datafile
datebook
```

EXPLANATION

The –l option causes grep to print out only the filenames where the pattern is found instead of the line of text

Example 3.27

```
grep –c 'west' datafile
3
```

EXPLANATION

The –c option causes grep to print the number of lines where the pattern was found. This does not mean the number of occurrences of the pattern. For example, if west is found three times on a line, it only counts the line once.

Example 3.28

```
grep  –w 'north' datafile
north            NO     Margot Weber     4.5  .89   5   9
```

EXPLANATION

The –w option causes grep to find the pattern only if it is a word,[2] not part of a word. Only the line containing the word north is printed, not northwest, northeast, etc.

Example 3.29

```
echo $LOGNAME
lewis
grep –i "$LOGNAME" datafile
southwest        SW     Lewis Dalsass   2.7  .8   2   18
```

EXPLANATION

The value of the shell ENV variable, LOGNAME, is printed. It contains the user's login name. If the variable is enclosed in double quotes, it will still be expanded by the shell, and in case there is more than one word assigned to the variable, whitespace is shielded from shell interpretation. If single quotes are used, variable substitution does not take place; that is, $LOGNAME is printed.

3.4.1 grep Review

Table 3.3 contains examples of grep commands and what they do.

Table 3.3. Review of grep

grep CommandWhat It Doesgrep '\<Tom\>' filePrints lines containing the word Tom.grep 'Tom Savage' filePrints lines containing Tom Savage.grep '^Tommy' filePrints lines if Tommy is at the beginning of the line.grep '\.bak$' filePrints lines ending in .bak. Single quotes protect the dollar sign ($) from interpretation.grep '[Pp]yramid' *Prints lines from all files containing pyramid or Pyramid in the current working directory.grep '[A–Z]' filePrints lines containing at least one capital letter.grep '[0–9]' filePrints lines containing at least one number.grep '[A–Z]…[0–9]' filePrints lines containing five−character patterns starting with a capital letter and ending with a number.grep –w '[tT]est' filesPrints lines with the word Test and/or test.grep –s "Mark Todd" fileFinds lines containing Mark Todd, but does not print the line. Can be used when checking grep's exit status.grep –v 'Mary' filePrints all lines not containing Mary.grep –i 'sam' filePrints all lines containing sam, regardless of case (e.g., SAM, sam, SaM, sAm).grep –l 'Dear Boss' *Lists all filenames containing Dear Boss.grep –n 'Tom' filePrecedes matching lines with line numbers.grep "$name" fileExpands the value of variable name and prints lines containing that value. Must use double quotes.grep '$5' filePrints lines containing literal $5. Must use single quotes.ps –ef| grep "^ *user1"Pipes output of ps –ef to grep, searching for user1 at the beginning of a line, even if it is preceded by zero or more spaces.

3.5 egrep (Extended grep)

The main advantage of using egrep is that additional regular expression metacharacters (see Table 3.4) have been added to the set provided by grep. The \(\) and \{\}, however, are not allowed. (See GNU grep –E if using Linux.)

Table 3.4. egrep's Regular Expression Metacharacters

Metacharacter Function ExampleWhat It Matches^Beginning−of−line anchor'^love'Matches all lines beginning with love.$End−of−line anchor'love$'Matches all lines ending with love..Matches one character'l..e'Matches lines containing an l, followed by two characters, followed by an e.*Matches zero or more characters'*love'Matches lines with zero or more spaces of the preceding characters followed by the pattern love.[ ]Matches one character in the set'[Ll]ove'Matches lines containing love or Love.[^]Matches one character not in the set'[^A–KM–Z]ove'Matches lines not containing A through K or M through Z, followed by ove. New with egrep:+Matches one or more of the preceding characters'[a–z]+ove'Matches one or more lowercase letters, followed by ove. Would find move, approve, love, behoove, etc.?Matches zero or one of the preceding characters'lo?ve'Matches for an l followed by either one or not any occurrences of the letter o. Would find love or lve.a|bMatches either a or b'love|hate'Matches for either expression, love or hate.()Groups characters'love(able|ly) (ov)+'Matches for lovable or lovely. Matches for one or more occurrences of ov.

3.5.1 egrep Examples

The following example illustrates only the way the new extended set of regular expression metacharacters is used with egrep. The grep examples presented earlier illustrate the use of the standard metacharacters, which behave the same way with egrep. Egrep also uses the same options at the command line as grep.

```
% cat datafile
northwest          NW   Charles Main       3.0    .98    3    34
western            WE   Sharon Gray        53     .97    5    23
southwest          SW   Lewis Dalsass      2.7    .8     2    18
southern           SO   Suan Chin          5.1    .95    4    15
southeast          SE   Patricia Hemenway  4.0    .7     4    17
eastern            EA   TB Savage          4.4    .84    5    20
northeast          NE   AM Main Jr.        5.1    .94    3    13
north              NO   Margot Weber       4.5    .89    5     9
central            CT   Ann Stephens       5.7    .94    5    13
```

Example 3.30

```
egrep 'NW|EA' datafile
northwest        NW     Charles Main    3.0  .98   3   34
eastern          EA     TB Savage       4.4  .84   5   20
```

EXPLANATION

Prints the line if it contains either the expression NW or the expression EA.

Example 3.31

```
egrep '3+' datafile
northwest        NW     Charles Main     3.0  .98   3   34
western          WE     Sharon Gray      5.3  .97   5   23
northeast        NE     AM Main          5.1  .94   3   13
central          CT     Ann Stephens     5.7  .94   5   13
```

EXPLANATION

Prints all lines containing one or more occurrences of the number 3.

Example 3.32

```
egrep '2\.?[0–9]' datafile
western          WE     Sharon Gray     5.3  .97   5   23
southwest        SW     Lewis Dalsass   2.7  .8    2   18
eastern          EA     TB Savage       4.4  .84   5   20
```

EXPLANATION

Prints all lines containing a 2, followed by zero or one period, followed by a number.

Example 3.33

```
egrep '(no)+' datafile
northwest        NW     Charles Main     3.0  .98   3   34
northeast        NE     AM Main          5.1  .94   3   13
north            NO     Margot Weber     4.5  .89   5    9
```

EXPLANATION

Prints lines containing one or more consecutive occurrences of the pattern group no.

Example 3.34

```
egrep 'S(h|u)' datafile
western          WE     Sharon Gray     5.3  .97   5   23
southern         SO     Suan Chin       5.1  .95   4   15
```

EXPLANATION

Prints all lines containing S, followed by either h or u.

Example 3.35

```
egrep 'Sh|u' datafile
western          WE    Sharon Gray       5.3  .97   5   23
southern         SO    Suan Chin         5.1  .95   4   15
southwest        SW    Lewis Dalsass     2.7  .8    2   18
southeast        SE    Patricia Hemenway 4.0  .7    4   17
```

EXPLANATION

Prints all lines containing the expression Sh or u.

3.5.2 egrep Review

Table 3.5 contains examples of egrep commands and what they do.

Table 3.5. Review of egrep

egrep CommandWhat It Doesegrep '^ +' filePrints lines beginning with one or more spaces.egrep '^ *' filePrints lines beginning with zero or more spaces[a]egrep '(Tom | Dan) Savage' filePrints lines containing Tom Savage or Dan Savage.egrep '(ab)+' filePrints lines with one or more occurrences of ab.egrep '^X[0–9]?'

filePrints lines beginning with X followed by zero or one single digit.egrep 'fun\.$' *Prints lines ending in fun. from all files.[a]egrep '[A–Z]+' filePrints lines containing one or more capital letters.egrep '[0–9]' filePrints lines containing a number.[a]egrep '[A–Z]…[0–9]' filePrints lines containing five−character patterns starting with a capital letter, followed by three of any character, and ending with a number.[a]egrep '[tT]est' filesPrints lines with Test and/or test.[a]egrep "Susan Jean" filePrints lines containing Susan Jean.[a]egrep –v 'Mary' filePrints all lines NOT containing Mary.[a]egrep –i 'sam' filePrints all lines containing sam, regardless of case (e.g., SAM, sam, SaM, sAm, etc.).[a]egrep –l 'Dear Boss' *Lists all filenames containing Dear Boss.[a]egrep –n 'Tom' filePrecedes matching lines with line numbers.[a]egrep –s "$name" fileExpands variable name, finds it, but prints nothing. Can be used to check the exit status of egrep.[a]

[a] egrep and grep handle this pattern in the same way.

3.6 Fixed grep or Fast grep

The fgrep command behaves like grep, but does not recognize any regular expression metacharacters as being special. All characters represent only themselves. A caret is simply a caret, a dollar sign is a dollar sign, and so forth. (See GNU grep –F if using Linux.)

Example 3.36

```
% fgrep '[A–Z]****[0–9]..$5.00'  file
```

EXPLANATION

Finds all lines in the file containing the literal string [A–Z]****[0–9]..$5.00. All characters are treated as themselves. There are no special characters.

UNIX TOOLS LAB EXERCISE

Lab 1: grep Exercise

Steve Blenheim:238−923−7366:95 Latham Lane, Easton, PA 83755:11/12/56:20300

Betty Boop:245−836−8357:635 Cutesy Lane, Hollywood, CA 91464:6/23/23:14500

Igor Chevsky:385−375−8395:3567 Populus Place, Caldwell, NJ 23875:6/18/68:23400

Norma Corder:397−857−2735:74 Pine Street, Dearborn, MI 23874:3/28/45:245700

Jennifer Cowan:548−834−2348:583 Laurel Ave., Kingsville, TX 83745:10/1/35:58900

Jon DeLoach:408−253−3122:123 Park St., San Jose, CA 04086:7/25/53:85100

Karen Evich:284−758−2857:23 Edgecliff Place, Lincoln, NB 92743:7/25/53:85100

Karen Evich:284−758−2867:23 Edgecliff Place, Lincoln, NB 92743:11/3/35:58200

Karen Evich:284−758−2867:23 Edgecliff Place, Lincoln, NB 92743:11/3/35:58200

Fred Fardbarkle:674−843−1385:20 Parak Lane, DeLuth, MN 23850:4/12/23:780900

Fred Fardbarkle:674−843−1385:20 Parak Lane, DeLuth, MN 23850:4/12/23:780900

Lori Gortz:327−832−5728:3465 Mirlo Street, Peabody, MA 34756:10/2/65:35200

Paco Gutierrez:835−365−1284:454 Easy Street, Decatur, IL 75732:2/28/53:123500

Ephram Hardy:293−259−5395:235 CarltonLane, Joliet, IL 73858:8/12/20:56700

James Ikeda:834−938−8376:23445 Aster Ave., Allentown, NJ 83745:12/1/38:45000

Barbara Kertz:385−573−8326:832 Ponce Drive, Gary, IN 83756:12/1/46:268500

Lesley Kirstin:408−456−1234:4 Harvard Square, Boston, MA 02133:4/22/62:52600

William Kopf:846−836−2837:6937 Ware Road, Milton, PA 93756:9/21/46:43500

Sir Lancelot:837−835−8257:474 Camelot Boulevard, Bath, WY 28356:5/13/69:24500

Jesse Neal:408−233−8971:45 Rose Terrace, San Francisco, CA 92303:2/3/36:25000

Zippy Pinhead:834−823−8319:2356 Bizarro Ave., Farmount, IL 84357:1/1/67:89500

Arthur Putie:923−835−8745:23 Wimp Lane, Kensington, DL 38758:8/31/69:126000

Popeye Sailor:156−454−3322:945 Bluto Street, Anywhere, USA 29358:3/19/35:22350

Jose Santiago:385−898−8357:38 Fife Way, Abilene, TX 39673:1/5/58:95600

Tommy Savage:408−724−0140:1222 Oxbow Court, Sunnyvale, CA 94087:5/19/66:34200

Yukio Takeshida:387−827−1095:13 Uno Lane, Ashville, NC 23556:7/1/29:57000

Vinh Tranh:438−910−7449:8235 Maple Street, Wilmington, VM 29085:9/23/63:68900

(Refer to the database called datebook on the CD.)

1: Print all lines containing the string San.

2: Print all lines where the person's first name starts with J.

3: Print all lines ending in 700.

4: Print all lines that don't contain 834.

5: Print all lines where birthdays are in December.

6: Print all lines where the phone number is in the 408 area code.

7: Print all lines containing an uppercase letter, followed by four lowercase letters, a comma, a space, and one uppercase letter.

8: Print lines where the last name begins with K or k.

9: Print lines preceded by a line number where the salary is a six−figure number.

10: Print lines containing Lincoln or lincoln (remember that grep is insensitive to case).

[1] A word is also called a token.

[2] A word ia a sequence of alphanumeric characters starting at the beginning of a line or preceded by whitespace and ending in whitespace, punctuation, or a newline

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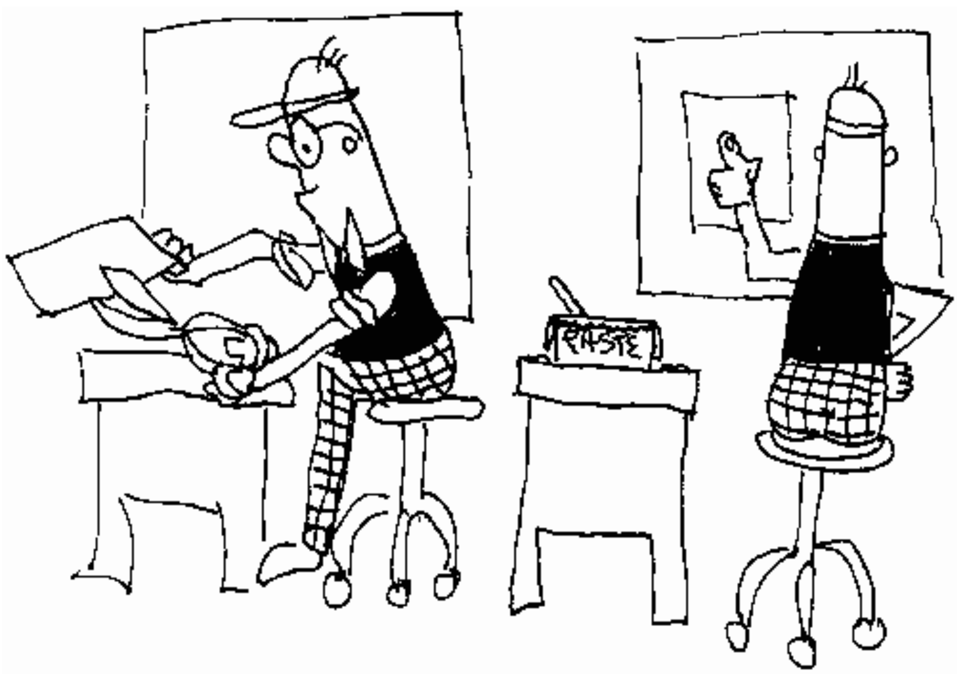
Chapter 4. sed, the Streamlined Editor



4.1 What Is sed?

Sed is a streamlined, noninteractive editor. It allows you to perform the same kind of editing tasks used in the vi and ex editors. Instead of working interactively with the editor, the sed program lets you type your editing commands at the command line, name the file, and then see the output of the editing command on the screen. The sed editor is nondestructive. It does not change your file unless you save the output with shell redirection. All lines are printed to the screen by default.

The sed editor is useful in shell scripts, where using interactive editors such as vi or ex would require the user of the script to have familiarity with the editor and would expose the user to making unwanted modifications to the open file. You can also put sed commands in a file called a sed script, if you need to perform multiple edits or do not like worrying about quoting the sed commands at the shell command line.[1]

4.2 How Does sed Work?

The sed editor processes a file (or input) one line at a time and sends its output to the screen. Its commands are those you may recognize from the vi and ed/ex editors. Sed stores the line it is currently processing in a temporary buffer called a pattern space. Once sed is finished processing the line in the pattern space (i.e., executing sed commands on that line), the line in the pattern space is sent to the screen (unless the command was to delete the line or suppress its printing). After the line has been processed, it is removed from the pattern space and the next line is then read into the pattern space, processed, and displayed. Sed ends when the last line of the input file has been processed. By storing each line in a temporary buffer and performing edits on that line, the original file is never altered or destroyed.

4.3 Addressing

You can use addressing to decide which lines you want to edit. The addresses can be in the form of numbers or regular expressions, or a combination of both. Without specifying an address, sed processes all lines of the input file.

When an address consists of a number, the number represents a line number. A dollar sign can be used to represent the last line of the input file. If a comma separates two line numbers, the addresses that will be processed are within that range of lines, including the first and last line in the range. The range may be numbers, regular expressions, or a combination of numbers and regular expressions.

Sed commands tell sed what to do with the line: print it, remove it, change it, and so forth.

FORMAT

```
sed 'command' filename(s)
```

Example 4.1

```
1  % sed '1,3p' myfile
2  % sed −n '/[Jj]ohn/p' datafile
```

EXPLANATION

1. Lines 1 through 3 of myfile are printed.
2. Only lines matching the pattern John or john in myfile are printed.

4.4 Commands and Options

Sed commands tell sed how to process each line of input specified by an address. If an address is not given, sed processes every line of input. (The % is the csh prompt.) See Table 4.1 for a list of sed commands and what they do, and see Table 4.2 for a list of options and how they control sed's behavior.

Example 4.2

```
% sed '1,3d' file
```

EXPLANATION

Sed will delete lines 1 through 3.

Table 4.1. sed Commands

Command Functiona\Appends one or more lines of text to the current line.c\Changes (replaces) text in the current line with new text.dDeletes lines.i\Inserts text above the current line.hCopies the contents of the pattern space to a holding buffer.HAppends the contents of the pattern space to a holding buffer.gGets what is in the holding buffer and copies it into the pattern buffer, overwriting what was there.GGets what is in the holding buffer and copies it into the pattern buffer, appending to what was there.lLists nonprinting characters.pPrints lines.nReads the next input line and starts processing the newline with the next command rather than the first command.qQuits or exits sed.rReads lines from a file.!Applies the command to all lines except the selected ones.sSubstitutes one string for another. Substitution Flags:gGlobally substitutes on a line.pPrints lines.wWrites lines out to a file.xExchanges contents of the holding buffer with the pattern space.yTranslates one character to another (cannot use regular expression metacharacters with y).

Table 4.2. sed Options

Options Function−eAllows multiple edits.−fPrecedes a sed script filename.−nSuppresses default output.

When multiple commands are used or addresses need to be nested within a range of addresses, the commands are enclosed in curly braces and each command is either on a separate line or terminated with semicolons.

The exclamation point (!) can be used to negate a command. For example,

```
% sed '/Tom/d' file
```

tells sed to delete all lines containing the pattern Tom, whereas

```
% sed '/Tom/!d' file
```

tells sed to delete lines not containing Tom.

The sed options are −e, −f, and, −n. The −e is used for multiple edits at the command line, the −f precedes a sed script filename, and the −n suppresses printing output.

4.5 Error Messages and Exit Status

When sed encounters a syntax error, it sends a pretty straightforward error message to standard error, but if it cannot figure out what you did wrong, sed gets "garbled," which we could guess means confused. The exit status that sed returns to the shell, if its syntax is error−free, is a zero for success and a nonzero integer for failure.[2]

Example 4.3

```
1   % sed '1,3v ' file
    sed: Unrecognized command: 1,3v
    % echo $status (echo $?  if using Korn or Bourne shell)
    2

2   % sed '/^John' file
    sed: Illegal or missing delimiter: /^John
```

```
3   % sed 's/134345/g' file
    sed: Ending delimiter missing on substitution: s/134345/g
```

EXPLANATION

1. The v command is unrecognized by sed. The exit status was 2, indicating that sed exited with a syntax problem.
2. The pattern /^John is missing the closing forward slash.
3. The substitution command, s, contains the search string but not the replacement string.

4.5.1 Metacharacters

Like grep, sed supports a number of special metacharacters to control pattern searching. See Table 4.3

Table 4.3. sed's Regular Expression Metacharacters.

Metacharacter Function ExampleWhat It Matches^Beginning−of−line anchor/^love/Matches all lines beginning with love.$End−of−line anchor/love$/Matches all lines ending with love..Matches one character, but not the newline character/l..e/Matches lines containing an l, followed by two characters, followed by an e.*Matches zero or more characters/ *love/Matches lines with zero or more spaces, followed by the pattern love.[ ]Matches one character in the set/[Ll]ove/Matches lines containing love or Love.[^]Matches one character not in the set/[^A−KM−Z]ove/Matches lines not containing A through K or M through Z followed by ove.\(..\)Saves matched characters s/\(love\)able/\1er/Tags marked portion and saves it as tag number 1. To reference later, use \1 to reference the pattern. May use up to nine tags, starting with the first tag at the leftmost part of the pattern. For example, love is saved in register 1 and remembered in the replacement string. lovable is replaced with lover.&Saves search string so it can be remembered in the replacement string s/love/**&**/The ampersand represents the search string. The string love will be replaced with itself surrounded by asterisks; i.e., love will become **love**.\<Beginning−of−word anchor/\<love/Matches lines containing a word that begins with love.\>End−of−word anchor/love\>/Matches lines containing a word that ends with love.

x\{m\}

x\{m,\}

x\{m,n\}[a]

Repetition of character x: m times

at least m times

at least m and not more than n times

/o\{5\}/Matches if line has 5 occurrences of o, at least 5 occurrences of o, or between 5 and 10 occurrences of o.

[a] Not dependable on all versions of UNIX or all pattern−matching utilities; usually works with vi and grep.

4.6 sed Examples

```
% cat datafile
northwest          NW   Charles Main       3.0    .98    3    43
western            WE   Sharon Gray        5.3    .97    5    23
southwest          SW   Lewis Dalsass      2.7    .8     2    18
southern           SO   Suan Chin          5.1    .95    4    15
southeast          SE   Patricia Hemenway  4.0    .7     4    17
eastern            EA   TB Savage          4.4    .84    5    20
northeast          NE   AM Main Jr.        5.1    .94    3    13
north              NO   Margot Weber       4.5    .89    5     9
central            CT   Ann Stephens       5.7    .94    5    13
```

4.6.1 Printing: The p Command

Example 4.4

```
sed '/north/p' datafile
northwest     NW     Charles Main        3.0  .98   3   34
northwest     NW     Charles Main        3.0  .98   3   34
western       WE     Sharon Gray         5.3  .97   5   23
southwest     SW     Lewis Dalsass       2.7  .8    2   18
southern      SO     Suan Chin           5.1  .95   4   15
southeast     SE     Patricia Hemenway   4.0  .7    4   17
eastern       EA     TB Savage           4.4  .84   5   20
northeast     NE     AM Main Jr.         5.1  .94   3   13
northeast     NE     AM Main Jr.         5.1  .94   3   13
north         NO     Margot Weber        4.5  .89   5   9
north         NO     Margot Weber        4.5  .89   5   9
central       CT     Ann Stephens        5.7  .94   5   13
```

EXPLANATION

Prints all lines to standard output by default. If the pattern north is found, sed will print that line in addition to all the other lines.

Example 4.5

```
sed −n '/north/p' datafile
northwest     NW     Charles Main        3.0  .98   3   34
northeast     NE     AM Main Jr.         5.1  .94   3   13
north         NO     Margot Weber        4.5  .89   5    9
```

EXPLANATION

The −n option suppresses the default behavior of sed when used with the p command. Without the −n option, sed will print duplicate lines of output as shown in the preceding example. Only the lines containing the pattern north are printed when −n is used.

```
% cat datafile
northwest          NW   Charles Main       3.0   .98   3   34
western            WE   Sharon Gray        5.3   .97   5   23
southwest          SW   Lewis Dalsass      2.7   .8    2   18
southern           SO   Suan Chin          5.1   .95   4   15
southeast          SE   Patricia Hemenway  4.0   .7    4   17
eastern            EA   TB Savage          4.4   .84   5   20
northeast          NE   AM Main Jr.        5.1   .94   3   13
north              NO   Margot Weber       4.5   .89   5    9
```

```
central             CT    Ann Stephens       5.7    .94    5    13
```

4.6.2 Deleting: The d Command

Example 4.6

```
sed '3d' datafile
northwest     NW     Charles Main       3.0  .98   3   34
western       WE     Sharon Gray        5.3  .97   5   23
southern      SO     Suan Chin          5.1  .95   4   15
southeast     SE     Patricia Hemenway  4.0  .7    4   17
eastern       EA     TB Savage          4.4  .84   5   20
northeast     NE     AM Main Jr.        5.1  .94   3   13
north         NO     Margot Weber       4.5  .89   5    9
central       CT     Ann Stephens       5.7  .94   5   13
```

EXPLANATION

Deletes the third line. All other lines are printed to the screen by default.

Example 4.7

```
sed '3,$d' datafile
northwest      NW    Charles Main       3.0  .98   3   34
western        WE    Sharon Gray        5.3  .97   5   23
```

EXPLANATION

The third line through the last line are deleted. The remaining lines are printed. The dollar sign ($) represents the last line of the file. The comma is called the range operator. In this example, the range of addresses starts at line 3 and ends at the last line, which is represented by the dollar sign ($).

Example 4.8

```
sed '$d' datafile
northwest     NW     Charles Main        3.0  .98   3  34
western       WE     Sharon Gray         5.3  .97   5  23
southwest     SW     Lewis Dalsass       2.7  .8    2  18
southern      SO     Suan Chin           5.1  .95   4  15
southeast     SE     Patricia Hemenway   4.0  .7    4  17
eastern       EA     TB Savage           4.4  .84   5  20
northeast     NE     AM Main Jr.         5.1  .94   3  13
north         NO     Margot Weber        4.5  .89   5   9
```

EXPLANATION

Deletes the last line. The dollar sign ($) represents the last line. The default is to print all of the lines except those affected by the d command.

Example 4.9

```
sed '/north/d' datafile
western       WE     Sharon Gray         5.3  .97   5   23
southwest     SW     Lewis Dalsass       2.7  .8    2   18
southern      SO     Suan Chin           5.1  .95   4   15
southeast     SE     Patricia Hemenway   4.0  .7    4   17
```

```
eastern        EA     TB Savage          4.4  .84   5   20
central        CT     Ann Stevens        5.7  .94   5   13
```

EXPLANATION

All lines containing the pattern north are deleted. The remaining lines are printed.

4.6.3 Substitution: The s Command

Example 4.10

```
sed 's/west/north/g' datafile
northnorth     NW     Charles Main       3.0  .98   3   34
northern       WE     Sharon Gray        5.3  .97   5   23
southnorth     SW     Lewis Dalsass      2.7  .8    2   18
southern       SO     Suan Chin          5.1  .95   4   15
southeast      SE     Patricia Hemenway  4.0  .7    4   17
eastern        EA     TB Savage          4.4  .84   5   20
northeast      NE     AM Main Jr.        5.1  .94   3   13
north          NO     Margot Weber       4.5  .89   5    9
central        CT     Ann Stephens       5.7  .94   5   13
```

EXPLANATION

The s command is for substitution. The g flag at the end of the command indicates that the substitution is global across the line; that is, if multiple occurrences of west are found, all of them will be replaced with north. Without the g command, only the first occurrence of west on each line would be replaced with north.

```
% cat datafile
northwest          NW   Charles Main       3.0   .98   3   34
western            WE   Sharon Gray        5.3   .97   5   23
southwest          SW   Lewis Dalsass      2.7   .8    2   18
southern           SO   Suan Chin          5.1   .95   4   15
southeast          SE   Patricia Hemenway  4.0   .7    4   17
eastern            EA   TB Savage          4.4   .84   5   20
northeast          NE   AM Main Jr.        5.1   .94   3   13
north              NO   Margot Weber       4.5   .89   5   9
central            CT   Ann Stephens       5.7   .94   5   13
```

Example 4.11

```
sed −n 's/^west/north/p' datafile
northern       WE     Sharon Gray       5.3  .97   5   23
```

EXPLANATION

The s command is for substitution. The −n option with the p flag at the end of the command tells sed to print only those lines where the substitution occurred; that is, if west is found at the beginning of the line and is replaced with north, just those lines are printed.

Example 4.12

```
sed 's/[0−9][0−9]$/&.5/' datafile
northwest      NW     Charles Main      3.0  .98   3   34.5
western        WE     Sharon Gray       5 3  .97   5   23.5
southwest      SW     Lewis Dalsass     2.7  .8    2   18.5
```

```
southern      SO     Suan Chin          5.1  .95   4   15.5
southeast     SE     Patricia Hemenway  4.0  .7    4   17.5
eastern       EA     TB Savage          4.4  .84   5   20.5
northeast     NE     AM Main Jr.        5.1  .94   3   13.5
north         NO     Margot Weber       4.5  .89   5   9
central       CT     Ann Stephens       5.7  .94   5   13.5
```

EXPLANATION

The ampersand[3] (&) in the replacement string represents exactly what was found in the search string. Each line that ends in two digits will be replaced by itself, and .5 will be appended to it.

Example 4.13

```
sed −n 's/Hemenway/Jones/gp' datafile
southeast     SE     Patricia Jones      4.0  .7   4     17
```

EXPLANATION

All occurrences of Hemenway are replaced with Jones, and only the lines that changed are printed. The −n option combined with the p command suppresses the default output. The g stands for global substitution across the line.

Example 4.14

```
sed −n 's/\(Mar\)got/\1ianne/p' datafile
north         NO     Marianne Weber      4.5  .89   5    9
```

EXPLANATION

The pattern Mar is enclosed in parentheses and saved as tag 1 in a special register. It will be referenced in the replacement string as \1. Margot is then replaced with Marianne.

Example 4.15

```
sed 's#3#88#g' datafile
northwest     NW     Charles Main       88.0  .98   88   884
western       WE     Sharon Gray        5.88  .97    5   288
southwest     SW     Lewis Dalsass      2.7   .8     2   18
southern      SO     Suan Chin          5.1   .95    4   15
southeast     SE     Patricia Hemenway  4.0   .7     4   17
eastern       EA     TB Savage          4.4   .84    5   20
northeast     NE     AM Main Jr.        5.1   .94   88   188
north         NO     Margot Weber       4.5   .89    5   9
central       CT     Ann Stephens       5.7   .94    5   188
```

EXPLANATION

The character after the s command is the delimiter between the search string and the replacement string. The delimiter character is a forward slash by default, but can be changed (only when the s command is used). Whatever character follows the s command is the new string delimiter. This technique can be useful when searching for patterns containing a forward slash, such as pathnames or birthdays.

```
% cat datafile
northwest          NW   Charles Main       3.0   .98   3    34
western            WE   Sharon Gray        5.3   .97   5    23
```

```
southwest          SW   Lewis Dalsass      2.7   .8    2    18
southern           SO   Suan Chin          5.1   .95   4    15
southeast          SE   Patricia Hemenway  4.0   .7    4    17
eastern            EA   TB Savage          4.4   .84   5    20
northeast          NE   AM Main Jr.        5.1   .94   3    13
north              NO   Margot Weber       4.5   .89   5     9
central            CT   Ann Stephens       5.7   .94   5    13
```

4.6.4 Range of Selected Lines: The Comma

Example 4.16

```
sed -n '/west/,/east/p' datafile
northwest      NW      Charles Main       3.0  .98   3    34
western        WE      Sharon Gray        5.3  .97   5    23
southwest      SW      Lewis Dalsass      2.7  .8    2    18
southern       SO      Suan Chin          5.1  .95   4    15
southeast      SE      Patricia Hemenway  4.0  .7    4    17
```

EXPLANATION

All lines in the range of patterns between west and east are printed. If west were to appear on a line after east, the lines from west to the next east or to the end of file, whichever comes first, would be printed. The arrows mark the range.

Example 4.17

```
sed -n '5,/^northeast/p' datafile
southeast     SE     Patricia Hemenway  4.0  .7    4   17
eastern       EA     TB Savage          4.4  .84   5   20
northeast     NE     AM Main Jr.        5.1  .94   3   13
```

EXPLANATION

Prints the lines from line 5 through the first line that begins with northeast.

Example 4.18

```
sed '/west/,/east/s/$/**VACA**/' datafile
northwest      NW      Charles Main       3.0  .98   3   34**VACA**
western        WE      Sharon Gray        5.3  .97   5   23**VACA**
southwest      SW      Lewis Dalsass      2.7  .8    2   18**VACA**
southern       SO      Suan Chin          5.1  .95   4   15**VACA**
southeast      SE      Patricia Hemenway  4.0  .7    4   17**VACA**
eastern        EA      TB Savage          4.4  .84   5   20
northeast      NE      AM Main Jr.        5.1  .94   3   13
north          NO      Margot Weber       4.5  .89   5   9
central        CT      Ann Stephens       5.7  .94   5   13
```

EXPLANATION

For lines in the range between the patterns east and west, the end of line ($) is replaced with the string **VACA**. The newline is moved over to the end of the new string. The arrows mark the range.

4.6.5 Multiple Edits: The e Command

Example 4.19

```
sed −e '1,3d' −e 's/Hemenway/Jones/' datafile
southern      SO     Suan Chin          5.1  .95   4   15
southeast     SE     Patricia Jones     4.0  .7    4   17
eastern       EA     TB Savage          4.4  .84   5   20
northeast     NE     AM Main            5.1  .94   3   13
north         NO     Margot Weber       4.5  .89   5   9
central       CT     Ann Stephens       5.7  .94   5   13
```

EXPLANATION

The −e option allows multiple edits. The first edit removes lines 1 through 3. The second edit substitutes Hemenway with Jones. Since both edits are done on a per−line basis (i.e., both commands are executed on the current line in the pattern space), the order of the edits may affect the outcome. For example, if both commands had performed substitutions on the line, the first substitution could affect the second substitution.

```
% cat datafile
northwest          NW   Charles Main       3.0   .98   3   34
western            WE   Sharon Gray        5.3   .97   5   23
southwest          SW   Lewis Dalsass      2.7   .8    2   18
southern           SO   Suan Chin          5.1   .95   4   15
southeast          SE   Patricia Hemenway  4.0   .7    4   17
eastern            EA   TB Savage          4.4   .84   5   20
northeast          NE   AM Main Jr.        5.1   .94   3   13
north              NO   Margot Weber       4.5   .89   5    9
central            CT   Ann Stephens       5.7   .94   5   13
```

4.6.6 Reading from Files: The r Command

Example 4.20

```
% cat newfile
              __________________________________
              | ***SUAN HAS LEFT THE COMPANY*** |
              |_________________________________|
% sed '/Suan/r newfile' datafile
northwest     NW     Charles Main       3.0  .98   3   34
western       WE     Sharon Gray        5.3  .97   5   23
southwest     SW     Lewis Dalsass      2.7  .8    2   18
southern      SO     Suan Chin          5.1  .95   4   15
              ___________________________________
              | ***SUAN HAS LEFT THE COMPANY***   |
              |___________________________________|
southeast     SE     Patricia Hemenway  4.0  .7    4   17
eastern       EA     TB Savage          4.4  .84   5   20
northeast     NE     AM Main            5.1  .94   3   13
north         NO     Margot Weber       4.5  .89   5   9
central       CT     Ann Stephens       5.7  .94   5   13
```

EXPLANATION

The r command reads specified lines from a file.The contents of newfile are read into the input file datafile, after the line where the pattern Suan is matched. If Suan had appeared on more than one line, the contents of newfile would have been read in under each occurrence.

4.6.7 Writing to Files: The w Command

Example 4.21

```
sed −n '/north/w newfile' datafile
cat newfile
northwest     NW     Charles Main       3.0  .98   3  34
northeast     NE     AM Main Jr.        5.1  .94   3  13
north         NO     Margot Weber       4.5  .89   5   9
```

EXPLANATION

The w command writes specified lines to a file. All lines containing the pattern north are written to a file called newfile.

4.6.8 Appending: The a Command

Example 4.22

```
sed '/^north  /a\\
−−−>THE NORTH SALES DISTRICT HAS MOVED<−−−' datafile
northwest     NW     Charles Main       3.0  .98   3   34
western       WE     Sharon Gray        5.3  .97   5   23
southwest     SW     Lewis Dalsass      2.7  .8    2   18
southern      SO     Suan Chin          5.1  .95   4   15
southeast     SE     Patricia Hemenway  4.0  .7    4   17
eastern       EA     TB Savage          4.4  .84   5   20
northeast     NE     AM Main Jr.        5.1  .94   3   13
north         NO     Margot Weber       4.5  .89   5   9
−−−>THE NORTH SALES DISTRICT HAS MOVED<−−−
central       CT     Ann Stephens       5.7  .94   5   13
```

EXPLANATION

The a command is the append command. The string −−−>THE NORTH SALES DISTRICT HAS MOVED<−−− is appended after lines beginning with the pattern north, when north is followed by a space. The text that will be appended must be on the line following the append command.

Sed requires a backslash after the a command. The second backslash is used by the C shell to escape the newline so that its closing quote can be on the next line.[4] If more than one line is appended, each line, except the last one, must also end in a backslash.

```
% cat datafile
northwest          NW   Charles Main       3.0   .98   3   34
western            WE   Sharon Gray        5.3   .97   5   23
southwest          SW   Lewis Dalsass      2.7   .8    2   18
southern           SO   Suan Chin          5.1   .95   4   15
southeast          SE   Patricia Hemenway  4.0   .7    4   17
eastern            EA   TB Savage          4.4   .84   5   20
northeast          NE   AM Main Jr.        5.1   .94   3   13
north              NO   Margot Weber       4.5   .89   5    9
```

```
central             CT    Ann Stephens       5.7    .94    5    13
```

4.6.9 Inserting: The i Command

Example 4.23

```
sed '/eastern/i\\
NEW ENGLAND REGION\\
-------------------------------------' datafile
northwest     NW     Charles Main       3.0  .98   3   34
western       WE     Sharon Gray        5.3  .97   5   23
southwest     SW     Lewis Dalsass      2.7  .8    2   18
southern      SO     Suan Chin          5.1  .95   4   15
southeast     SE     Patricia Hemenway  4.0  .7    4   17
NEW ENGLAND REGION
-------------------------------------
eastern       EA     TB Savage          4.4  .84   5   20
northeast     NE     AM Main Jr.        5.1  .94   3   13
north         NO     Margot Weber       4.5  .89   5   9
central       CT     Ann Stephens       5.7  .94   5   13
```

EXPLANATION

The i command is the insert command. If the pattern eastern is matched, the i command causes the text following the backslash to be inserted above the line containing eastern. A backslash is required after each line to be inserted, except the last one. (The extra backslash is for the C shell.)

4.6.10 Next: The n Command

Example 4.24

```
sed '/eastern/{ n; s/AM/Archie/; }' datafile
northwest     NW     Charles Main       3.0  .98   3   34
western       WE     Sharon Gray        5.3  .97   5   23
southwest     SW     Lewis Dalsass      2.7  .8    2   18
southern      SO     Suan Chin          5.1  .95   4   15
southeast     SE     Patricia Hemenway  4.0  .7    4   17
eastern       EA     TB Savage          4.4  .84   5   20
--> northeast NE     Archie Main Jr.    5.1  .94   3   13
north         NO     Margot Weber       4.5  .89   5   9
central       CT     Ann Stephens       5.7  .94   5   13
```

EXPLANATION

If the pattern eastern is matched on a line, the n command causes sed to get the next line of input (the line with AM Main Jr.), replace the pattern space with this line, substitute (s) AM with Archie, print the line, and continue.

4.6.11 Transform: The y Command

Example 4.25

```
sed '1,3y/abcdefghijklmnopqrstuvwxyz/ABCDEFGHIJKL
 MNOPQRSTUVWXYZ/'  datafile
NORTHWEST      NW    CHARLES MAIN       3.0  .98   3   34
WESTERN        WE    SHARON GRAY        5.3  .97   5   23
SOUTHWEST      SW    LEWIS DALSASS      2.7  .8    2   18
southern       SO    Suan Chin          5.1  .95   4   15
southeast      SE    Patricia Hemenway  4.0  .7    4   17
eastern        EA    TB Savage          4.4  .84   5   20
northeast      NE    AM Main Jr.        5.1  .94   3   13
north          NO    Margot Weber       4.5  .89   5   9
central        CT    Ann Stephens       5.7  .94   5   13
```

EXPLANATION

For lines 1 through 3, the y command translates all lowercase letters to uppercase letters. Regular expression metacharacters do not work with this command.

```
% cat datafile
northwest          NW   Charles Main       3.0   .98   3   34
western            WE   Sharon Gray        5.3   .97   5   23
southwest          SW   Lewis Dalsass      2.7   .8    2   18
southern           SO   Suan Chin          5.1   .95   4   15
southeast          SE   Patricia Hemenway  4.0   .7    4   17
eastern            EA   TB Savage          4.4   .84   5   20
northeast          NE   AM Main Jr.        5.1   .94   3   13
north              NO   Margot Weber       4.5   .89   5   9
central            CT   Ann Stephens       5.7   .94   5   13
```

4.6.12 Quit: The q Command

Example 4.26

```
sed '5q' datafile
northwest     NW     Charles Main       3.0  .98   3   34
western       WE     Sharon Gray        5.3  .97   5   23
southwest     SW     Lewis Dalsass      2.7  .8    2   18
southern      SO     Suan Chin          5.1  .95   4   15
southeast     SE     Patricia Hemenway  4.0  .7    4   17
```

EXPLANATION

After the line 5 is printed, the q command causes the sed program to quit.

Example 4.27

```
sed  '/Lewis/{ s/Lewis/Joseph/;q; }' datafile
northwest     NW      Charles Main       3.0  .98   3   34
western       WE      Sharon Gray        5.3  .97   5   23
southwest     SW      Joseph Dalsass     2.7  .8    2   18
```

EXPLANATION

When the pattern Lewis is matched on a line, first the substitution command (s) replaces Lewis with Joseph, and then the q command causes the sed program to quit.

4.6.13 Holding and Getting: The h and g Commands

Example 4.28

```
sed -e '/northeast/h'  -e  '$G'  datafile
northwest      NW     Charles Main        3.0  .98   3   34
western        WE     Sharon Gray         5.3  .97   5   23
southwest      SW     Lewis Dalsass       2.7  .8    2   18
southern       SO     Suan Chin           5.1  .95   4   15
southeast      SE     Patricia Hemenway   4.0  .7    4   17
eastern        EA     TB Savage           4.4  .84   5   20
northeast      NE     AM Main Jr.         5.1  .94   3   13
north          NO     Margot Weber        4.5  .89   5   9
central        CT     Ann Stephens        5.7  .94   5   13
northeast      NE     AM Main Jr.         5.1  .94   3   13
```

EXPLANATION

As sed processes the file, each line is stored in a temporary buffer called the pattern space. Unless the line is deleted or suppressed from printing, the line will be printed to the screen after it is processed. The pattern space is then cleared and the next line of input is stored there for processing. In this example, after the line containing the pattern northeast is found, it is placed in the pattern space and the h command copies it and places it into another special buffer called the holding buffer. In the second sed instruction, when the last line is reached ($) the G command tells sed to get the line from the holding buffer and put it back in the pattern space buffer, appending it to the line that is currently stored there, in this case, the last line. Simply stated: Any line containing the pattern northeast will be copied and appended to the end of the file. (See Figure 4.1.)

Figure 4.1. The pattern space and holding buffer. See Example 4.31.

```
% cat datafile
northwest          NW   Charles Main       3.0   .98   3   34
western            WE   Sharon Gray        5.3   .97   5   23
southwest          SW   Lewis Dalsass      2.7   .8    2   18
southern           SO   Suan Chin          5.1   .95   4   15
southeast          SE   Patricia Hemenway  4.0   .7    4   17
eastern            EA   TB Savage          4.4   .84   5   20
northeast          NE   AM Main Jr.        5.1   .94   3   13
north              NO   Margot Weber       4.5   .89   5    9
central            CT   Ann Stephens       5.7   .94   5   13
```

Example 4.29

```
sed -e '/WE/{h; d; }' -e '/CT/{G; }' datafile
northwest      NW     Charles Main       3.0  .98   3   34
southwest      SW     Lewis Dalsass      2.7  .8    2   18
southern       SO     Suan Chin          5.1  .95   4   15
southeast      SE     Patricia Hemenway  4.0  .7    4   17
eastern        EA     TB Savage          4.4  .84   5   20
northeast      NE     AM Main Jr.        5.1  .94   3   13
north          NO     Margot Weber       4.5  .89   5    9
central        CT     Ann Stephens       5.7  .94   5   13
western        WE     Sharon Gray        5.3  .97   5   23
```

EXPLANATION

If the pattern WE is found on a line, the h command causes the line to be copied from the pattern space into a holding buffer. When stored in the holding buffer, the line can be retrieved (G or g command) at a later time. In this example, when the pattern WE is found, the line in which it was found is stored in the pattern buffer first. The h command then puts a copy of the line in the holding buffer. The d command deletes the copy in the pattern buffer. The second command searches for CT in a line, and when it is found, sed gets (G) the line that was stored in the holding buffer and appends it to the line currently in the pattern space. Simply stated: The line containing WE is moved and appended after the line containing CT. (See "Holding and Exchanging: The h and x Commands".)

Example 4.30

```
sed -e '/northeast/h'  -e  '$g'  datafile
northwest      NW     Charles Main       3.0  .98   3   34
western        WE     Sharon Gray        5.3  .97   5   23
southwest      SW     Lewis Dalsass      2.7  .8    2   18
southern       SO     Suan Chin          5.1  .95   4   15
southeast      SE     Patricia Hemenway  4.0  .7    4   17
eastern        EA     TB Savage          4.4  .84   5   20
northeast      NE     AM Main Jr.        5.1  .94   3   13
north          NO     Margot Weber       4.5  .89   5    9
northeast      NE     AM Main Jr.        5.1  .94   3   13
```

EXPLANATION

As sed processes the file, each line is stored in a temporary buffer called the pattern space. Unless the line is deleted or suppressed from printing, the line will be printed to the screen after it is processed. The pattern space is then cleared and the next line of input is stored there for processing. In this example, after the line containing the pattern northeast is found, it is placed in the pattern space. The h command takes a copy of it and places it in another special buffer called the holding buffer. In the second sed instruction, when the last line is reached ($), the g command tells sed to get the line from the holding buffer and put it back in the pattern space buffer, replacing the line that is currently stored there, in this case, the last line. Simply stated: The line containing the pattern northeast is copied and moved to overwrite the last line in the file.

```
% cat datafile
northwest          NW   Charles Main       3.0   .98   3   34
western            WE   Sharon Gray        5.3   .97   5   23
southwest          SW   Lewis Dalsass      2.7   .8    2   18
southern           SO   Suan Chin          5.1   .95   4   15
southeast          SE   Patricia Hemenway  4.0   .7    4   17
eastern            EA   TB Savage          4.4   .84   5   20
northeast          NE   AM Main Jr.        5.1   .94   3   13
north              NO   Margot Weber       4.5   .89   5   9
central            CT   Ann Stephens       5.7   .94   5   13
```

Example 4.31

```
sed −e '/WE/{h; d; }' −e '/CT/{g; }' datafile
northwest     NW      Charles Main       3.0  .98   3   34
southwest     SW      Lewis Dalsass      2.7  .8    2   18
southern      SO      Suan Chin          5.1  .95   4   15
southeast     SE      Patricia Hemenway  4.0  .7    4   17
eastern       EA      TB Savage          4.4  .84   5   20
northeast     NE      AM Main Jr.        5.1  .94   3   13
north         NO      Margot Weber       4.5  .89   5   9
western       WE      Sharon Gray        5.3  .97   5   23
```

EXPLANATION

If the pattern WE is found, the h command copies the line into the holding buffer; the d command deletes the line in the pattern space. When the pattern CT is found, the g command gets the copy in the holding buffer and overwrites the line currently in the pattern space. Simply stated: Any line containing the pattern WE will be moved to overwrite lines containing CT. (See Figure 4.1.)

4.6.14 Holding and Exchanging: The h and x Commands

Example 4.32

```
sed −e '/Patricia/h'  −e '/Margot/x' datafile
northwest     NW      Charles Main       3.0  .98   3   34
western       WE      Sharon Gray        5.3  .97   5   23
southwest     SW      Lewis Dalsass      2.7  .8    2   18
southern      SO      Suan Chin          5.1  .95   4   15
southeast     SE      Patricia Hemenway  4.0  .7    4   17
eastern       EA      TB Savage          4.4  .84   5   20
northeast     NE      AM Main Jr.        5.1  .94   3   13
southeast     SE      Patricia Hemenway  4.0  .7    4   17
central       CT      Ann Stephens       5.7  .94   5   13
```

EXPLANATION

The x command exchanges (swaps) the contents of the holding buffer with the current pattern space. When the line containing the pattern Patricia is found, it will be stored in the holding buffer. When the line containing Margot is found, the pattern space will be exchanged for the line in the holding buffer. Simply stated: The line containing Margot will be replaced with the line containing Patricia.

4.7 sed Scripting

A sed script is a list of sed commands in a file. To let sed know your commands are in a file, when invoking sed at the command line, use the −f option followed by the name of the sed script. Sed is very particular about the way you type lines into the script. There cannot be any trailing whitespace or text at the end of the command. If commands are not placed on a line by themselves, they must be terminated with a semicolon. A line from the input file is copied into the pattern buffer, and all commands in the sed script are executed on that line. After the line has been processed, the next line from the input file is placed in the pattern buffer, and all commands in the script are executed on that line. Sed gets "garbled" if your syntax is incorrect.

The nice thing about sed scripts is that you don't have to worry about the shell's interaction as you do when at the command line. Quotes are not needed to protect sed commands from interpretation by the shell. In fact, you cannot use quotes in a sed script at all, unless they are part of a search pattern.

```
% cat datafile
northwest          NW   Charles Main       3.0   .98   3   34
western            WE   Sharon Gray        5.3   .97   5   23
southwest          SW   Lewis Dalsass      2.7   .8    2   18
southern           SO   Suan Chin          5.1   .95   4   15
southeast          SE   Patricia Hemenway  4.0   .7    4   17
eastern            EA   TB Savage          4.4   .84   5   20
northeast          NE   AM Main Jr.        5.1   .94   3   13
north              NO   Margot Weber       4.5   .89   5    9
central            CT   Ann Stephens       5.7   .94   5   13
```

4.7.1 sed Script Examples

Example 4.33

```
% cat sedding1 (Look at the contents of the sed script.)
1  # My first sed script by Jack Sprat
2  /Lewis/a\
3     Lewis is the TOP Salesperson for April!!\
      Lewis is moving to the southern district next month.\
4     CONGRATULATIONS!
5  /Margot/c\
      *******************\
      MARGOT HAS RETIRED\
      ********************
6  1i\
   EMPLOYEE DATABASE\
   ---------------------
7  $d

% sed −f sedding1 datafile   (Execute the sed script commands; the
                               input file is datafile.)
EMPLOYEE DATABASE
---------------------
northwest     NW     Charles Main       3.0  .98   3   34
western       WE     Sharon Gray        5.3  .97   5   23
southwest     SW     Lewis Dalsass      2.7  .8    2   18
Lewis is the TOP Salesperson for April!!
Lewis is moving to the southern district next month
CONGRATULATIONS!
southern      SO     Suan Chin          5.1  .95   4   15
southeast     SE     Patricia Hemenway  4.0  .7    4   17
eastern       EA     TB Savage          4.4  .84   5   20
northeast     NE     AM Main Jr.        5.1  .94   3   13
********************
MARGOT HAS RETIRED
*****************
```

EXPLANATION

1. This line is a comment. Comments must be on lines by themselves and start with a pound sign (#).
2. If a line contains the pattern Lewis, the next three lines are appended to that line.
3. Each line being appended, except the last one, is terminated with a backslash. The backslash must be followed immediately with a newline. If there is any trailing text, even one space after the newline, sed will complain.
4. The last line to be appended does not have the terminating backslash. This indicates to sed that this is the last line to be appended and that the next line is another command.
5. Any lines containing the pattern Margot will be replaced (c command) with the next three lines of text.
6. The next two lines will be inserted (i command) above line 1.
7. The last line ($) will be deleted.

Example 4.34

```
%  cat sedding2 (Look at the contents of the sed script.)
# This script demonstrates the use of curly braces to nest addresses
```

```
# and commands. Comments are preceded by a pound sign(#) and must
# be on a line by themselves. Commands are terminated with a newline
# or semicolon.  If there is any text after a command, even one
# space, you receive an error message:
#      sed: Extra text at end of command:

1  /western/, /southeast/{
      /^ *$/d
      /Suan/{ h; d; }
   }
2   /Ann/g
3   s/TB \(Savage\)/Thomas \1/

% sed −f sedding2 datafile
northwest     NW     Charles Main       3.0  .98   3   34
western       WE     Sharon Gray        5.3  .97   5   23
southwest     SW     Lewis Dalsass      2.7  .8    2   18
southeast     SE     Patricia Hemenway  4.0  .7    4   17
eastern       EA     Thomas Savage      4.4  .84   5   20
northeast     NE     AM Main Jr.        5.1  .94   3   13
north         NO     Margot Weber       4.5  .89   5    9
southern      SO     Suan Chin          5.1  .95   4   15
```

EXPLANATION

1. In the range of lines starting at western and ending at southeast, blank lines are deleted, and lines matching Suan are copied from the pattern buffer into the holding buffer, then deleted from the pattern buffer.
2. When the pattern Ann is matched, the g command copies the line in the holding buffer to the pattern buffer, overwriting what is in the pattern buffer.
3. All lines containing the pattern TB Savage are replaced with Thomas and the pattern that was tagged, Savage. In the search string, Savage is enclosed in escaped parentheses, tagging the enclosed string so that it can be used again. It is tag number 1, referenced by \1.

4.7.2 Review

Table 4.4 lists sed commands and what they do.

Table 4.4. sed Review

CommandWhat It Doessed −n '/sentimental/p' filexPrints to the screen all lines containing sentimental. The file filex does not change. Without the −n option, all lines with sentimental will be printed twice.sed '1,3d' filex > newfilexDeletes lines 1, 2, and 3 from filex and saves changes in newfilex.sed '/[Dd]aniel/d' filexDeletes lines containing Daniel or daniel.sed −n '15,20p' filexPrints only lines 15 through 20.sed '1,10s/Montana/MT/g' filexSubstitutes Montana with MT globally in lines 1 through 10.

```
sed '/March/\!d' filex    (csh)
sed '/March/!d' filex      (sh)
```

Deletes all lines not containing March. (The backslash is used only in the csh to escape the history character.)sed '/report/s/5/8/' filexChanges the first occurrence of 5 to 8 on all lines containing report.sed 's/….//' filexDeletes the first four characters of each line.sed 's/…$//' filexDeletes the last three characters of each line.sed '/east/,/west/s/North/South/' filexFor any lines falling in the range from east to west, substitutes North with South.sed −n '/Time off/w timefile' filexWrites all lines containing Time off to the file timefile.sed 's/\([Oo]ccur\)ence/\1rence/' fileSubstitutes either Occurence or occurence with Occurrence or occurrence.sed −n 'l' filexPrints all lines showing nonprinting characters as \nn, where nn is the octal value of the character, and showing tabs as >.

UNIX TOOLS LAB EXERCISE

Lab 2: sed Exercise

Steve Blenheim:238−923−7366:95 Latham Lane, Easton, PA 83755:11/12/56:20300

Betty Boop:245−836−8357:635 Cutesy Lane, Hollywood, CA 91464:6/23/23:14500

Igor Chevsky:385−375−8395:3567 Populus Place, Caldwell, NJ 23875:6/18/68:23400

Norma Corder:397−857−2735:74 Pine Street, Dearborn, MI 23874:3/28/45:245700

Jennifer Cowan:548−834−2348:583 Laurel Ave., Kingsville, TX 83745:10/1/35:58900

Jon DeLoach:408−253−3122:123 Park St., San Jose, CA 04086:7/25/53:85100

Karen Evich:284−758−2857:23 Edgecliff Place, Lincoln, NB 92743:7/25/53:85100

Karen Evich:284−758−2867:23 Edgecliff Place, Lincoln, NB 92743:11/3/35:58200

Karen Evich:284−758−2867:23 Edgecliff Place, Lincoln, NB 92743:11/3/35:58200

Fred Fardbarkle:674−843−1385:20 Parak Lane, DeLuth, MN 23850:4/12/23:780900

Fred Fardbarkle:674−843−1385:20 Parak Lane, DeLuth, MN 23850:4/12/23:780900

Lori Gortz:327−832−5728:3465 Mirlo Street, Peabody, MA 34756:10/2/65:35200

Paco Gutierrez:835−365−1284:454 Easy Street, Decatur, IL 75732:2/28/53:123500

Ephram Hardy:293−259−5395:235 CarltonLane, Joliet, IL 73858:8/12/20:56700

James Ikeda:834−938−8376:23445 Aster Ave., Allentown, NJ 83745:12/1/38:45000

Barbara Kertz:385−573−8326:832 Ponce Drive, Gary, IN 83756:12/1/46:268500

Lesley Kirstin:408−456−1234:4 Harvard Square, Boston, MA 02133:4/22/62:52600

William Kopf:846−836−2837:6937 Ware Road, Milton, PA 93756:9/21/46:43500

Sir Lancelot:837−835−8257:474 Camelot Boulevard, Bath, WY 28356:5/13/69:24500

Jesse Neal:408−233−8971:45 Rose Terrace, San Francisco, CA 92303:2/3/36:25000

Zippy Pinhead:834−823−8319:2356 Bizarro Ave., Farmount, IL 84357:1/1/67:89500

Arthur Putie:923−835−8745:23 Wimp Lane, Kensington, DL 38758:8/31/69:126000

Popeye Sailor:156−454−3322:945 Bluto Street, Anywhere, USA 29358:3/19/35:22350

Jose Santiago:385−898−8357:38 Fife Way, Abilene, TX 39673:1/5/58:95600

Tommy Savage:408−724−0140:1222 Oxbow Court, Sunnyvale, CA 94087:5/19/66:34200

Yukio Takeshida:387−827−1095:13 Uno Lane, Ashville, NC 23556:7/1/29:57000

Vinh Tranh:438−910−7449:8235 Maple Street, Wilmington, VM 29085:9/23/63:68900

(Refer to the database called datebook on the CD.)

1: Change Jon's name to Jonathan.

2: Delete the first three lines.

3: Print lines 5 through 10.

4: Delete lines containing Lane.

5: Print all lines where the birthdays are in November or December.

6: Append three stars to the end of lines starting with Fred.

7: Replace the line containing Jose with JOSE HAS RETIRED.

8: Change Popeye's birthday to 11/14/46.

9: Delete all blank lines.

10: Write a sed script that will:

a. Insert above the first line the title PERSONNEL FILE.
b. Remove the salaries ending in 500.
c. Print the contents of the file with the last names and first names reversed.
d. Append at the end of the file THE END.

[1] Remember, the shell will try to evaluate any metacharacters or whitespace when a command is typed at the command line; any characters in the sed command that could be interpreted by the shell must be quoted.

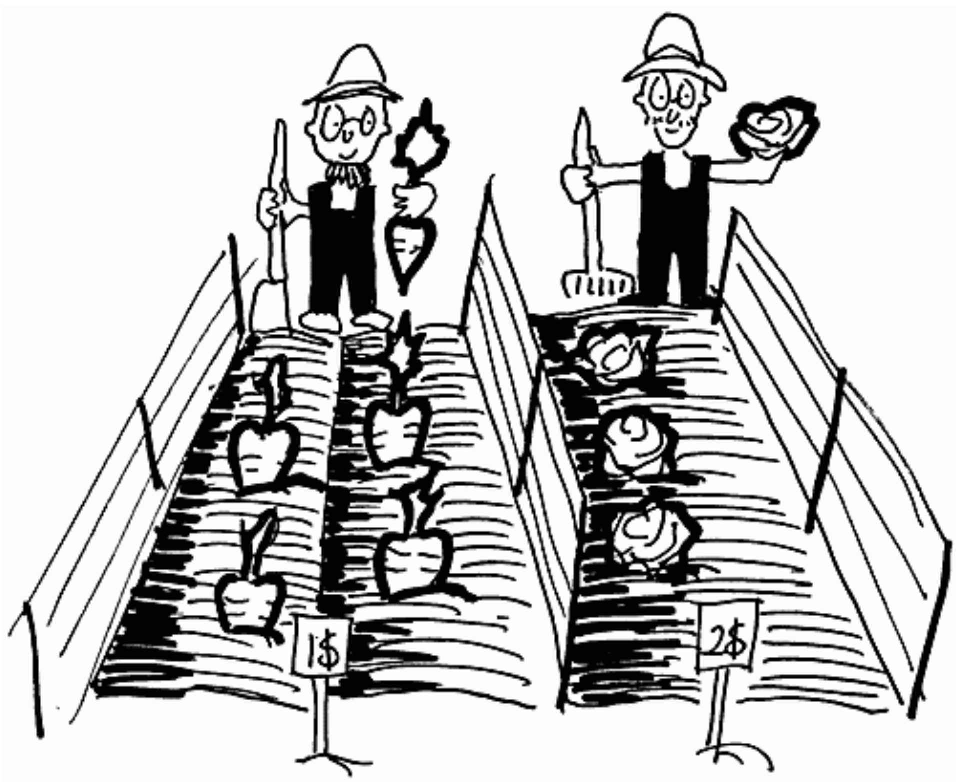
[2] For a complete list of diagnostics, see the UNIX man page for sed.

[3] To represent a literal ampersand in the replacement string, it must be escaped: \&.

[4] The Bourne and Korn shells do not require the second backslash to escape the newline because they do not require quotes to be matched on the same line, only that they match.

CONTENTS

Chapter 5. The awk Utility: awk as a UNIX Tool



5.1 What Is awk?

Awk is a programming language used for manipulating data and generating reports. The data may come from standard input, one or more files, or as output from a process. Awk can be used at the command line for simple operations, or it can be written into programs for larger applications. Because awk can manipulate data, it is an indispensable tool used in shell scripts and for managing small databases.

Awk scans a file (or input) line by line, from the first to the last line, searching for lines that match a specified pattern and performing selected actions (enclosed in curly braces) on those lines. If there is a pattern with no specific action, all lines that match the pattern are displayed; if there is an action with no pattern, all input lines specified by the action are executed upon.

5.1.1 What Does awk Stand for?

Awk stands for the first initials in the last names of each of the authors of the language, Alfred Aho, Brian Kernighan, and Peter Weinberger. They could have called it wak or kaw, but for whatever reason, awk won out.

5.1.2 Which awk?

There are a number of versions of awk: old awk, new awk, gnu awk (gawk), POSIX awk, and others. Awk was originally written in 1977, and in 1985, the original implementation was improved so that awk could handle larger programs. Additional features included user−defined functions, dynamic regular expressions, processing multiple input files, and more. On most systems, the command is awk if using the old version, nawk if using the new version, and gawk if using the gnu version.[1]

5.2 awk's Format

An awk program consists of the awk command, the program instructions enclosed in quotes (or in a file), and the name of the input file. If an input file is not specified, input comes from standard input (stdin), the keyboard.

Awk instructions consist of patterns, actions, or a combination of patterns and actions. A pattern is a statement consisting of an expression of some type. If you do not see the keyword if, but you think the word if when evaluating the expression, it is a pattern. Actions consist of one or more statements separated by semicolons or newlines and enclosed in curly braces. Patterns cannot be enclosed in curly braces, and consist of regular expressions enclosed in forward slashes or expressions consisting of one or more of the many operators provided by awk.

Awk commands can be typed at the command line or in awk script files. The input lines can come from files, pipes, or standard input.

5.2.1 Input from Files

In the following examples, the percent sign (%) is the C shell prompt.

FORMAT

```
% nawk 'pattern' filename
% nawk '{action}' filename
% nawk 'pattern {action}' filename
```

Here is a sample file called employees:

Example 5.1

```
% cat employees
Tom Jones     4424   5/12/66   543354
Mary Adams    5346   11/4/63   28765
Sally Chang   1654   7/22/54   650000
Billy Black   1683   9/23/44   336500

% nawk '/Mary/' employees
Mary Adams    5346   11/4/63   28765
```

EXPLANATION

Nawk prints all lines that contain the pattern Mary.

Example 5.2

```
% cat employees
Tom Jones     4424    5/12/66   543354
Mary Adams    5346    11/4/63   28765
Sally Chang   1654    7/22/54   650000
Billy Black   1683    9/23/44   336500

% nawk '{print $1}' employees
Tom
Mary
Sally
Billy
```

EXPLANATION

Nawk prints the first field of file employees, where the field starts at the left margin of the line and is delimited by whitespace.

Example 5.3

```
% cat employees
Tom Jones     4424    5/12/66   543354
Mary Adams    5346    11/4/63   28765
Sally Chang   1654    7/22/54   650000
Billy Black   1683    9/23/44   336500

% nawk '/Sally/{print $1, $2}' employees
Sally Chang
```

EXPLANATION

Nawk prints the first and second fields of file employees, only if the line contains the pattern Sally. Remember, the field separator is whitespace.

5.2.2 Input from Commands

The output from a UNIX command or commands can be piped to awk for processing. Shell programs commonly use awk for manipulating commands.

FORMAT

```
% command | nawk 'pattern'
% command | nawk '{action}'
% command | nawk 'pattern {action}'
```

Example 5.4

```
1   % df | nawk '$4 > 75000'
    /oracle   (/dev/dsk/c0t0d057 ):390780 blocks      105756 files
    /opt      (/dev/dsk/c0t0d058 ):1943994 blocks      49187 files
```

```
2   % rusers  | nawk '/root$/{print  $1}'
    owl
    crow
    bluebird
```

EXPLANATION

1. The df command reports the free disk space on file systems. The output of the df command is piped to nawk (new awk). If the fourth field is greater than 75,000 blocks, the line is printed.
2. The rusers command prints those logged on remote machines on the network. The output of the rusers command is piped to nawk as input. The first field is printed if the regular expression root is matched at the end of the line ($); that is, all machine names are printed where root is logged on.

5.3 Formatting Output

5.3.1 The print Function

The action part of the awk command is enclosed in curly braces. If no action is specified and a pattern is matched, awk takes the default action, which is to print the lines that are matched to the screen. The print function is used to print simple output that does not require fancy formatting. For more sophisticated formatting, the printf or sprintf functions are used. If you are familiar with C, then you already know how printf and sprintf work.

The print function can also be explicitly used in the action part of awk as {print}. The print function accepts arguments as variables, computed values, or string constants. Strings must be enclosed in double quotes. Commas are used to separate the arguments; if commas are not provided, the arguments are concatenated together. The comma evaluates to the value of the output field separator (OFS), which is by default a space.

The output of the print function can be redirected or piped to another program, and the output of another program can be piped to awk for printing. (See "Redirection" on page 16 and "Pipes" on page 19.)

Example 5.5

```
% date
Wed Jul 28 22:23:16 PDT 2001

% date | nawk '{ print "Month: " $2 "\nYear: " , $6 }'
Month: Jul
Year: 2001
```

EXPLANATION

The output of the UNIX date command will be piped to nawk. The string Month: is printed, followed by the second field, the string containing the newline character, \n, and Year:, followed by the sixth field ($6).

Escape Sequences. Escape sequences are represented by a backslash and a letter or number. They can be used in strings to represent tabs, newlines, form feeds, and so forth (see Table 5.1).

Table 5.1. print Escape Sequences

Escape Sequence Meaning\bBackspace.\fForm feed.\nNewline.\rCarriage return.\tTab.\047Octal value 47, a single quote.\cc represents any other character, e.g., \".

Example 5.6

```
Tom Jones      4424    5/12/66   543354
Mary Adams     5346    11/4/63   28765
Sally Chang    1654    7/22/54   650000
Billy Black    1683    9/23/44   336500

% nawk '/Sally/{print "\t\tHave a nice day, " $1, $2 "\!"}' employees
        Have a nice day, Sally Chang!
```

EXPLANATION

If the line contains the pattern Sally, the print function prints two tabs, the string Have a nice day, the first (where $1 is Sally) and second fields (where $2 is Chang), followed by a string containing two exclamation marks.

5.3.2 The OFMT Variable

When printing numbers, you may want to control the format of the number. Normally this would be done with the printf function, but the special awk variable, OFMT, can be set to control the printing of numbers when using the print function. It is set by default to "%.6g"—six significant digits to the right of the decimal are printed. (The following section describes how this value can be changed.)

Example 5.7

```
% nawk  'BEGIN{OFMT="%.2f"; print 1.2456789, 12E−2}'
1.25  0.12
```

EXPLANATION

The OFMT variable is set so that floating point numbers (f) will be printed with two numbers following the decimal point. The percent sign (%) indicates a format is being specified.

5.3.3 The printf Function

When printing output, you may want to specify the amount of space between fields so that columns line up neatly. Since the print function with tabs does not always guarantee the desired output, the printf function can be used for formatting fancy output.

The printf function returns a formatted string to standard output, like the printf statement in C. The printf statement consists of a quoted control string that may be imbedded with format specifications and modifiers. The control string is followed by a comma and a list of comma−separated expressions that will be formatted according to the specifications stated in the control string. Unlike the print function, printf does not provide a newline. The escape sequence, \n, must be provided if a newline is desired.

For each percent sign and format specifier, there must be a corresponding argument. To print a literal percent sign, two percent signs must be used. See Table 5.2 for a list of printf conversion characters and Table 5.3 for printf modifiers. The format specifiers are preceded by a percent sign; see Table 5.4 for a list of format printf specifiers.

When an argument is printed, the place where the output is printed is called the field, and the width of the field is the number of characters contained in that field.

The pipe symbol (vertical bar) in the following examples, when part of the printf string, is part of the text and is used to indicate where the formatting begins and ends.

Example 5.8

```
1   % echo "UNIX" | nawk ' {printf "|%−15s|\n", $1}'
    (Output)
    |UNIX           |

2   % echo "UNIX" | nawk '{ printf "|%15s|\n", $1}'
    (Output)
    |           UNIX|
```

EXPLANATION

1. The output of the echo command, UNIX, is piped to nawk. The printf function contains a control string. The percent sign alerts printf that it will be printing a 15−space, left−justified string enclosed in vertical bars and terminated with a newline. The dash after the percent sign indicates left justification. The control string is followed by a comma and $1. The string UNIX will be formatted according to the format specification in the control string.
2. The string UNIX is printed in a right−justified, 15−space string, enclosed in vertical bars, and terminated with a newline.

Example 5.9

```
% cat employees
Tom Jones     4424    5/12/66   543354
Mary Adams    5346    11/4/63   28765
Sally Chang   1654    7/22/54   650000
Billy Black   1683    9/23/44   336500

% nawk '{printf "The name is: %−15s ID  is %8d\n", $1, $3}' employees
The name is Tom              ID is4424
The name is Mary             ID is5346
The name is Sally            ID is1654
The name is Billy            ID is1683
```

EXPLANATION

The string to be printed is enclosed in double quotes. The first format specifier is %−15s. It has a corresponding argument, $1, positioned directly to the right of the comma after the closing quote in the control string. The percent sign indicates a format specification: The dash means left justify, the 15s means 15−space string. At this spot, print a left−justified, 15−space string followed by the string ID is and a number.

The %8d format specifies that the decimal (integer) value of $2 will be printed in its place within the string. The number will be right justified and take up eight spaces. Placing the quoted string and expressions within parentheses is optional.

Table 5.2. printf Conversion Characters

Conversion Character DefinitioncCharacter.sString.dDecimal number.ldLong decimal number.uUnsigned decimal number.luLong unsigned decimal number.xHexadecimal number.lxLong hexidecimal number.oOctal number.loLong octal number.eFloating point number in scientific notation (e−notation).fFloating point number.gFloating point number using either e or f conversion, whichever takes the least space.

Table 5.3. printf Modifiers

Character Definition−Left−justification modifier.#Integers in octal format are displayed with a leading 0; integers in hexadecimal form are displayed with a leading 0x.+For conversions using d, e, f, and g, integers are displayed with a numeric sign + or −.0The displayed value is padded with zeros instead of whitespace.

Table 5.4. printf Format Specifiers

Format SpecifierWhat It Does Given x = 'A', y = 15, z = 2.3, and $1 = Bob Smith:%c

Prints a single ASCII character.

printf("The character is %c\n",x) prints: The character is A.

%d

Prints a decimal number.

printf("The boy is %d years old\n", y) prints: The boy is 15 years old.

%e

Prints the e notation of a number.

printf("z is %e\n",z) prints: z is 2.3e+01.

%f

Prints a floating point number.

printf("z is %f\n", 2.3 *2) prints: z is 4.600000.

%o

Prints the octal value of a number.

printf("y is %o\n", y) prints: z is 17.

%s

Prints a string of characters.

printf("The name of the culprit is %s\n", $1) prints: The name of the culprit is Bob Smith.

%x

Prints the hex value of a number.

printf ("y is %x\n", y) prints: x is f.

5.4 awk Commands from Within a File

If awk commands are placed in a file, the –f option is used with the name of the awk file, followed by the name of the input file to be processed. A record is read into awk's buffer and each of the commands in the awk file are tested and executed for that record. After awk has finished with the first record, it is discarded and the next record is read into the buffer, and so on. If an action is not controlled by a pattern, the default behavior is to print the entire record. If a pattern does not have an action associated with it, the default is to print the record where the pattern matches an input line.

Example 5.10

```
(The Database)
   $1       $2         $3         $4           $5
   Tom      Jones      4424       5/12/66      543354
   Mary     Adams      5346       11/4/63      28765
   Sally    Chang      1654       7/22/54      650000
   Billy    Black      1683       9/23/44      336500

   % cat awkfile
1  /^Mary/{print "Hello Mary!"}
2  {print $1, $2, $3}

   % nawk –f awkfile employees
   Tom Jones 4424
   Hello Mary!
   Mary Adams 5346
   Sally Chang 1654
   Billy Black 1683
```

EXPLANATION

1. If the record begins with the regular expression Mary, the string Hello Mary! is printed. The action is controlled by the pattern preceding it. Fields are separated by whitespace.
2. The first, second, and third field of each record are printed. The action occurs for each line because there is not a pattern controlling the action.

5.5 Records and Fields

5.5.1 Records

Awk does not see input data as an endless string of characters, but sees it as having a format or structure. By default, each line is called a record and is terminated with a newline.

The Record Separator. By default, the output and input record separator (line separator) is a carriage return, stored in the built−in awk variables ORS and RS, respectively. The ORS and RS values can be changed, but only in a limited fashion.

The $0 Variable. An entire record is referenced as $0 by awk. (When $0 is changed by substitution or assignment, the value of NF, the number of fields, may be changed.) The newline value is stored in awk's built−in variable RS, a carriage return by default.

Example 5.11

```
% cat employees
Tom Jones     4424     5/12/66     543354
Mary Adams    5346     11/4/63     28765
Sally Chan    1654     7/22/54     650000
Billy Blac    1683     9/23/44     336500

% nawk '{print $0}' employees
Tom Jones     4424     5/12/66     543354
Mary Adams    5346     11/4/63     28765
Sally Chang   1654     7/22/54     650000
Billy Black   1683     9/23/44     336500
```

EXPLANATION

The nawk variable $0 holds the current record. It is printed to the screen. By default, nawk would also print the record if the command were

```
% nawk '{print}' employees
```

The NR Variable. The number of each record is stored in awk's built−in variable, NR. After a record has been processed, the value of NR is incremented by one.

Example 5.12

```
% cat employees
Tom Jones     4424     5/12/66     543354
Mary Adams    5346     11/4/63     28765
Sally Chang   1654     7/22/54     650000
Billy Black   1683     9/23/44     336500

% nawk '{print NR, $0}' employees
1 Tom Jones   4424     5/12/66     543354
2 Mary Adams  5346     11/4/63     28765
3 Sally Chang 1654     7/22/54     650000
4 Billy Black 1683     9/23/44     336500
```

EXPLANATION

Each record, $0, is printed as it is stored in the file and is preceded with the number of the record, NR.

5.5.2 Fields

Each record consists of words called fields which, by default, are separated by whitespace, that is, blank spaces or tabs. Each of these words is called a field, and awk keeps track of the number of fields in its built−in variable, NF. The value of NF can vary from line to line, and the limit is implementation−dependent, typically 100 fields per line. New fields can be created. The following example has four records (lines) and five fields (columns). Each record starts at the first field, represented as $1, then moves to the second field, $2, and so forth.

Example 5.13

```
(Fields are represented by a dollar sign and the number of the field.)
(The Database)

$1        $2          $3        $4          $5
Tom       Jones       4424      5/12/66     543354
Mary      Adams       5346      11/4/63     28765
Sally     Chang       1654      7/22/54     650000
Billy     Black       1683      9/23/44     336500

% nawk '{print NR, $1, $2, $5}'  employees
1 Tom Jones 543354
2 Mary Adams 28765
3 Sally Chang 650000
4 Billy Black 336500
```

EXPLANATION

Nawk will print the number of the record (NR), and the first, second, and fifth fields (columns) of each line in the file.

Example 5.14

```
% nawk  '{print $0, NF}'  employees
Tom Jones      44234  5/12/66  543354    5
Mary Adams     5346   11/4/63  28765     5
Sally Chang    1654   7/22/54  650000    5
Billy Black    1683   9/23/44  336500    5
```

EXPLANATION

Nawk will print each record ($0) in the file, followed by the number of fields.

5.5.3 Field Separators

The Input Field Separator. Awk's built−in variable, FS, holds the value of the input field separator. When the default value of FS is used, awk separates fields by spaces and/or tabs, stripping leading blanks and tabs. The FS can be changed by assigning a new value to it, either in a BEGIN statement or at the command line. For now, we will assign the new value at the command line. To change the value of FS at the command line, the –F option is used, followed by the character representing the new separator.

Changing the Field Separator at the Command Line

Example 5.15

```
% cat employees
Tom Jones:4424:5/12/66:543354
Mary Adams:5346:11/4/63:28765
Sally Chang:1654:7/22/54:650000
Billy Black:1683:9/23/44:336500

% nawk –F: '/Tom Jones/{print $1, $2}'  employees2
Tom Jones  4424
```

EXPLANATION

The –F option is used to reassign the value of the input field separator at the command line. When a colon is placed directly after the –F option, nawk will look for colons to separate the fields in the employees file.

Using More Than One Field Separator. You may specify more than one input separator. If more than one character is used for the field separator, FS, then the string is a regular expression and is enclosed in square brackets. In the following example, the field separator is a space, colon, or tab. (The old version of awk did not support this feature.)

Example 5.16

```
% nawk –F'[ :\t]'  '{print $1, $2, $3}' employees
Tom Jones 4424
Mary Adams 5346
Sally Chang 1654
Billy Black 1683
```

EXPLANATION

The –F option is followed by a regular expression enclosed in brackets. If a space, colon, or tab is encountered, nawk will use that character as a field separator. The expression is surrounded by quotes so that the shell will not pounce on the metacharacters for its own. (Remember that the shell uses brackets for filename expansion.)

The Output Field Separator. The default output field separator is a single space and is stored in awk's internal variable, OFS. In all of the examples thus far, we have used the print statement to send output to the screen. The comma that is used to separate fields in print statements evaluates to whatever the OFS has been set. If the default is used, the comma inserted between $1 and $2 will evaluate to a single space and the print function will print the fields with a space between them. The OFS can be changed.

The fields are jammed together because the comma was not used to separate the fields. The OFS will not be evaluated unless the comma separates the fields.

Example 5.17

```
% cat employees2
Tom Jones:4424:5/12/66:543354
Mary Adams:5346:11/4/63:28765
Sally Chang:1654:7/22/54:650000
Billy Black:1683:9/23/44:336500
```

```
(The Command Line)
% nawk -F: '/Tom Jones/{print $1, $2, $3, $4}' employees2
Tom Jones  4424 5/12/66  543354
```

EXPLANATION

The output field separator, a space, is stored in nawk's OFS variable. The comma between the fields evaluates to whatever is stored in OFS. The fields are printed to standard output separated by a space.

Example 5.18

```
% nawk -F: '/Tom Jones/{print $1 $2 $3 $4}' employees2
Tom Jones44245/12/66543354
```

EXPLANATION

```
% nawk -F: '/Tom Jones/{print $0}' employees2
Tom Jones:4424:5/12/66:543354
```

The $0 variable holds the current record exactly as it is found in the input file. The record will be printed as−is.

5.6 Patterns and Actions

5.6.1 Patterns

Awk patterns control what actions awk will take on a line of input. A pattern consists of a regular expression, an expression resulting in a true or false condition, or a combination of these. The default action is to print each line where the expression results in a true condition. When reading a pattern expression, there is an implied if statement. When an if is implied, there can be no curly braces surrounding it. When the if is explicit, it becomes an action statement and the syntax is different. (See "Conditional Statements".)

Example 5.19

```
% cat employees
Tom Jones      4424    5/12/66   543354
Mary Adams     5346    11/4/63   28765
Sally Chang    1654    7/22/54   650000
Billy Black    1683    9/23/44   336500


(The Command Line)
1    nawk '/Tom/' employees
     Tom Jones   4424  5/12/66   543354

2    nawk '$3 < 4000' employees
     Sally Chang 1654  7/22/54   650000
     Billy Black 1683  9/23/44   336500
```

EXPLANATION

1. If the pattern Tom is matched in the input file, the record is printed. The default action is to print the line if no explicit action is specified. This is equivalent to

   ```
   nawk '$0 ~ /Tom/{print $0}' employees
   ```
2. If the third field is less than 4000, the record is printed.

5.6.2 Actions

Actions are statements enclosed within curly braces and separated by semicolons.[2] If a pattern precedes an action, the pattern dictates when the action will be performed. Actions can be simple statements or complex groups of statements. Statements are separated by semicolons, or by a newline if placed on their own line.

```
nawk '/Tom/\{print "hi Tom"\};\{x=5\}' file
```

FORMAT

```
{ action }
```

Example 5.20

```
{ print $1, $2 }
```

EXPLANATION

The action is to print fields 1 and 2.

Patterns can be associated with actions. Remember, actions are statements enclosed in curly braces. A pattern controls the action from the first open curly brace to the first closing curly brace. If an action follows a pattern, the first opening curly brace must be on the same line as the pattern. Patterns are never enclosed in curly braces.

FORMAT

```
pattern{ action statement; action statement; etc. }
       or
pattern{
       action statement
       action statement
}
```

Example 5.21

```
% nawk '/Tom/{print "Hello there, "  $1}' employees
Hello there, Tom
```

EXPLANATION

If the record contains the pattern Tom, the string Hello there, Tom will print.

A pattern with no action displays all lines matching the pattern. String−matching patterns contain regular expressions enclosed in forward slashes.

5.7 Regular Expressions

A regular expression to awk is a pattern that consists of characters enclosed in forward slashes. Awk supports the use of regular expression metacharacters (same as egrep) to modify the regular expression in some way. If a string in the input line is matched by the regular expression, the resulting condition is true, and any actions associated with the expression are executed. If no action is specified and an input line is matched by the regular expression, the record is printed. See Table 5.5.

Example 5.22

```
% nawk  '/Mary/'  employees
Mary Adams     5346   11/4/63   28765
```

EXPLANATION

All lines in the employees file containing the regular expression pattern Mary are displayed.

Example 5.23

```
% nawk  '/Mary/{print $1, $2}'  employees
Mary Adams
```

EXPLANATION

The first and second fields of all lines in the employees file containing the regular expression pattern Mary are displayed.

Table 5.5. awk Regular Expression Metacharacters

^Matches at the beginning of string.$Matches at the end of string..Matches for a single character.*Matches for zero or more of preceding character.+Matches for one or more of preceding character.?Matches for zero or one of preceding character.[ABC]Matches for any one character in the set of characters, i.e., A, B, or C.[^ABC]Matches character not in the set of characters, i.e., A, B, or C.[A–Z]Matches for any character in the range from A to Z.A|BMatches either A or B.(AB)+Matches one or more sets of AB.*Matches for a literal asterisk.&Used in the replacement string, to represent what was found in the search string.

Example 5.24

```
% nawk  '/^Mary/'  employees
Mary Adams    5346   11/4/63   28765
```

EXPLANATION

All lines in the employees file that start with the regular expression Mary are displayed.

Example 5.25

```
% nawk  '/^[A-Z][a-z]+ /'  employees
Tom Jones     4424   5/12/66   543354
Mary Adams    5346   11/4/63   28765
Sally Chang   1654   7/22/54   650000
Billy Black   1683   9/23/44   336500
```

EXPLANATION

All lines in the employees file where the line begins with an uppercase letter, followed by one or more lowercase letters, followed by a space are displayed.

5.7.1 The match Operator

The match operator, the tilde (~), is used to match an expression within a record or field.

Example 5.26

```
% cat employees
Tom Jones     44234  5/12/66   543354
Mary Adams    5346   11/4/63   28765
Sally Chang   1654   7/22/54   650000
Billy Black   1683   9/23/44   336500

% nawk '$1 ~ /[Bb]ill/' employees
Billy Black    1683    9/23/44   336500
```

EXPLANATION

Any lines matching Bill or bill in the first field are displayed.

Example 5.27

```
% nawk '$1 !~ /ly$/' employees
Tom Jones     4424    5/12/66   543354
Mary Adams    5346    11/4/63   28765
```

EXPLANATION

Any lines not matching ly, when ly is at the end of the first field are displayed.

5.8 awk Commands in a Script File

When you have multiple awk pattern/action statements, it is often much easier to put the statements in a script. The script is a file containing awk comments and statements. If statements and actions are on the same line, they are separated by semicolons. If statements are on separate lines, semicolons are not necessary. If an action follows a pattern, the opening curly brace must be on the same line as the pattern. Comments are preceded by a pound (#) sign.

Example 5.28

```
% cat employees
Tom Jones:4424:5/12/66:54335
Mary Adams:5346:11/4/63:28765
Billy Black:1683:9/23/44:336500
Sally Chang:1654:7/22/54:65000
Jose Tomas:1683:9/23/44:33650

(The Awk Script)
% cat info
1   # My first awk script by Jack Sprat
    # Script name: info; Date: February 28, 2001
2   /Tom/{print  "Tom's birthday is "$3}
3   /Mary/{print NR, $0}
4   /^Sally/{print "Hi Sally. "  $1 " has a salary of  $" $4 "."}
    # End of info script

(The Command Line)
5   % nawk –F: –f info employees2
    Tom's birthday is 5/12/66
    2 Mary Adams:5346:11/4/63:28765
    Hi Sally. Sally Chang has a salary of $65000.
```

EXPLANATION

1. These are comment lines.
2. If the regular expression Tom is matched against an input line, the string Tom's birthday is and the value of the third field ($3) are printed.
3. If the regular expression Mary is matched against an input line, the action block prints NR, the number of the current record, and the record.
4. If the regular expression Sally is found at the beginning of the input line, the string Hi Sally. is printed, followed by the value of the first field ($1), the string has a salary of $, and the value of the fourth field ($4).
5. The nawk command is followed by the –F: option, specifying the colon to be the field separator. The –f option is followed by the name of the awk script. Awk will read instructions from the info file. The input file, employees2, is next.

5.9 Review

The examples in this section use a sample database, called datafile. In the database, the input field separator, FS, is whitespace, the default. The number of fields, NF, is 8. The number may vary from line to line, but in this file, the number of fields is fixed. The record separator, RS, is the newline, which separates each line of the file. Awk keeps track of the number of each record in the NR variable. The output field separator, OFS, is a space. If a comma is used to separate fields, when the line is printed, each field printed will be separated by a space.

5.9.1 Simple Pattern Matching

```
% cat datafile
northwest          NW    Joel Craig          3.0     .98     3       4
western            WE    Sharon Kelly        5.3     .97     5       23
southwest          SW    Chris Foster        2.7     .8      2       18
southern           SO    May Chin            5.1     .95     4       15
southeast          SE    Derek Johnson       4.0     .7      4       17
eastern            EA    Susan Beal          4.4     .84     5       20
```

```
northeast          NE    TJ Nichols          5.1     .94     3       13
north              NO    Val Shultz          4.5     .89     5       9
central            CT    Sheri Watson        5.7     .94     5       13
```

Example 5.29

```
nawk '/west/'  datafile
northwest     NW      Joel Craig         3.0  .98  3      4
western       WE      Sharon Kelly       5.3  .97  5      23
southwest     SW      Chris Foster       2.7  .8   2      18
```

EXPLANATION

All lines containing the pattern west are printed.

Example 5.30

```
nawk '/^north/' datafile
northwest     NW      Joel Craig          3.0  .98  3    4
northeast     NE      TJ Nichols          5.1  .94  3    13
north         NO      Val Shultz          4.5  .89  5    9
```

EXPLANATION

All lines beginning with the pattern north are printed.

Example 5.31

```
nawk '/^(no|so)/' datafile
northwest     NW      Joel Craig          3.0  .98  3    4
southwest     SW      Chris Foster        2.7  .8   2    18
southern      SO      May Chin            5.1  .95  4    15
southeast     SE      Derek Johnson       4.0  .7   4    17
northeast     NE      TJ Nichols          5.1  .94  3    13
north         NO      Val Shultz          4.5  .89  5    9
```

EXPLANATION

All lines beginning with the pattern no or so are printed.

5.9.2 Simple Actions

Example 5.32

```
nawk '{print $3, $2}' datafile
Joel NW
Sharon WE
Chris SW
May SO
Derek SE
Susan EA
TJ NE
Val NO
Sheri CT
```

EXPLANATION

The output field separator, OFS, is a space by default. The comma between $3 and $2 is translated to the value of the OFS. The third field is printed, followed by a space and the second field.

```
% cat datafile
northwest          NW   Joel Craig          3.0    .98     3     4
western            WE   Sharon Kelly        5.3    .97     5     23
southwest          SW   Chris Foster        2.7    .8      2     18
southern           SO   May Chin            5.1    .95     4     15
southeast          SE   Derek Johnson       4.0    .7      4     17
eastern            EA   Susan Beal          4.4    .84     5     20
northeast          NE   TJ Nichols          5.1    .94     3     13
north              NO   Val Shultz          4.5    .89     5     9
central            CT   Sheri Watson        5.7    .94     5     13
```

Example 5.33

```
nawk '{print $3 $2}' datafile
JoelNW
SharonWE
ChrisSW
MaySO
DerekSE
SusanEA
TJNE
ValNO
SheriCT
```

EXPLANATION

The third field is followed by the second field. Since the comma does not separate fields $3 and $2, the output is displayed without spaces between the fields.

Example 5.34

```
nawk 'print $1' datafile
nawk: syntax error at source line 1
 context is
        >>> print <<<  $1
nawk: bailing out at source line 1
```

EXPLANATION

This is the nawk (new awk) error message. Nawk error messages are much more verbose than those of the old awk. In this program, the curly braces are missing in the action statement.

Example 5.35

```
awk 'print $1' datafile
awk: syntax error near line 1
awk: bailing out near line 1
```

EXPLANATION

This is the awk (old awk) error message. Old awk programs were difficult to debug since almost all errors produced this same message. The curly braces are missing in the action statement.

Example 5.36

```
nawk '{print $0}' datafile
northwest     NW      Joel Craig          3.0  .98  3    4
western       WE      Sharon Kelly        5.3  .97  5    23
southwest     SW      Chris Foster        2.7  .8   2    18
southern      SO      May Chin            5.1  .95  4    15
southeast     SE      Derek Johnson       4.0  .7   4    17
eastern       EA      Susan Beal          4.4  .84  5    20
northeast     NE      TJ Nichols          5.1  .94  3    13
north         NO      Val Shultz          4.5  .89  5    9
central       CT      Sheri Watson        5.7  .94  5    13
```

EXPLANATION

Each record is printed. $0 holds the current record.

Example 5.37

```
nawk '{print "Number of fields: "NF}' datafile
Number of fields: 8
Number of fields: 8
Number of fields: 8
Number of fields: 8
Number of fields: 8
Number of fields: 8
Number of fields: 8
Number of fields: 8
Number of fields: 8
```

EXPLANATION

There are 8 fields in each record. The built−in awk variable NF holds the number of fields and is reset for each record.

```
% cat datafile
northwest           NW   Joel Craig          3.0    .98    3     4
western             WE   Sharon Kelly        5.3    .97    5     23
southwest           SW   Chris Foster        2.7    .8     2     18
southern            SO   May Chin            5.1    .95    4     15
southeast           SE   Derek Johnson       4.0    .7     4     17
eastern             EA   Susan Beal          4.4    .84    5     20
northeast           NE   TJ Nichols          5.1    .94    3     13
north               NO   Val Shultz          4.5    .89    5     9
central             CT   Sheri Watson        5.7    .94    5     13
```

5.9.3 Regular Expressions in Pattern and Action Combinations

Example 5.38

```
nawk '/northeast/{print $3, $2}' datafile
TJ NE
```

EXPLANATION

If the record contains (or matches) the pattern northeast, the third field, followed by the second field, is printed.

Example 5.39

```
nawk '/E/' datafile
western       WE      Sharon Kelly        5.3  .97  5    23
southeast     SE      Derek Johnson       4.0  .7   4    17
eastern       EA      Susan Beal          4.4  .84  5    20
northeast     NE      TJ Nichols          5.1  .94  3    13
```

EXPLANATION

If the record contains an E, the entire record is printed.

Example 5.40

```
nawk '/^[ns]/{print $1}' datafile
northwest
southwest
southern
southeast
northeast
north
```

EXPLANATION

If the record begins with an n or s, the first field is printed.

Example 5.41

```
nawk '$5 ~ /\.[7-9]+/' datafile
southwest     SW     Chris Foster       2.7  .8  2    18
central       CT     Sheri Watson       5.7  .94 5    13
```

EXPLANATION

If the fifth field ($5) contains a literal period, followed by one or more numbers between 7 and 9, the record is printed.

Example 5.42

```
nawk '$2 !~ /E/{print $1, $2}' datafile
northwest NW
southwest SW
southern SO
north NO
central CT
```

EXPLANATION

If the second field does not contain the pattern E, the first field followed by the second field ($1, $2) is printed.

```
% cat datafile
```

```
northwest          NW   Joel Craig          3.0    .98    3    4
western            WE   Sharon Kelly        5.3    .97    5    23
southwest          SW   Chris Foster        2.7    .8     2    18
southern           SO   May Chin            5.1    .95    4    15
southeast          SE   Derek Johnson       4.0    .7     4    17
eastern            EA   Susan Beal          4.4    .84    5    20
northeast          NE   TJ Nichols          5.1    .94    3    13
north              NO   Val Shultz          4.5    .89    5    9
central            CT   Sheri Watson        5.7    .94    5    13
```

Example 5.43

```
nawk '$3 ~ /^Joel/{print $3 " is a nice guy."}' datafile
Joel is a nice guy.
```

EXPLANATION

If the third field ($3) begins with the pattern Joel, the third field followed by the string is a nice guy. is printed. Note that a space is included in the string if it is to be printed.

Example 5.44

```
nawk '$8 ~ /[0-9][0-9]$/{print $8}' datafile
23
18
15
17
20
13
13
```

EXPLANATION

If the eighth field ($8) ends in two digits, it is printed.

Example 5.45

```
nawk '$4 ~ /Chin$/{print "The price is $" $8 "."}' datafile
The price is $15.
```

EXPLANATION

If the fourth field ($4) ends with Chin, the string enclosed in double quotes ("The price is $"), the eighth field ($8), and the string containing a period are printed.

Example 5.46

```
nawk '/TJ/{print $0}' datafile
northeast     NE      TJ Nichols           5.1   .94    3    13
```

EXPLANATION

If the record contains the pattern TJ, $0 (the record) is printed.

5.9.4 Input Field Separators

```
% cat datafile2
Joel Craig:northwest:NW:3.0:.98:3:4
Sharon Kelly:western:WE:5.3:.97:5:23
Chris Foster:southwest:SW:2.7:.8:2:18
May Chin:southern:SO:5.1:.95:4:15
Derek Johnson:southeast:SE:4.0:.7:4:17
Susan Beal:eastern:EA:4.4:.84:5:20
TJ Nichols:northeast:NE:5.1:.94:3:13
Val Shultz:north:NO:4.5:.89:5:9
Sheri Watson:central:CT:5.7:.94:5:13
```

Example 5.47

```
nawk '{print $1}' datafile2
Joel
Sharon
Chris
May
Derek
Susan
TJ
Val
Sheri
```

EXPLANATION

The default input field separator is whitespace. The first field ($1) is printed.


```
% cat datafile2
Joel Craig:northwest:NW:3.0:.98:3:4
Sharon Kelly:western:WE:5.3:.97:5:23
Chris Foster:southwest:SW:2.7:.8:2:18
May Chin:southern:SO:5.1:.95:4:15
Derek Johnson:southeast:SE:4.0:.7:4:17
Susan Beal:eastern:EA:4.4:.84:5:20
TJ Nichols:northeast:NE:5.1:.94:3:13
Val Shultz:north:NO:4.5:.89:5:9
Sheri Watson:central:CT:5.7:.94:5:13
```


Example 5.48

```
nawk −F: '{print $1}' datafile2
Joel Craig
Sharon Kelly
Chris Foster
              <more output here>
Val Shultz
Sheri Watson
```

EXPLANATION

The –F option specifies the colon as the input field separator. The first field ($1) is printed.

Example 5.49

```
nawk '{print "Number of fields: "NF}' datafile2
Number of fields: 2
Number of fields: 2
Number of fields: 2
              <more of the same output here>
Number of fields: 2
Number of fields: 2
```

EXPLANATION

Since the field separator is the default (whitespace) the number of fields for each record is 2. The only space is between the first and last name.

Example 5.50

```
nawk −F: '{print "Number of fields: "NF}' datafile2
Number of fields: 7
Number of fields: 7
Number of fields: 7
              <more of the same output here>
Number of fields: 7
Number of fields: 7
```

EXPLANATION

Since the field separator is a colon, the number of fields in each record is 7.

Example 5.51

```
nawk −F"[ :]" '{print $1, $2}' datafile2
Joel Craig northwest
Sharon Kelly western
Chris Foster southwest
May Chin southern
Derek Johnson southeast
Susan Beal eastern
TJ Nichols northeast
Val Shultz north
Sheri Watson central
```

EXPLANATION

Multiple field separators can be specified with nawk as a regular expression. Either a space or a colon will be designated as a field separator. The first and second fields ($1, $2) are printed.

```
% cat datafile
northwest          NW   Joel Craig          3.0     .98     3    4
western            WE   Sharon Kelly        5.3     .97     5    23
southwest          SW   Chris Foster        2.7     .8      2    18
southern           SO   May Chin            5.1     .95     4    15
southeast          SE   Derek Johnson       4.0     .7      4    17
eastern            EA   Susan Beal          4.4     .84     5    20
northeast          NE   TJ Nichols          5.1     .94     3    13
north              NO   Val Shultz          4.5     .89     5    9
central            CT   Sheri Watson        5.7     .94     5    13
```

5.9.5 awk Scripting

Example 5.52

```
cat nawk.sc1
# This is a comment
# This is my first awk script
1   /^north/{print $1, $2, $3}
2   /^south/{print "The " $1 " district."}

nawk −f nawk.sc1 datafile
3   northwest NW Joel
    The southwest district.
    The southern district.
    The southeast district.
    northeast NE TJ
    north NO Val
```

EXPLANATION

1. If the record begins with the pattern north, the first, second, and third fields ($1, $2, $3) are printed.
2. If the record begins with the pattern south, the string The, followed by the value of the first field ($1), and the string district. are printed.
3. The –f option precedes the name of the awk script file, followed by the input file that is to be processed.

UNIX TOOLS LAB EXERCISE

Lab 3: awk Exercise

Mike Harrington:(510) 548−1278:250:100:175

Christian Dobbins:(408) 538−2358:155:90:201

Susan Dalsass:(206) 654−6279:250:60:50

Archie McNichol:(206) 548−1348:250:100:175

Jody Savage:(206) 548−1278:15:188:150

Guy Quigley:(916) 343−6410:250:100:175

Dan Savage:(406) 298−7744:450:300:275

Nancy McNeil:(206) 548−1278:250:80:75

John Goldenrod:(916) 348−4278:250:100:175

Chet Main:(510) 548−5258:50:95:135

Tom Savage:(408) 926−3456:250:168:200

Elizabeth Stachelin:(916) 440−1763:175:75:300

The database above contains the names, phone numbers, and money contributions to the party campaign for the past three months.

1: Print all the phone numbers.

2: Print Dan's phone number.

3: Print Susan's name and phone number.

4: Print all last names beginning with D.

5: Print all first names beginning with either a C or E.

6: Print all first names containing only four characters.

7: Print the first names of all those in the 916 area code.

8: Print Mike's campaign contributions. Each value should be printed with a leading dollar sign; e.g., $250 $100 $175.

9: Print last names followed by a comma and the first name.

10: Write an awk script called facts that:

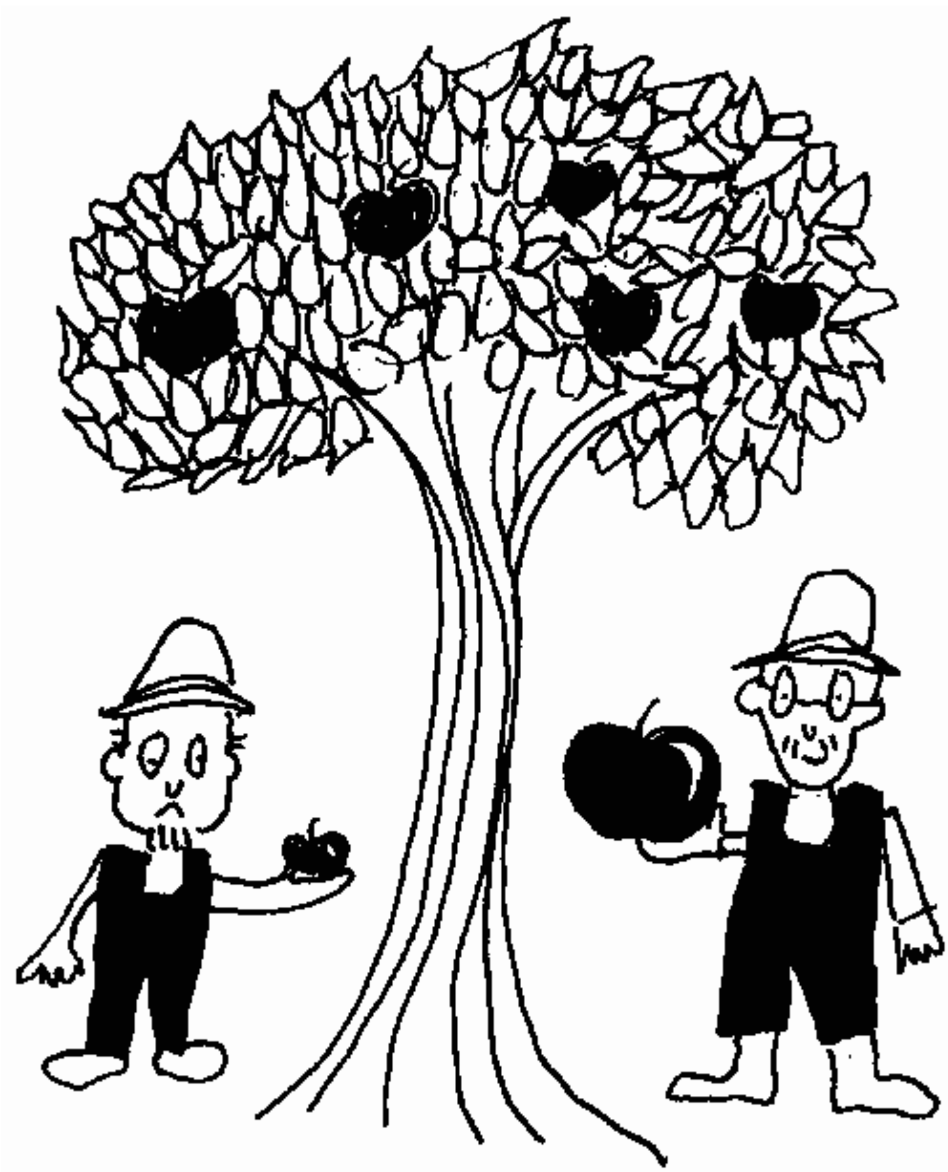
a. Prints full names and phone numbers for the Savages.
b. Prints Chet's contributions.
c. Prints all those who contributed $250 the first month.

[1] On SCO UNIX, the new version is spelled awk, and on Linux, the gnu version is spelled awk. This text pertains primarily to the new awk, nawk. The gnu implementation, gawk, is fully upward−compatible with nawk.

[2] On some versions of awk, actions must be separated by semicolons or newlines, and the statements within the curly braces also must be separated by semicolons or newlines. SVR4's nawk requires the use of semicolons or newlines to separate statements within an action, but does not require the use of semicolons to separate actions; for example, the two actions that follow do not need a semicolon:

CONTENTS

Chapter 6. The awk Utility: awk Programming Constructs



6.1 Comparison Expressions

Comparison expressions match lines where if the condition is true, the action is performed. These expressions use relational operators and are used to compare numbers or strings. Table 6.1 provides a list of the relational operators. The value of the expression is 1 if the expression evaluates true, and 0 if false.

6.1.1 Relational Operators

Table 6.1. Relational Operators

Operator	Meaning	Example
<	Less than.	x < y
<=	Less than or equal to.	x <= y
==	Equal to.	x == y
!=	Not equal to.	x != y
>=	Greater than or equal to.	x >= y
>	Greater than.	x > y
~	Matched by regular expression.	x ~ /y/
!~	Not matched by regular expression.	x !~ /y/

Example 6.1

```
(The Database)
% cat employee
Tom Jones      4423      5/12/66   543354
Mary Adams     5346      11/4/63   28765
Sally Chang    1654      7/22/54   650000
Billy Black    1683      9/23/44   336500

(The Command Line)
1   % nawk '$3 == 5346' employees
    Mary Adams  5346     11/4/63   28765

2   % nawk '$3 > 5000{print $1} ' employees
    Mary

3   % nawk '$2 ~ /Adam/ ' employees
    Mary Adams   5346    11/4/63   28765

4   % nawk '$2 !~ /Adam/ ' employees
    Tom Jones    4423    5/12/66   543354
    Sally Chang  1654    7/22/54   650000
    Billy Black  1683    9/23/44   336500
```

EXPLANATION

1. If the third field is equal to 5346, the condition is true and awk will perform the default action—print the line. When an if condition is implied, it is a conditional pattern test.
2. If the third field is greater than 5000, awk prints the first field.
3. If the second field matches the regular expression Adam, the record is printed.
4. If the second field does not match the regular expression Adam, the record is printed. If an expression is a numeric value and is being compared to a string value with an operator that requires a numeric comparison, the string value will be converted to a numeric value. If the operator requires a string value, the numeric value will be converted to a string value.

6.1.2 Conditional Expressions

A conditional expression uses two symbols, the question mark and the colon, to evaluate expressions. It is really just a short way to achieve the same result as doing an if/else statement. The general format is shown below.

FORMAT

```
conditional expression1 ? expression2 : expression3
```

This produces the same result as the if/else shown below. (A complete discussion of the if/else construct is given later.)

```
{
if (expression1)
       expression2
else
       expression3
}
```

Example 6.2

```
nawk '{max=($1 > $2) ? $1 : $2; print max}' filename
```

EXPLANATION

If the first field is greater than the second field, the value of the expression after the question mark is assigned to max, otherwise the value of the expression after the colon is assigned to max.

This is comparable to

```
if ($1 > $2)
     max=$1
else
     max=$2
```

6.1.3 Computation

Computation can be performed within patterns. Awk performs all arithmetic in floating point. The arithmetic operators are provided in Table 6.2.

Table 6.2. Arithmetic Operators

Operator	Meaning	Example
+	Add	x+y
−	Subtract	x−y
*	Multiply	x*y
/	Divide	x/y
%	Modulus	x%y
^	Exponentiation	x^y

Example 6.3

```
nawk '$3 * $4 > 500' filename
```

EXPLANATION

Awk will multiply the third field ($3) by the fourth field ($4), and if the result is greater than 500, it will display those lines. (filename is assumed to be a file containing the input.)

6.1.4 Compound Patterns

Compound patterns are expressions that combine patterns with logical operators (see Table 6.3). An expression is evaluated from left to right.

Table 6.3. Logical Operators

<table>
<tr><th>Operator</th><th>Meaning</th><th>Example</th></tr>
<tr><td>&&</td><td>Logical and</td><td>a && b</td></tr>
<tr><td>||</td><td>Logical or</td><td>a || b</td></tr>
<tr><td>!</td><td>not</td><td>! a</td></tr>
</table>

Example 6.4

```
nawk '$2 > 5 && $2 <= 15' filename
```

EXPLANATION

Awk will display those lines that match both conditions; that is, where the second field ($2) is greater than 5 and the second field ($2) is also less than or equal to 15. With the && operator, both conditions must be true. (filename is assumed to be a file containing the input.)

Example 6.5

```
nawk '$3 == 100 || $4 > 50' filename
```

EXPLANATION

Awk will display those lines that match one of the conditions; that is, where the third field is equal to 100 or the fourth field is greater than 50. With the || operator, only one of the conditions must be true. (filename is assumed to be a file containing the input.)

Example 6.6

```
nawk '!($2 < 100 && $3 < 20)' filename
```

EXPLANATION

If both conditions are true, awk will negate the expression and display those lines. So the lines displayed will have one or both conditions false. The unary ! operator negates the result of the condition so that if the expression yields a true condition, the not will make it false, and vice versa. (filename is assumed to be a file containing the input.)

6.1.5 Range Patterns

Range patterns match from the first occurrence of one pattern to the first occurrence of the second pattern, then match for the next occurrence of the first pattern to the next occurrence of the second pattern, etc. If the first pattern is matched and the second pattern is not found, awk will display all lines to the end of the file.

Example 6.7

```
nawk '/Tom/,/Suzanne/' filename
```

EXPLANATION

Awk will display all lines, inclusive, that range between the first occurrence of Tom and the first occurrence of Suzanne. If Suzanne is not found, awk will continue processing lines until the end of file. If, after the range between Tom and Suzanne is printed, Tom appears again, awk will start displaying lines until another Suzanne is found or the file ends.

6.1.6 A Data Validation Program

Using the awk commands discussed so far, the following password−checking program from the book, *The AWK Programming Language*,[1] illustrates how the data in a file can be validated.

Example 6.8

```
(The Password Database)
1   % cat /etc/passwd
    tooth:pwHfudo.eC9sM:476:40:Contract Admin.:/home/rickenbacker/tooth:/bin/csh
    lisam:9JY7OuS2f3lHY:4467:40:Lisa M. Spencer:/home/fortune1/lisam:/bin/csh
    goode:v7Ww.nWJCeSIQ:32555:60:Goodwill Guest User:/usr/goodwill:/bin/csh
    bonzo:eTZbu6M2jM7VA:5101:911: SSTOOL Log account :/home/sun4/bonzo:/bin/csh
    info:mKZsrioPtW9hA:611:41:Terri Stern:/home/chewie/info:/bin/csh
    cnc:IN1IVqVj1bVv2:10209:41:Charles Carnell:/home/christine/cnc:/bin/csh
    bee:*:347:40:Contract Temp.:/home/chanel5/bee:/bin/csh
    friedman:oyuIiKoFTV0TE:3561:50:Jay Friedman:/home/ibanez/friedman:/bin/csh
    chambers:Rw7R1k77yUY4.:592:40:Carol Chambers:/usr/callisto2/chambers:/bin/csh
    gregc:nkLulOg:7777:30:Greg Champlin FE Chicago
    ramona:gbDQLdDBeRc46:16660:68:RamonaLeininge MWA CustomerService Rep:/
    home/forsh:

(The Awk Commands)
2   % cat /etc/passwd | nawk –F: '\
3   NF != 7{\
4   printf("line %d, does not have 7 fields: %s\n",NR,$0)} \
5   $1 !~ /[A–Za–z0–9]/{printf("line %d, nonalphanumeric user id: %s\n",NR,$0)} \
6   $2 == "*" {printf("line %d, no password: %s\n",NR,$0)} '

(The Output)
line 7, no password: bee:*:347:40:Contract Temp.:/home/chanel5/bee:/bin/csh
line 10, does not have 7 fields: gregc:nk2EYi7kLulOg:7777:30:Greg Champlin
FE Chicago
line 11, does not have 7 fields: ramona:gbDQLdDBeRc46:16660:68:Ramona
Leininger MWA Customer Service Rep:/home/forsh:
```

EXPLANATION

1. The contents of the /etc/passwd file are displayed.
2. The cat program sends its output to awk. Awk's field separator is a colon.
3. If the number of fields (NF) is not equal to 7, the following action block is executed.
4. The printf function prints the string line <number>, does not have 7 fields: followed by the number of the current record (NR) and the record itself ($0).
5. If the first field ($1) does not contain any alphanumeric characters, the printf function prints the string nonalphanumeric user id:, followed by the number of the record and the record.
6. If the second field ($2) equals an asterisk, the string no passwd: is printed, followed by the number of the record and the record itself.

6.2 Review

6.2.1 Equality Testing

```
% cat datafile
northwest           NW   Joe Craig         3.0   .98    3    4
western             WE   Sharon Kelly      5.3   .97    5    23
southwest           SW   Chris Foster      2.7   .8     2    18
```

```
southern        SO   May Chin        5.1   .95    4    15
southeast       SE   Derek Johnson   4.0   .7     4    17
eastern         EA   Susan Beal      4.4   .84    5    20
northeast       NE   TJ Nichols      5.1   .94    3    13
north           NO   Val Shultz      4.5   .89    5    9
central         CT   Sheri Watson    5.7   .94    5    13
```

Example 6.9

```
nawk '$7 == 5' datafile
western       WE      Sharon Kelly       5.3  .97  5    23
eastern       EA      Susan Beal         4.4  .84  5    20
north         NO      Val Shultz         4.5  .89  5    9
central       CT      Sheri Watson       5.7  .94  5    13
```

EXPLANATION

If the seventh field ($7) is equal to the number 5, the record is printed.

Example 6.10

```
nawk '$2 == "CT"{print $1, $2}' datafile
central       CT
```

EXPLANATION

If the second field is equal to the string CT, fields one and two ($1, $2) are printed. Strings must be quoted.

```
% cat datafile
northwest       NW   Joel Craig      3.0    .98    3    4
western         WE   Sharon Kelly    5.3    .97    5    23
southwest       SW   Chris Foster    2.7    .8     2    18
southern        SO   May Chin        5.1    .95    4    15
southeast       SE   Derek Johnson   4.0    .7     4    17
eastern         EA   Susan Beal      4.4    .84    5    20
northeast       NE   TJ Nichols      5.1    .94    3    13
north           NO   Val Shultz      4.5    .89    5    9
central         CT   Sheri Watso     5.7    .94    5    13
```

6.2.2 Relational Operators

Example 6.11

```
nawk '$7 != 5' datafile
northwest     NW     Joel Craig        3.0  .98  3    4
southwest     SW     Chris Foster      2.7  .8   2    18
southern      SO     May Chin          5.1  .95  4    15
southeast     SE     Derek Johnson     4.0  .7   4    17
northeast     NE     TJ Nichols        5.1   94  3    13
```

EXPLANATION

If the seventh field ($7) is not equal to the number 5, the record is printed.

Example 6.12

```
nawk '$7 < 5 {print $4, $7}' datafile
Craig 3
Foster 2
Chin 4
Johnson 4
Nichols 3
```

EXPLANATION

If the seventh field ($7) is less than 5, fields 4 and 7 are printed.

Example 6.13

```
nawk '$6 > .9 {print $1, $6}' datafile
northwest .98
western .97
southern .95
northeast .94
central .94
```

EXPLANATION

If the sixth field ($6) is greater than .9, fields 1 and 6 are printed.

Example 6.14

```
nawk '$8 <= 17 { print $8}' datafile
4
15
17
13
9
13
```

EXPLANATION

If the eighth field ($8) is less than or equal to 17, it is printed.

Example 6.15

```
nawk '$8 >= 17 {print $8}' datafile
23
18
17
20
```

EXPLANATION

If the eighth field is greater than or equal to 17, the eighth field is printed.

```
% cat datafile
northwest          NW   Joel Craig        3.0    .98    3    4
western            WE   Sharon Kelly      5.3    .97    5    23
southwest          SW   Chris Foster      2.7    .8     2    18
southern           SO   May Chin          5.1    .95    4    15
southeast          SE   Derek Johnson     4.0    .7     4    17
```

```
eastern              EA   Susan Beal        4.4    .84    5    20
northeast            NE   TJ Nichols        5.1    .94    3    13
north                NO   Val Shultz        4.5    .89    5    9
central              CT   Sheri Watson      5.7    .94    5    13
```

6.2.3 Logical Operators

Example 6.16

```
nawk '$8 > 10 && $8 < 17' datafile
southern      SO     May Chin         5.1  .95  4    15
northeast     NE     TJ Nichols       5.1  .94  3    13
central       CT     Sheri Watson     5.7  .94  5    13
```

EXPLANATION

If the eighth field ($8) is greater than 10 and less than 17,the record is printed. The record will be printed only if both expressions are true.

Example 6.17

```
nawk '$2 == "NW" || $1 ~ /south/{print $1, $2}' datafile
northwest NW
southwest SW
southern SO
southeast SE
```

EXPLANATION

If the second field ($2) is equal to the string NW or the first field ($1) contains the pattern south, the first and second fields ($1, $2) are printed. The record will be printed if only one of the expressions is true.

6.2.4 Logical not Operator

Example 6.18

```
nawk '!($8 == 13){print $8}' datafile
4
23
18
15
17
20
9
```

EXPLANATION

If the eighth field ($8) is equal to 13, the ! (not operator) nots the expression and prints the eighth field ($8). The ! is a unary negation operator.

6.2.5 Arithmetic Operators

Example 6.19

```
nawk '/southern/{print $5 + 10}' datafile
15.1
```

EXPLANATION

If the record contains the regular expression southern, 10 is added to the value of the fifth field ($5) and printed. Note that the number prints in floating point.

Example 6.20

```
nawk '/southern/{print $8 + 10}' datafile
25
```

EXPLANATION

If the record contains the regular expression southern, 10 is added to the value of the eighth field ($8) and printed. Note that the number prints in decimal.

```
% cat datafile
northwest           NW   Joel Craig        3.0    .98    3    4
western             WE   Sharon Kelly      5.3    .97    5    23
southwest           SW   Chris Foster      2.7    .8     2    18
southern            SO   May Chin          5.1    .95    4    15
southeast           SE   Derek Johnson     4.0    .7     4    17
eastern             EA   Susan Beal        4.4    .84    5    20
northeast           NE   TJ Nichols        5.1    .94    3    13
north               NO   Val Shultz        4.5    .89    5    9
central             CT   Sheri Watson      5.7    .94    5    13
```

Example 6.21

```
nawk '/southern/{print $5 + 10.56}' datafile
15.66
```

EXPLANATION

If the record contains the regular expression southern, 10.56 is added to the value of the fifth field ($5) and printed.

Example 6.22

```
nawk '/southern/{print $8 − 10}' datafile
5
```

EXPLANATION

If the record contains the regular expression southern, 10 is subtracted from the value of the eighth field ($8) and printed.

Example 6.23

```
nawk '/southern/{print $8 / 2}' datafile
7.5
```

EXPLANATION

If the record contains the regular expression southern, the value of the eighth field ($8) is divided by 2 and printed.

Example 6.24

```
nawk '/northeast/{print $8 / 3}' datafile
4.33333
```

EXPLANATION

If the record contains the regular expression northeast, the value of the eighth field ($8) is divided by 3 and printed. The precision is five places to the right of the decimal point.

Example 6.25

```
nawk '/southern/{print $8 * 2}' datafile
30
```

EXPLANATION

If the record contains the regular expression southern, the eighth field ($8) is multiplied by 2 and printed.

Example 6.26

```
nawk '/northeast/ {print $8 % 3}' datafile
1
```

EXPLANATION

If the record contains the regular expression northeast, the eighth field ($8) is divided by 3 and the remainder (modulus) is printed.

Example 6.27

```
nawk '$3 ~ /^Susan/\
{print "Percentage: "$6 + .2 " Volume: " $8}' datafile
Percentage: 1.04 Volume: 20
```

EXPLANATION

If the third field ($3) begins with the regular expression Susan, the print function prints the result of the calculations and the strings in double quotes.

```
% cat datafile
northwest          NW   Joel Craig         3.0    .98    3     4
western            WE   Sharon Kelly       5.3    .97    5     23
southwest          SW   Chris Foster       2.7    .8     2     18
southern           SO   May Chin           5.1    .95    4     15
southeast          SE   Derek Johnson      4.0    .7     4     17
eastern            EA   Susan Beal         4.4    .84    5     20
northeast          NE   TJ Nichols         5.1    .94    3     13
north              NO   Val Shultz         4.5    .89    5     9
central            CT   Sheri Watson       5.7    .94    5     13
```

6.2.6 Range Operator

Example 6.28

```
nawk '/^western/,/^eastern/' datafile
western       WE     Sharon Kelly       5.3  .97  5   23
southwest     SW     Chris Foster       2.7  .8   2   18
southern      SO     May Chin           5.1  .95  4   15
southeast     SE     Derek Johnson      4.0  .7   4   17
eastern       EA     Susan Beal         4.4  .84  5   20
```

EXPLANATION

All records within the range beginning with the regular expression western are printed until a record beginning with the expression eastern is found. Records will start being printed again if the pattern western is found and will continue to print until eastern or end of file is reached.

6.2.7 Conditional Operator

Example 6.29

```
nawk '{print ($7 > 4 ? "high "$7 : "low "$7)}' datafile
low 3
high 5
low 2
low 4
low 4
high 5
low 3
high 5
high 5
```

EXPLANATION

If the seventh field ($7) is greater than 4, the print function gets the value of the expression after the question mark (the string high and the seventh field), else the print function gets the value of the expression after the colon (the string low and the value of the seventh field).

6.2.8 Assignment Operators

Example 6.30

```
nawk '$3 == "Chris"{ $3 = "Christian"; print}' datafile
southwest SW Christian Foster 2.7 .8 2 18
```

EXPLANATION

If the third field ($3) is equal to the string Chris, the action is to assign Christian to the third field ($3) and print the record. The double equal tests its operands for equality, whereas the single equal is used for assignment.

Example 6.31

```
nawk '/Derek/{$8 += 12; print $8}' datafile
29
```

EXPLANATION

If the regular expression Derek is found, 12 is added and assigned to (+=) the eighth field ($8), and that value is printed. Another way to write this is: `$8 = $8 + 12`.

Example 6.32

```
nawk '{$7 %= 3; print $7}' datafile
0
2
2
1
1
2
0
2
2
```

EXPLANATION

For each record, the seventh field ($7) is divided by 3, and the remainder of that division (modulus) is assigned to the seventh field and printed.

UNIX TOOLS LAB EXERCISE

Lab 4: awk Exercise

Mike Harrington:(510) 548−1278:250:100:175

Christian Dobbins:(408) 538−2358:155:90:201

Susan Dalsass:(206) 654−6279:250:60:50

Archie McNichol:(206) 548−1348:250:100:175

Jody Savage:(206) 548−1278:15:188:150

Guy Quigley:(916) 343−6410:250:100:175

Dan Savage:(406) 298−7744:450:300:275

Nancy McNeil:(206) 548−1278:250:80:75

John Goldenrod:(916) 348−4278:250:100:175

Chet Main:(510) 548−5258:50:95:135

Tom Savage:(408) 926−3456:250:168:200

Elizabeth Stachelin:(916) 440−1763:175:75:300

(Refer to the database called lab4.data on the CD.)

The database above contains the names, phone numbers, and money contributions to the party campaign for the past three months.

1: Print the first and last names of those who contributed over $100 in the first month.

2: Print the names and phone numbers of those who contributed less than $60 in the first month.

3: Print those who contributed between $90 and $150 in the third month.

4: Print those who contributed more than $800 over the three−month period.

5: Print the names and phone numbers of those with an average monthly contribution greater than $150.

6: Print the first name of those not in the 916 area code.

7: Print each record preceded by the number of the record.

8: Print the name and total contribution of each person.

9: Add $10 to Elizabeth's second contribution.

10: Change Nancy McNeil's name to Louise McInnes.

[1] Alfred V. Aho, Brian W. Kernighan, and Peter J. Weinberger, *The AWK Programming Language* (Boston: Addison−Wesley, 1988). ©1988 Bell Telephone Laboratories, Inc. Reprinted by permission of Pearson Education, Inc.

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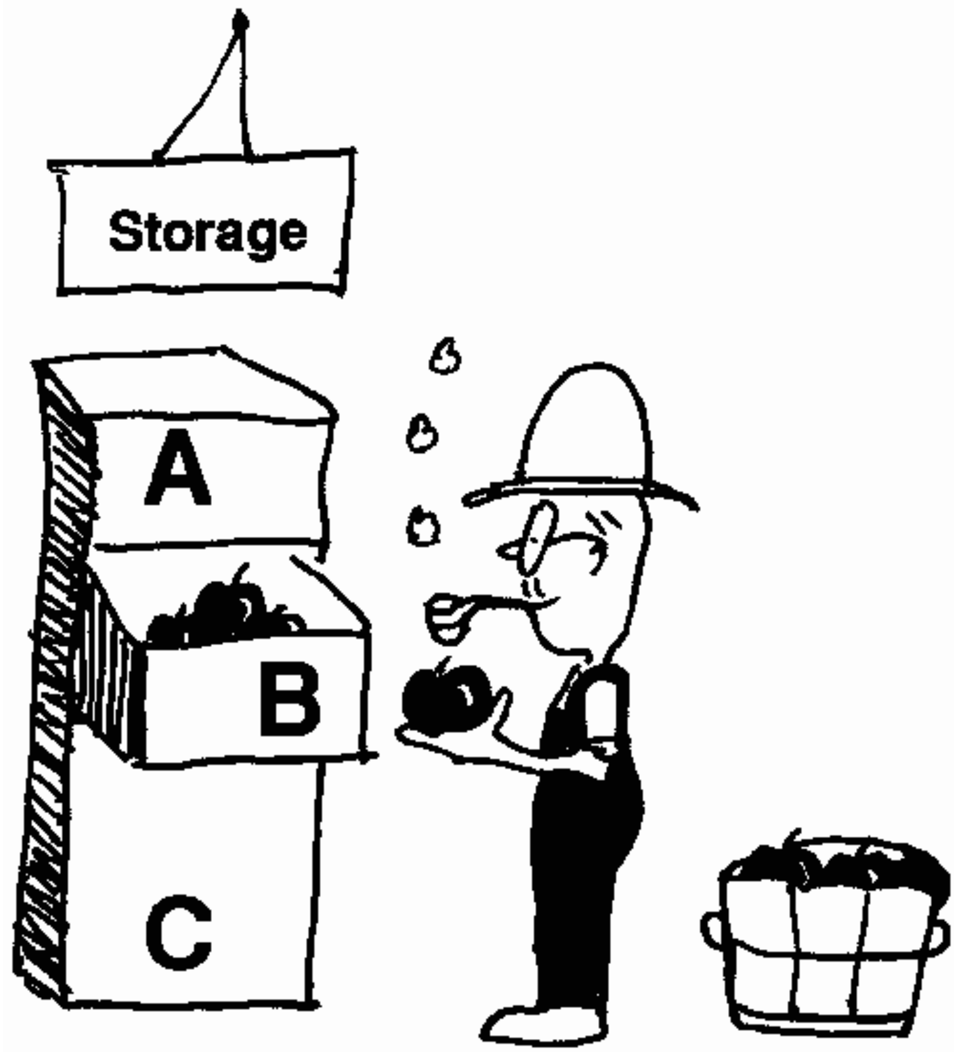
Chapter 7. The awk Utility: awk Programming



7.1 Variables

7.1.1 Numeric and String Constants

Numeric constants can be represented as integers, such as 243, floating point numbers, such as 3.14, or numbers using scientific notation, such as .723E−1 or 3.4e7. Strings, such as Hello world, are enclosed in double quotes.

Initialization and Type Coercion. Just mentioning a variable in your awk program causes it to exist. A variable can be a string, a number, or both. When it is set, it becomes the type of the expression on the right−hand side of the equal sign.

Uninitialized variables have the value zero or the value " ", depending on the context in which they are used.

```
name = "Nancy" name is a string

x++            x is a number;
               x is initialized to zero and incremented by 1

number = 35    number is a number
```

To coerce a string to be a number:

```
name + 0
```

To coerce a number to be a string:

```
number " "
```

All fields and array elements created by the split function are considered strings, unless they contain only a numeric value. If a field or array element is null, it has the string value of null. An empty line is also considered to be a null string.

7.1.2 User−Defined Variables

User−defined variables consist of letters, digits, and underscores, and cannot begin with a digit. Variables in awk are not declared. Awk infers data type by the context of the variable in the expression. If the variable is not initialized, awk initializes string variables to null and numeric variables to zero. If necessary, awk will convert a string variable to a numeric variable, and vice versa. Variables are assigned values with awk's assignment operators. See Table 7.1.

Table 7.1. Assignment Operators

Operator	Meaning	Equivalence
=	a = 5	a = 5
+=	a = a + 5	a += 5
−=	a = a − 5	a −= 5
*=	a = a * 5	a *= 5
/=	a = a / 5	a /= 5
%=	a = a % 5	a %= 5
^=	a = a ^ 5	a ^= 5

The simplest assignment takes the result of an expression and assigns it to a variable.

FORMAT

```
variable = expression
```

Example 7.1

```
% nawk '$1 ~  /Tom/ {wage = $2 * $3; print wage}'  filename
```

EXPLANATION

Awk will scan the first field for Tom and when there is a match, it will multiply the value of the second field by the value of the third field and assign the result to the user−defined variable wage. Since the multiplication operation is arithmetic, awk assigns wage an initial value of zero. (The % is the UNIX prompt and filename is an input file.)

Increment and Decrement Operators. To add one to an operand, the increment operator is used. The expression x++ is equivalent to x = x + 1. Similarly, the decrement operator subtracts one from its operand. The expression x− − is equivalent to x = x − 1. This notation is useful in looping operations when you simply want to increment or decrement a counter. You can use the increment and decrement operators either preceding the operator, as in ++x, or after the operator, as in x++. If these expressions are used in assignment statements, their placement will make a difference in the result of the operation.

```
{x = 1;  y = x++ ; print x, y}
```

The ++ here is called a post−increment operator; y is assigned the value of one, and then x is increased by one, so that when all is said and done, y will equal one, and x will equal two.

```
{x = 1; y = ++x;  print x, y}
```

The ++ here is called a pre−increment operator; x is incremented first, and the value of two is assigned to y, so that when this statement is finished, y will equal two, and x will equal two.

User−Defined Variables at the Command Line. A variable can be assigned a value at the command line and passed into an awk script. For more on processing arguments, see "Processing Command Arguments (nawk)", ARGV, the array of command line arguments.

Example 7.2

```
nawk –F: –f awkscript    month=4  year=2001 filename
```

EXPLANATION

The user−defined variables month and year are assigned the values 4 and 2001, respectively. In the awk script, these variables may be used as though they were created in the script. Note: If filename precedes the arguments, the variables will not be available in the BEGIN statements. (See "BEGIN Patterns".)

The –v Option (nawk). The –v option provided by nawk allows command line arguments to be processed within a BEGIN statement. For each argument passed at the command line, there must be a –v option preceding it.

Field Variables. Field variables can be used like user−defined variables, except they reference fields. New fields can be created by assignment. A field value that is referenced and has no value will be assigned the null string. If a field value is changed, the $0 variable is recomputed using the current value of OFS as a field separator. The number of fields allowed is usually limited to 100.

Example 7.3

```
% nawk ' { $5 = 1000 * $3 / $2;  print } '  filename
```

EXPLANATION

If $5 does not exist, awk will create it and assign the result of the expression 1000 * $3 / $2 to the fifth field ($5). If the fifth field exists, the result will be assigned to it, overwriting what is there.

Example 7.4

```
% nawk ' $4 == "CA" { $4  = "California"; print}'  filename
```

EXPLANATION

If the fourth field ($4) is equal to the string CA, awk will reassign the fourth field to California. The double quotes are essential. Without them, the strings become user−defined variables with an initial value of null.

Built−In Variables. Built−in variables have uppercase names. They can be used in expressions and can be reset. See Table 7.2 for a list of built−in variables.

Table 7.2. Built−In Variables

Variable Name Variable ContentsARGCNumber of command line argument.ARGVArray of command line arguments.FILENAMEName of current input file.FNRRecord number in current file.FSThe input field separator, by default a space.NFNumber of fields in current record.NRNumber of records so far.OFMTOutput format for numbers.OFSOutput field separator.ORSOutput record separator.RLENGTHLength of string matched by match function.RSInput record separator.RSTARTOffset of string matched by match function.SUBSEPSubscript separator.

Example 7.5

```
(The Employees Database)
% cat employees2
Tom Jones:4423:5/12/66:543354
Mary Adams:5346:11/4/63:28765
Sally Chang:1654:7/22/54:650000
Mary Black:1683:9/23/44:336500

(The Command Line)
% nawk  –F:  '$1 == "Mary Adams"{print NR, $1, $2, $NF}' employees2

(The Output)
2  Mary Adams 5346  28765
```

EXPLANATION

The –F option sets the field separator to a colon. The print function prints the record number, the first field, the second field, and the last field ($NF).

7.1.3 BEGIN Patterns

The BEGIN pattern is followed by an action block that is executed before awk processes any lines from the input file. In fact, a BEGIN block can be tested without any input file, since awk does not start reading input until the BEGIN action block has completed. The BEGIN action is often used to change the value of the built−in variables, OFS, RS, FS, and so forth, to assign initial values to user−defined variables and to print headers or titles as part of the output.

Example 7.6

```
% nawk 'BEGIN{FS=":"; OFS="\t"; ORS="\n\n"}{print $1,$2,$3}' file
```

EXPLANATION

Before the input file is processed, the field separator (FS) is set to a colon, the output field separator (OFS) to a tab, and the output record separator (ORS) to two newlines. If there are two or more statements in the action block, they should be separated with semicolons or placed on separate lines (use a backslash to escape the newline character if at the shell prompt).

Example 7.7

```
% nawk 'BEGIN{print "MAKE YEAR"}'
make year
```

EXPLANATION

Awk will display MAKE YEAR. The print function is executed before awk opens the input file, and even though the input file has not been assigned, awk will still print MAKE and YEAR. When debugging awk scripts, you can test the BEGIN block actions before writing the rest of the program.

7.1.4 END Patterns

END patterns do not match any input lines, but execute any actions that are associated with the END pattern. END patterns are handled after all lines of input have been processed.

Example 7.8

```
% nawk 'END{print "The number of records is " NR }' filename
The number of records is 4
```

EXPLANATION

The END block is executed after awk has finished processing the file. The value of NR is the number of the last record read.

Example 7.9

```
% nawk '/Mary/{count++}END{print "Mary was found " count " times."}'\
  employees
Mary was found 2 times.
```

EXPLANATION

For every line that contains the pattern sun, the value of the count variable is incremented by one. After awk has processed the entire file, the END block prints the string Sun was found, the value of count, and the string times.

7.2 Redirection and Pipes

7.2.1 Output Redirection

When redirecting output from within awk to a UNIX file, the shell redirection operators are used. The filename must be enclosed in double quotes. When the > symbol is used, the file is opened and truncated. Once the file is opened, it remains open until explicitly closed or the awk program terminates. Output from subsequent print statements to that file will be appended to the file.

The >> symbol is used to open the file, but does not clear it out; instead it simply appends to it.

Example 7.10

```
% nawk '$4 >= 70 {print $1, $2  > "passing_file" }' filename
```

EXPLANATION

If the value of the fourth field is greater than or equal to 70, the first and second fields will be printed to the file passing_ file.

7.2.2 Input Redirection (getline)

The getline Function. The getline function is used to read input from the standard input, a pipe, or a file other than the current file being processed. It gets the next line of input and sets the NF, NR, and the FNR built−in variables. The getline function returns one if a record is found and zero if EOF (end of file) is reached. If there is an error, such as failure to open a file, the getline function returns a value of −1.

Example 7.11

```
% nawk 'BEGIN{ "date" | getline d; print d}' filename
Thu Jan 14 11:24:24 PST 2001
```

EXPLANATION

Will execute the UNIX date command, pipe the output to getline, assign it to the user−defined variable d, and then print d.

Example 7.12

```
% nawk 'BEGIN{ "date " | getline d; split( d, mon) ; print mon[2]}'\
  filename
Jan
```

EXPLANATION

Will execute the date command and pipe the output to getline. The getline function will read from the pipe and store the input in a user−defined variable, d. The split function will create an array called mon out of variable d and then the second element of the array mon will be printed.

Example 7.13

```
% nawk 'BEGIN{while("ls" | getline) print}'
a.out
db
dbook
getdir
file
sortedf
```

EXPLANATION

Will send the output of the ls command to getline; for each iteration of the loop, getline will read one more line of the output from ls and then print it to the screen. An input file is not necessary, since the BEGIN block is processed before awk attempts to open input.

Example 7.14

```
(The Command Line)
1  % nawk 'BEGIN{ printf "What is your name?" ;\
     getline name < "/dev/tty"}\
2  $1 ~ name {print "Found " name " on line ", NR "."}\
3  END{print "See ya, " name "."}' filename

(The Output)
What is your name?  Ellie     < Waits for input from user >
Found Ellie on line 5.
See ya, Ellie.
```

EXPLANATION

1. Will print to the screen What is your name? and wait for user response; the getline function will accept input from the terminal (/dev/tty) until a newline is entered, and then store the input in the user−defined variable name.
2. If the first field matches the value assigned to name, the print function is executed.
3. The END statement prints out See ya, and then the value Ellie, stored in variable name, is displayed, followed by a period.

Example 7.15

```
(The Command Line)
% nawk 'BEGIN{while (getline < "/etc/passwd"  > 0 )lc++; print lc}'\
  file

(The Output)
16
```

EXPLANATION

Awk will read each line from the /etc/passwd file, increment lc until EOF is reached, then print the value of lc, which is the number of lines in the passwd file.

Note

The value returned by getline is negative one if the file does not exist. If the end of file is reached, the return value is zero, and if a line was read, the return value is one. Therefore, the command

```
while ( getline < "/etc/junk")
```

would start an infinite loop if the file /etc/junk did not exist, since the return value of negative one yields a true condition.

7.3 Pipes

If you open a pipe in an awk program, you must close it before opening another one. The command on the right−hand side of the pipe symbol is enclosed in double quotes. Only one pipe can be open at a time.

Example 7.16

```
(The Database)
% cat names
john smith
alice cheba
george goldberg
susan goldberg
tony tram
barbara nguyen
elizabeth lone
dan savage
eliza goldberg
john goldenrod

(The Command Line)
% nawk '{print $1, $2 | "sort −r +1 −2 +0 −1 "}' names
(The Output)
tony tram
john smith
dan savage
barbara nguyen
elizabeth lone
john goldenrod
susan goldberg
george goldberg
eliza goldberg
alice cheba
```

EXPLANATION

Awk will pipe the output of the print statement as input to the UNIX sort command, which does a reversed sort using the second field as the primary key and the first field as the secondary key. The UNIX command must be enclosed in double quotes. (See "sort" in Appendix A.)

7.4 Closing Files and Pipes

If you plan to use a file or pipe in an awk program again for reading or writing, you may want to close it first, since it remains open until the script ends. Once opened, the pipe remains open until awk exits. Therefore, statements in the END block will also be affected by the pipe. The first line in the END block closes the pipe.

Example 7.17

```
(In Script)
1   { print $1, $2, $3 | " sort −r +1 −2 +0 −1"}
    END{
2   close("sort −r +1 −2 +0 −1")
     <rest of statements>  }
```

EXPLANATION

1. Awk pipes each line from the input file to the UNIX sort utility.
2. When the END block is reached, the pipe is closed. The string enclosed in double quotes must be identical to the pipe string where the pipe was initially opened.

The system Function. The built−in system function takes a UNIX system command as its argument, executes the command, and returns the exit status to the awk program. It is similar to the C standard library function, also called system(). The UNIX command must be enclosed in double quotes.

FORMAT

```
system( "UNIX Command")
```

Example 7.18

```
(In Script)
    {
1   system ( "cat" $1 )
2   system ( "clear" )
    }
```

EXPLANATION

1. The system function takes the UNIX cat command and the value of the first field in the input file as its arguments. The cat command takes the value of the first field, a filename, as its argument. The UNIX shell causes the cat command to be executed.
2. The system function takes the UNIX clear command as its argument. The shell executes the command, causing the screen to be cleared.

7.5 Review

7.5.1 Increment and Decrement Operators

```
% cat datafile
northwest          NW    Joel Craig        3.0    .98    3     4
western            WE    Sharon Kelly      5.3    .97    5     23
southwest          SW    Chris Foster      2.7    .8     2     18
southern           SO    May Chin          5.1    .95    4     15
southeast          SE    Derek Johnson     4.0    .7     4     17
eastern            EA    Susan Beal        4.4    .84    5     20
northeast          NE    TJ Nichols        5.1    .94    3     13
north              NO    Val Shultz        4.5    .89    5     9
central            CT    Sheri Watson      5.7    .94    5     13
```

Example 7.19

```
% nawk '/^north/{count += 1; print count}' datafile
1
2
3

% cat datafile
northwest          NW    Joel Craig        3.0    .98    3     4
western            WE    Sharon Kelly      5.3    .97    5     23
southwest          SW    Chris Foster      2.7    .8     2     18
southern           SO    May Chin          5.1    .95    4     15
southeast          SE    Derek Johnson     4.0    .7     4     17
eastern            EA    Susan Beal        4.4    .84    5     20
northeast          NE    TJ Nichols        5.1    .94    3     13
north              NO    Val Shultz        4.5    .89    5     9
central            CT    Sheri Watson      5.7    .94    5     13
```

EXPLANATION

If the record begins with the regular expression north, a user−defined variable, count, is created; count is incremented by 1 and its value is printed.

Example 7.20

```
% nawk '/^north/{count++; print count}' datafile
1
2
3
```

EXPLANATION

The auto−increment operator increments the user−defined variable count by 1. The value of count is printed.

Example 7.21

```
% nawk '{x = $7−−; print "x = "x ", $7 = "$7}' datafile
x = 3, $7 = 2
x = 5, $7 = 4
x = 2, $7 = 1
x = 4, $7 = 3
x = 4, $7 = 3
x = 5, $7 = 4
x = 3, $7 = 2
x = 5, $7 = 4
x = 5, $7 = 4
```

EXPLANATION

After the value of the seventh field ($7) is assigned to the user−defined variable x, the auto−decrement operator decrements the seventh field by one. The value of x and the seventh field are printed.

7.5.2 Built−In Variables

```
EXAMPLE 7.22
% nawk '/^north/{print "The record number is " NR}' datafile
The record number is 1
The record number is 7
The record number is 8
```

EXPLANATION

If the record begins with the regular expression north, the string The record number is and the value of NR (record number) are printed.

Example 7.23

```
% nawk '{print NR, $0}' datafile
1 northwest   NW     Joel Craig          3.0  .98  3    4
2 western     WE     Sharon Kelly        5.3  .97  5    23
3 southwest   SW     Chris Foster        2.7  .8   2    18
4 southern    SO     May Chin            5.1  .95  4    15
5 southeast   SE     Derek Johnson       4.0  .7   4    17
```

```
6 eastern     EA     Susan Beal          4.4  .84  5    20
7 northeast   NE     TJ Nichols          5.1  .94  3    13
8 north       NO     Val Shultz          4.5  .89  5    9
9 central     CT     Sheri Watson        5.7  .94  5    13
```

EXPLANATION

The value of NR, the number of the current record, and the value of $0, the entire record, are printed.

Example 7.24

```
% nawk 'NR==2,NR==5{print NR, $0}' datafile
2 western     WE      Sharon Kelly       5.3  97   5    23
3 southwest   SW      Chris Foster       2.7   8   2    18
4 southern    SO      May Chin           5.1  95   4    15
5 southeast   SE      Derek Johnson      4.0   7   4    17
```

EXPLANATION

If the value of NR is in the range between 2 and 5 (record numbers 2–5), the number of the record (NR) and the record ($0) are printed.

```
% cat datafile
northwest          NW   Joel Craig          3.0    .98    3    4
western            WE   Sharon Kelly        5.3    .97    5    23
southwest          SW   Chris Foster        2.7    .8     2    18
southern           SO   May Chin            5.1    .95    4    15
southeast          SE   Derek Johnson       4.0    .7     4    17
eastern            EA   Susan Beal          4.4    .84    5    20
northeast          NE   TJ Nichols          5.1    .94    3    13
north              NO   Val Shultz          4.5    .89    5    9
central            CT   Sheri Watson        5.7    .94    5    13
```

Example 7.25

```
% nawk '/^north/{print NR, $1, $2, $NF, RS}' datafile
1 northwest NW 4

7 northeast NE 13

8 north NO 9
```

EXPLANATION

If the record begins with the regular expression north, the number of the record (NR), followed by the first field, the second field, the value of the last record (NF preceded by a dollar sign) and the value of RS (a newline) are printed. Since the print function generates a newline by default, RS will generate another newline, resulting in double spacing between records.

```
% cat datafile2
Joel Craig:northwest:NW:3.0:.98:3:4
Sharon Kelly:western:WE:5.3:.97:5:23
Chris Foster:southwest:SW:2.7:.8:2:18
May Chin:southern:SO:5.1:.95:4:15
Derek Johnson:southeast:SE:4.0:.7:4:17
Susan Beal:eastern:EA:4.4:.84:5:20
TJ Nichols:northeast:NE:5.1:.94:3:13
```

```
Val Shultz:north:NO:4.5:.89:5:9
Sheri Watson:central:CT:5.7:.94:5:131.
```

Example 7.26

```
% nawk −F: 'NR == 5{print NF}' datafile2
7
```

EXPLANATION

The field separator is set to a colon at the command line with the –F option. If the number of the record (NR) is 5, the number of fields (NF) is printed.

Example 7.27

```
% nawk 'BEGIN{OFMT="%.2f";print 1.2456789,12E−2}' datafile2
1.25 0.12
```

EXPLANATION

The OFMT, output format variable for the print function, is set so that floating point numbers will be printed with a decimal−point precision of two digits. The numbers 1.23456789 and 12E−2 are printed in the new format.

```
% cat datafile
northwest          NW   Joel Craig          3.0    .98     3     4
western            WE   Sharon Kelly        5.3    .97     5     23
southwest          SW   Chris Foster        2.7    .8      2     18
southern           SO   May Chin            5.1    .95     4     15
southeast          SE   Derek Johnson       4.0    .7      4     17
eastern            EA   Susan Beal          4.4    .84     5     20
northeast          NE   TJ Nichols          5.1    .94     3     13
north              NO   Val Shultz          4.5    .89     5     9
central            CT   Sheri Watson        5.7    .94     5     13
```

Example 7.28

```
% nawk '{$9 = $6 * $7; print $9}' datafile
2.94
4.85
1.6
3.8
2.8
4.2
2.82
4.45
4.7
```

EXPLANATION

The result of multiplying the sixth field ($6) and the seventh field ($7) is stored in a new field, $9, and printed. There were eight fields; now there are nine.

Example 7.29

```
% nawk '{$10 = 100; print NF, $9, $0}' datafile
10  northwest NW     Joel Craig         3.0  .98  3    4    100
10  western   WE     Sharon Kelly       5.3  .97  5    23   100
10  southwest SW     Chris Foster       2.7  .8   2    18   100
10  southern  SO     May Chin           5.1  .95  4    15   100
10  southeast SE     Derek Johnson      4.0  .7   4    17   100
10  eastern   EA     Susan Beal         4.4  .84  5    20   100
10  northeast NE     TJ Nichols         5.1  .94  3    13   100
10  north     NO     Val Shultz         4.5  .89  5    9    100
10  central   CT     Sheri Watson       5.7  .94  5    13   100
```

EXPLANATION

The tenth field ($10) is assigned 100 for each record. This is a new field. The ninth field ($9) does not exist, so it will be considered a null field. The number of fields is printed (NF), followed by the value of $9, the null field, and the entire record ($0). The value of the tenth field is 100.

7.5.3 BEGIN Patterns

Example 7.30

```
% nawk 'BEGIN{print "---------EMPLOYEES---------"}'
---------EMPLOYEES---------
```

EXPLANATION

The BEGIN pattern is followed by an action block. The action is to print out the string ---------EMPLOYEES--------- before opening the input file. Note that an input file has not been provided and awk does not complain.

Example 7.31

```
% nawk 'BEGIN{print "\t\t---------EMPLOYEES-------\n"}\
  {print $0}' datafile
                     ---------EMPLOYEES-------
northwest     NW    Joel Craig         3.0   .98  3    4
western       WE    Sharon Kelly       5.3   .97  5    23
southwest     SW    Chris Foster       2.7   .8   2    18
southern      SO    May Chin           5.1   .95  4    15
southeast     SE    Derek Johnson      4.0   .7   4    17
eastern       EA    Susan Beal         4.4   .84  5    20
northeast     NE    TJ Nichols         5.1   .94  3    13
north         NO    Val Shultz         4.5   .89  5    9
central       CT    Sheri Watson       5.7   .94  5    13
```

EXPLANATION

The BEGIN action block is executed first. The title ---------EMPLOYEES------- is printed. The second action block prints each record in the input file. When breaking lines, the backslash is used to suppress the carriage return. Lines can be broken at a semicolon or a curly brace.

```
% cat datafile2
Joel Craig:northwest:NW:3.0:.98:3:4
Sharon Kelly:western:WE:5.3:.97:5:23
```

```
Chris Foster:southwest:SW:2.7:.8:2:18
May Chin:southern:SO:5.1:.95:4:15
Derek Johnson:southeast:SE:4.0:.7:4:17
Susan Beal:eastern:EA:4.4:.84:5:20
TJ Nichols:northeast:NE:5.1:.94:3:13
Val Shultz:north:NO:4.5:.89:5:9
Sheri Watson:central:CT:5.7:.94:5:131.
```

Example 7.32

```
% nawk 'BEGIN{ FS=":";OFS="\t"};/^Sharon/{print $1, $2, $8 }'\
  datafile2
Sharon Kelly      western     28
```

EXPLANATION

The BEGIN action block is used to initialize variables. The FS variable (field separator) is assigned a colon. The OFS variable (output field separator) is assigned a tab (\t). If a record begins with the regular expression Sharon, the first, second, and eighth fields ($1, $2, $8) are printed. Each field in the output is separated by a tab.

7.5.4 END Patterns

```
% cat datafile
northwest          NW   Joel Craig          3.0    .98    3    4
western            WE   Sharon Kelly        5.3    .97    5    23
southwest          SW   Chris Foster        2.7    .8     2    18
southern           SO   May Chin            5.1    .95    4    15
southeast          SE   Derek Johnson       4.0    .7     4    17
eastern            EA   Susan Beal          4.4    .84    5    20
northeast          NE   TJ Nichols          5.1    .94    3    13
north              NO   Val Shultz          4.5    .89    5    9
central            CT   Sheri Watson        5.7    .94    5    13
```

Example 7.33

```
% nawk 'END{print "The total number of records is " NR}' datafile
The total number of records is 9
```

EXPLANATION

After awk has finished processing the input file, the statements in the END block are executed. The string The total number of records is is printed, followed by the value of NR, the number of the last record.

Example 7.34

```
% nawk '/^north/{count++}END{print count}' datafile
3
```

EXPLANATION

If the record begins with the regular expression north, the user−defined variable count is incremented by one. When awk has finished processing the input file, the value stored in the variable count is printed.

7.5.5 awk Script with BEGIN and END

Example 7.35

```
# Second awk script-- awk.sc2
1   BEGIN{ FS=":"; OFS="\t"
       print "  NAME\t\tDISTRICT\tQUANTITY"
       print "___________________________________________\n"
    }

2      {print $1"\t  " $3"\t\t" $7}
       {total+=$7}
       /north/{count++}

3   END{
       print "---------------------------------------------"
       print "The total quantity is " total
       print "The number of northern salespersons is " count "."
    }
(The Output)
4  % nawk -f awk.sc2 datafile2
     NAME      DISTRICT  QUANTITY
   ___________________________________________
   Joel Craig        NW       4
   Sharon Kelly      WE       23
   Chris Foster      SW       18
   May Chin          SO       15
   Derek Johnson     SE       17
   Susan Beal        EA       20
   TJ Nichols        NE       13
   Val Shultz        NO       9
   Sheri Watson      CT       13
   ---------------------------------------------
   The total quantity is 132
   The number of northern salespersons is 3.

% cat datafile2
Joel Craig:northwest:NW:3.0:.98:3:4
Sharon Kelly:western:WE:5.3:.97:5:23
Chris Foster:southwest:SW:2.7:.8:2:18
May Chin:southern:SO:5.1:.95:4:15
Derek Johnson:southeast:SE:4.0:.7:4:17
Susan Beal:eastern:EA:4.4:.84:5:20
TJ Nichols:northeast:NE:5.1:.94:3:13
Val Shultz:north:NO:4.5:.89:5:9
Sheri Watson:central:CT:5.7:.94:5:131.
```

EXPLANATION

1. The BEGIN block is executed first. The field separator (FS) and the output field separator (OFS) are set. Header output is printed.
2. The body of the awk script contains statements that are executed for each line of input coming from datafile2.
3. Statements in the END block are executed after the input file has been closed, i.e., before awk exits.
4. At the command line, the nawk program is executed. The –f option is followed by the script name, awk.sc2, and then by the input file, datafile2.

7.5.6 The printf Function

Example 7.36

```
% nawk '{printf "$%6.2f\n",$6 * 100}' datafile
$ 98.00
$ 97.00
$ 80.00
$ 95.00
$ 70.00
$ 84.00
$ 94.00
$ 89.00
$ 94.00
```

EXPLANATION

The printf function formats a floating point number to be right−justified (the default) with a total of 6 digits, one for the decimal point, and two for the decimal numbers to the right of the period. The number will be rounded up and printed.

Example 7.37

```
% nawk '{printf "|%−15s|\n",$4}' datafile
|Craig          |
|Kelly          |
|Foster         |
|Chin           |
|Johnson        |
|Beal           |
|Nichols        |
|Shultz         |
|Watson         |
```

EXPLANATION

A left−justified, 15−space string is printed. The fourth field ($4) is printed enclosed in vertical bars to illustrate the spacing.

```
% cat datafile
northwest          NW   Joel Craig          3.0    .98    3    4
western            WE   Sharon Kelly        5.3    .97    5    23
southwest          SW   Chris Foster        2.7    .8     2    18
southern           SO   May Chin            5.1    .95    4    15
southeast          SE   Derek Johnson       4.0    .7     4    17
eastern            EA   Susan Beal          4.4    .84    5    20
northeast          NE   TJ Nichols          5.1    .94    3    13
north              NO   Val Shultz          4.5    .89    5    9
central            CT   Sheri Watson        5.7    .94    5    13
```

7.5.7 Redirection and Pipes

Example 7.38

```
% nawk '/north/{print $1, $3, $4 > "districts"}' datafile
% cat districts
northwest Joel Craig
northeast TJ Nichols
```

```
north Val Shultz
```

EXPLANATION

If the record contains the regular expression north, the first, third, and fourth fields ($1, $3, $4) are printed to an output file called districts. Once the file is opened, it remains open until closed or the program terminates. The filename "districts" must be enclosed in double quotes.

Example 7.39

```
% nawk '/south/{print $1, $2, $3 >> "districts"}' datafile
% cat districts
northwest Joel Craig
northeast TJ Nichols
north Val Shultz
southwest SW Chris
southern SO May
southeast SE Derek
```

EXPLANATION

If the record contains the pattern south, the first, second, and third fields ($1, $2, $3) are appended to the output file districts.

7.5.8 Opening and Closing a Pipe

Example 7.40

```
# awk script using pipes -- awk.sc3
1  BEGIN{
2     printf " %-22s%s\n", "NAME", "DISTRICT"
      print "--------------------------------------"
3   }
4   /west/{count++}
5   {printf "%s %s\t\t%-15s\n", $3, $4, $1| "sort +1" }
6   END{
7       close "sort +1"
        printf "The number of sales persons in the western "
        printf "region is " count "."}

(The Output)
   % nawk -f awk.sc3 datafile
1  NAME                        DISTRICT
2  --------------------------------------------------
3  Susan Beal                  eastern
   May Chin                    southern
   Joel Craig                  northwest
   Chris Foster                southwest
   Derek Johnson               southeast
   Sharon Kelly                western
   TJ Nichols                  northeast
   Val Shultz                  north
   Sheri Watson                central
   The number of sales persons in the western region is 3.
```

EXPLANATION

1. The special BEGIN pattern is followed by an action block. The statements in this block are executed first, before awk processes the input file.
2. The printf function displays the string NAME as a 22−character, left−justified string, followed by the string DISTRICT, which is right−justified.
3. The BEGIN block ends.
4. Now awk will process the input file, one line at a time. If the pattern west is found, the action block is executed, i.e., the user−defined variable count is incremented by one. The first time awk encounters the count variable, it will be created and given an initial value of zero.
5. The print function formats and sends its output to a pipe. After all of the output has been collected, it will be sent to the sort command
6. The END block is started.
7. The pipe (sort +1) must be closed with exactly the same command that opened it; in this example, "sort +1". Otherwise, the END statements will be sorted with the rest of the output.

UNIX TOOLS LAB EXERCISE

Lab 5: nawk Exercise

Mike Harrington:(510) 548−1278:250:100:175

Christian Dobbins:(408) 538−2358:155:90:201

Susan Dalsass:(206) 654−6279:250:60:50

Archie McNichol:(206) 548−1348:250:100:175

Jody Savage:(206) 548−1278:15:188:150

Guy Quigley:(916) 343−6410:250:100:175

Dan Savage:(406) 298−7744:450:300:275

Nancy McNeil:(206) 548−1278:250:80:75

John Goldenrod:(916) 348−4278:250:100:175

Chet Main:(510) 548−5258:50:95:135

Tom Savage:(408) 926−3456:250:168:200

Elizabeth Stachelin:(916) 440−1763:175:75:300

(Refer to the database called lab5.data on the CD.)

The database above contains the names, phone numbers, and money contributions to the party campaign for the past three months.

Write a nawk script to produce the following output:

```
% nawk −f nawk.sc db
                    ***CAMPAIGN 1998 CONTRIBUTIONS***
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
NAME                 PHONE           Jan  |  Feb  |  Mar | Total Donated
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
Mike Harrington     (510) 548−1278    250.00   100.00  175.00   525.00
Christian Dobbins   (408) 538−2358    155.00    90.00  201.00   446.00
Susan Dalsass       (206) 654−6279    250.00    60.00   50.00   360.00
Archie McNichol     (206) 548−1348    250.00   100.00  175.00   525.00
Jody Savage         (206) 548−1278     15.00   188.00  150.00   353.00
Guy Quigley         (916) 343−6410    250.00   100.00  175.00   525.00
Dan Savage          (406) 298−7744    450.00   300.00  275.00  1025.00
Nancy McNeil        (206) 548−1278    250.00    80.00   75.00   405.00
John Goldenrod      (916) 348−4278    250.00   100.00  175.00   525.00
Chet Main           (510) 548−5258     50.00    95.00  135.00   280.00
Tom Savage          (408) 926−3456    250.00   168.00  200.00   618.00
Elizabeth Stacheli  (916) 440−1763    175.00    75.00  300.00   550.00
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
                              SUMMARY
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
The campaign received a total of $6137.00 for this quarter.
The average donation for the 12 contributors was $511.42.
The highest contribution was $300.00.
The lowest contribution was $15.00.
```

7.6 Conditional Statements

The conditional statements in awk were borrowed from the C language. They are used to control the flow of the program in making decisions.

7.6.1 if Statements

Statements beginning with the if construct are action statements. With conditional patterns, the if is implied; with a conditional action statement, the if is explicitly stated, and followed by an expression enclosed in parentheses. If the expression evaluates true (nonzero or non−null), the statement or block of statements following the expression is executed. If there is more than one statement following the conditional expression, the statements are separated either by semicolons or a newline, and the group of statements must be enclosed in curly braces so that the statements are executed as a block.

FORMAT

```
if (expression) {
    statement; statement; ...
    }
```

Example 7.41

```
1   % nawk '{if ( $6 > 50 ) print $1 "Too high"}' filename

2   % nawk '{if ($6 > 20 && $6  <= 50){safe++; print "OK"}}' filename
```

EXPLANATION

1. In the if action block, the expression is tested. If the value of the sixth field is greater than 50, the print statement is executed. Since the statement following the expression is a single statement, curly braces are not required. (filename represents the input file.)
2. In the if action block, the expression is tested. If the sixth field is greater than 20 and the sixth field is less than or equal to 50, the statements following the expression are executed as a block and must be enclosed in curly braces.

7.6.2 if/else Statements

The if/else statement allows a two−way decision. If the expression after the if keyword is true, the block of statements associated with that expression are executed. If the first expression evaluates to false or zero, the block of statements after the else keyword is executed. If multiple statements are to be included with the if or else, they must be blocked with curly braces.

FORMAT

```
{if (expression) {
    statement; statement; ...
    }
else{
    statement; statement; ...
    }
}
```

Example 7.42

```
1   % nawk '{if( $6 > 50) print  $1 " Too high" ;\
      else print "Range is OK"}' filename
2   % nawk '{if ( $6 > 50 ) { count++; print $3 } \
      else { x+5; print $2 } }' filename
```

EXPLANATION

1. If the first expression is true, that is, the sixth field ($6) is greater than 50, the print function prints the first field and Too high; otherwise, the statement after the else, Range is OK, is printed.
2. If the first expression is true, that is, the sixth field ($6) is greater than 50, the block of statements is executed; otherwise, the block of statements after the else is executed. Note that the blocks are enclosed in curly braces.

7.6.3 if/else and else if Statements

The if/else and else if statements allow a multiway decision. If the expression following the keyword if is true, the block of statements associated with that expression is executed and control starts again after the last closing curly brace associated with the final else. Otherwise, control goes to the else if and that expression is tested. When the first else if condition is true, the statements following the expression are executed. If none of the conditional expressions test true, control goes to the else statements. The else is called the default action because if none of the other statements are true, the else block is executed.

FORMAT

```
{if (expression) {
    statement; statement; ...
    }
else if (expression){
    statement; statement; ...
    }
else if (expression){
    statement; statement; ...
    }
else{
    statement
    }
}
```

Example 7.43

```
(In the Script)
1   {if ( $3 > 89 && $3 < 101 ) Agrade++
2   else if ( $3 > 79 ) Bgrade++
3   else if ( $3 > 69 ) Cgrade++
4   else if ( $3 > 59 ) Dgrade++
5   else Fgrade++
    }
    END{print "The number of failures is" Fgrade }
```

EXPLANATION

1. The if statement is an action and must be enclosed in curly braces. The expression is evaluated from left to right. If the first expression is false, the whole expression is false; if the first expression is true, the expression after the logical and (&&) is evaluated. If it is true, the variable Agrade is incremented by one.
2. If the first expression following the if keyword evaluates to false (0), the else if expression is tested. If it evaluates to true, the statement following the expression is executed; that is, if the third field ($3) is greater than 79, Bgrade is incremented by one.
3. If the first two statements are false, the else if expression is tested, and if the third field ($3) is greater than 69, Cgrade is incremented.
4. If the first three statements are false, the else if expression is tested, and if the third field is greater than 59, Dgrade is incremented.
5. If none of the expressions tested above is true, the else block is executed. The curly brace ends the action block. Fgrade is incremented.

7.7 Loops

Loops are used to repeatedly execute the statements following the test expression if a condition is true. Loops are often used to iterate through the fields within a record and to loop through the elements of an array in the END block. Awk has three types of loops: the while loop, the for loop, and the special for loop, which will be discussed later when working with awk arrays.

7.7.1 while Loop

The first step in using a while loop is to set a variable to an initial value. The value is then tested in the while expression. If the expression evaluates to true (nonzero), the body of the loop is entered and the statements within that body are executed. If there is more than one statement within the body of the loop, those statements must be enclosed in curly braces. Before ending the loop block, the variable controlling the loop expression must be updated or the loop will continue forever. In the following example, the variable is reinitialized each time a new record is processed.

The do/while loop is similar to the while loop, except that the expression is not tested until the body of the loop is executed at least once.

Example 7.44

```
% nawk '{ i  = 1; while ( i <= NF ) { print NF, $i ; i++ } }' filename
```

EXPLANATION

The variable i is initialized to one; while i is less than or equal to the number of fields (NF) in the record, the print statement will be executed, then i will be incremented by one. The expression will then be tested again, until the variable i is greater than the value of NF. The variable i is not reinitialized until awk starts processing the next record.

7.7.2 for Loop

The for loop and while loop are essentially the same, except the for loop requires three expressions within the parentheses: the initialization expression, the test expression, and the expression to update the variables within the test expression. In awk, the first statement within the parentheses of the for loop can perform only one initialization. (In C, you can have multiple initializations separated by commas.)

Example 7.45

```
% nawk '{ for( i = 1; i <= NF; i++) print NF,$i }' filex
```

EXPLANATION

The variable i is initialized to one and tested to see whether it is less than or equal to the number of fields (NF) in the record. If so, the print function prints the value of NF and the value of $i (the $ preceding the i is the number of the ith field), then i is incremented by one. (Frequently the for loop is used with arrays in an END action to loop through the elements of an array.) See "Arrays".

7.7.3 Loop Control

break and continue Statements. The break statement lets you break out of a loop if a certain condition is true. The continue statement causes the loop to skip any statements that follow if a certain condition is true, and returns control to the top of the loop, starting at the next iteration.

Example 7.46

```
(In the Script)
1   {for ( x = 3; x <= NF; x++ )
        if ( $x < 0 ){ print "Bottomed out!"; break}
        # breaks out of for loop
    }

2   {for ( x = 3; x <= NF; x++ )
        if ( $x == 0 ) { print "Get next item"; continue}
        # starts next iteration of  the for loop
```

```
}
```

EXPLANATION

1. If the value of the field $x is less than zero, the break statement causes control to go to the statement after the closing curly brace of the loop body; i.e., it breaks out of the loop.
2. If the value of the field $x is equal to zero, the continue statement causes control to start at the top of the loop and start execution, in the third expression at the for loop at x++.

7.8 Program Control Statements

7.8.1 next Statement

The next statement gets the next line of input from the input file, restarting execution at the top of the awk script.

Example 7.47

```
(In Script)
{ if ($1 ~ /Peter/){next}
    else {print}
}
```

EXPLANATION

If the first field contains Peter, awk skips over this line and gets the next line from the input file. The script resumes execution at the beginning.

7.8.2 exit Statement

The exit statement is used to terminate the awk program. It stops processing records, but does not skip over an END statement. If the exit statement is given a value between 0 and 255 as an argument (exit 1), this value can be printed at the command line to indicate success or failure by typing:

Example 7.48

```
(In Script)
   {exit (1) }

(The Command Line)
% echo $status     (csh)
1

$ echo $?    (sh/ksh)
1
```

EXPLANATION

An exit status of zero indicates success, and an exit value of nonzero indicates failure (a convention in UNIX). It is up to the programmer to provide the exit status in a program. The exit value returned in this example is 1.

7.9 Arrays

Arrays in awk are called associative arrays because the subscripts can be either numbers or strings. The subscript is often called the key and is associated with the value assigned to the corresponding array element. The keys and values are stored internally in a table where a hashing algorithm is applied to the value of the key in question. Due to the techniques used for hashing, the array elements are not stored in a sequential order, and when the contents of the array are displayed, they may not be in the order you expected.

An array, like a variable, is created by using it, and awk can infer whether it is used to store numbers or strings. Array elements are initialized with numeric value zero and string value null, depending on the context. You do not have to declare the size of an awk array. Awk arrays are used to collect information from records and may be used for accumulating totals, counting words, tracking the number of times a pattern occurred, and so forth.

7.9.1 Subscripts for Associative Arrays

Using Variables as Array Indexes

Example 7.49

```
(The Input File)
% cat employees
Tom Jones      4424   5/12/66   543354
Mary Adams     5346   11/4/63   28765
Sally Chang    1654   7/22/54   650000
Billy Black    1683   9/23/44   336500

(The Command Line)
1  % nawk '{name[x++]=$2};END{for(i=0; i<NR; i++)\
     print i, name[i]}' employees
   0 Jones
   1 Adams
   2 Chang
   3 Black

2  % nawk '{id[NR]=$3};END{for(x = 1; x <= NR; x++)\
     print id[x]}' employees
   4424
   5346
   1654
   1683
```

EXPLANATION

1. The subscript in array name is a user−defined variable, x. The ++ indicates a numeric context. Awk initializes x to zero and increments x by one after (post−increment operator) it is used. The value of the second field is assigned to each element of the name array. In the END block, the for loop is used to loop through the array, printing the value that was stored there, starting at subscript zero. Since the subscript is just a key, it does not have to start at zero. It can start at any value, either a number or a string.
2. The awk variable NR contains the number of the current record. By using NR as a subscript, the value of the third field is assigned to each element of the array for each record. At the end, the for loop will loop through the array, printing out the values that were stored there.

The Special for Loop. The special for loop is used to read through an associative array in cases where the for loop is not practical; that is, when strings are used as subscripts or the subscripts are not consecutive numbers. The special for loop uses the subscript as a key into the value associated with it.

FORMAT

```
{for(item in arrayname){
    print arrayname[item]
    }
}
```

Example 7.50

```
(The Input File)
% cat db
Tom Jones
Mary Adams
Sally Chang
Billy Black
Tom Savage
Tom Chung
Reggie Steel
Tommy Tucker

(The Command Line, for Loop)
1  % nawk '/^Tom/{name[NR]=$1};\
     END{for( i = 1; i <= NR; i++ )print name[i]}' db
   Tom



   Tom
   Tom

   Tommy

(The Command Line, Special for Loop)
2  % nawk '/^Tom/{name[NR]=$1};\
     END{for(i in name){print name[i]}}' db
   Tom
   Tommy
   Tom
   Tom
```

EXPLANATION

1. If the regular expression Tom is matched against an input line, the name array is assigned a value. Since the subscript used is NR, the number of the current record, the subscripts in the array will not be in numeric order. Therefore, when printing the array with the traditional for loop, there will be null values printed where an array element has no value.
2. The special for loop iterates through the array, printing only values where there was a subscript associated with that value. The order of the printout is random because of the way the associative arrays are stored (hashed).

Using Strings as Array Subscripts. A subscript may consist of a variable containing a string or literal string. If the string is a literal, it must be enclosed in double quotes.

Example 7.51

```
(The Input File)
% cat datafile3
tom
mary
sean
tom
mary
mary
bob
mary
alex

(The Script)
    # awk.sc script
1   /tom/ { count["tom"]++ }
2   /mary/ { count["mary"]++ }
3   END{print "There are " count["tom"] " Toms in the file and
       " count["mary"]" Marys in the file."}
(The Command Line)
   % nawk -f awk.sc datafile3
   There are 2 Toms in the file and 4 Marys in the file.
```

EXPLANATION

1. An array called count consists of two elements, count["tom"] and count["mary"]. The initial value of each of the array elements is zero. Every time tom is matched, the value of the array is incremented by one.
2. The same procedure applies to count["mary"]. Note: Only one tom is recorded for each line, even if there are multiple occurrences on the line.
3. The END pattern prints the value stored in each of the array elements.

Using Field Values as Array Subscripts. Any expression can be used as a subscript in an array. Therefore, fields can be used. The program in Example 7.52 counts the frequency of all names appearing in the second field and introduces a new form of the for loop.

Example 7.52

```
(The Input File)
% cat datafile4
4234  Tom    43
4567  Arch   45
2008  Eliza  65
4571  Tom    22
3298  Eliza  21
4622  Tom    53
2345  Mary   24

(The Command Line)
% nawk '{count[$2]++}END{for(name in count)print name,count[name] }'\
  datafile4
Tom 3
Arch 1
Eliza 2
Mary 1
```

EXPLANATION

The awk statement first will use the second field as an index in the count array. The index varies as the second field varies, thus the first index in the count array is Tom and the value stored in count["Tom"] is one.

Next, count["Arch"] is set to one, count["Eliza"] to one, and count["Mary"] to one. When awk finds the next occurrence of Tom in the second field, count["Tom"] is incremented, now containing the value 2. The same thing happens for each occurrence of Arch, Eliza, and Mary.

Figure 7.1. Using strings as subscripts in an array (Example 7.51).


```
for( index_value in array ) statement
```

The for loop found in the END block of the previous example works as follows: The variable name is set to the index value of the count array. After each iteration of the for loop, the print action is performed, first printing the value of the index, and then the value stored in that element. (The order of the printout is not guaranteed.)

Example 7.53

```
(The Input File)
% cat datafile4
4234  Tom    43
4567  Arch   45
2008  Eliza  65
4571  Tom    22
3298  Eliza  21
4622  Tom    53
2345  Mary   24

(The Command Line)
% nawk  '{dup[$2]++; if (dup[$2] > 1){name[$2]++ }}\
  END{print "The duplicates were"\
  for (i in name){print i, name[i]}}' datafile4

(The Output)
Tom 2
Eliza 2
```

EXPLANATION

The subscript for the dup array is the value in the second field, that is, the name of a person. The value stored there is initially zero, and it is incremented by one each time a new record is processed. If the name is a duplicate, the value stored for that subscript will go up to two, and so forth. If the value in the dup array is greater than one, a new array called name also uses the second field as a subscript and keeps track of the number of names greater than one.

Arrays and the split Function. Awk's built−in split function allows you to split a string into words and store them in an array. You can define the field separator or use the value currently stored in FS.

FORMAT

```
split(string, array, field separator)
split (string, array)
```

Example 7.54

```
(The Command Line)
% nawk BEGIN{ split( "3/15/2001", date, "/");\
  print "The month is " date[1] "and the year is "date[3]"} \
  filename

(The Output)
The month is 3 and the year is 2001.
```

EXPLANATION

The string 3/15/2001 is stored in the array date, using the forward slash as the field separator. Now date[1] contains 3, date[2] contains 15, and date[3] contains 2001. The field separator is specified in the third argument; if not specified, the value of FS is used as the separator.

The delete Function. The delete function removes an array element.

Example 7.55

```
% nawk '{line[x++]=$2}END{for(x in line) delete(line[x])}'\
  filename
```

EXPLANATION

The value assigned to the array line is the value of the second field. After all the records have been processed, the special for loop will go through each element of the array, and the delete function will in turn remove each element.

Multidimensional Arrays (nawk). Although awk does not officially support multidimensional arrays, a syntax is provided that gives the appearance of a multidimensional array. This is done by concatenating the indices into a string separated by the value of a special built−in variable, SUBSEP. The SUBSEP variable contains the value "\034," an unprintable character that is so unusual that it is unlikely to be found as an index character. The expression matrix[2,8] is really the array matrix[2 SUBSEP 8], which evaluates to matrix["2\0348"]. The index becomes a unique string for an associative array.

Example 7.56

```
(The Input File)
1 2 3 4 5
2 3 4 5 6
6 7 8 9 10

(The Script)
1   {nf=NF
2   for(x = 1; x <= NF; x++ ){
3      matrix[NR, x] = $x
```

```
        }
    }
4   END { for (x=1; x <= NR; x++ ){
        for (y = 1; y <= nf; y++ )
           printf "%d ", matrix[x,y]
    printf"\n"
       }
    }

(The Output)
1 2 3 4 5
2 3 4 5 6
6 7 8 9 10
```

EXPLANATION

1. The variable nf is assigned the value of NF, the number of fields. (This program assumes a fixed number of five fields per record.)
2. The for loop is entered, storing the number of each field on the line in the variable x.
3. The matrix array is a two−dimensional array. The two indices, NR (number of the current record) and x, are assigned the value of each field.
4. In the END block, the two for loops are used to iterate through the matrix array, printing out the values stored there. This example does nothing more than demonstrate that multidimensional arrays can be simulated.

7.9.2 Processing Command Arguments (nawk)

ARGV. Command line arguments are available to nawk (the new version of awk) with the built−in array called ARGV. These arguments include the command nawk, but not any of the options passed to nawk. The index of the ARGV array starts at zero. (This works only for nawk.)

ARGC. ARGC is a built−in variable that contains the number of command line arguments.

Example 7.57

```
(The Script)
# This script is called argvs
BEGIN{
    for  ( i=0; i < ARGC; i++ ){
        printf("argv[%d] is %s\n", i, ARGV[i])
        }
    printf("The number of arguments, ARGC=%d\n", ARGC)
}

(The Output)
% nawk −f argvs datafile
argv[0] is nawk
argv[1] is datafile
The number of arguments, ARGC=2
```

EXPLANATION

In the for loop, i is set to zero, i is tested to see if it is less than the number of command line arguments (ARGC), and the printf function displays each argument encountered, in turn. When all of the arguments have been processed, the last printf statement outputs the number of arguments, ARGC. The example demonstrates that awk does not count command line options as arguments.

Example 7.58

```
(The Command Line)
% nawk –f argvs datafile "Peter Pan" 12
argv[0] is nawk
argv[1] is datafile
argv[2] is Peter Pan
argv[3] is 12
The number of arguments, ARGC=4
```

EXPLANATION

As in the last example, each of the arguments is printed. The nawk command is considered the first argument, whereas the –f option and script name, argvs, are excluded.

Example 7.59

```
(The Datafile)
% cat datafile5
Tom Jones:123:03/14/56
Peter Pan:456:06/22/58
Joe Blow:145:12/12/78
Santa Ana:234:02/03/66
Ariel Jones:987:11/12/66

(The Script)
% cat arging.sc
# This script is called arging.sc
1   BEGIN{FS=":"; name=ARGV[2]
2      print "ARGV[2] is "ARGV[2]
    }
    $1  ~ name { print $0 }

(The Command Line)
% nawk –f arging.sc datafile5 "Peter Pan"
ARGV[2] is Peter Pan
Peter Pan:456:06/22/58
nawk: can't open Peter Pan
input record number 5, file Peter Pan
source line number 2
```

EXPLANATION

1. In the BEGIN block, the variable name is assigned the value of ARGV[2], Peter Pan.
2. Peter Pan is printed, but then awk tries to open Peter Pan as an input file after it has processed and closed the datafile. Awk treats arguments as input files.

Example 7.60

```
(The Script)
% cat arging2.sc
BEGIN{FS=":"; name=ARGV[2]
   print "ARGV[2] is " ARGV[2]
   delete ARGV[2]
}
$1  ~ name { print $0 }

(The Command Line)
```

```
% nawk –f arging2.sc datafile "Peter Pan"
ARGV[2] is Peter Pan
Peter Pan:456:06/22/58
```

EXPLANATION

Awk treats the elements of the ARGV array as input files; after an argument is used, it is shifted to the left and the next one is processed, until the ARGV array is empty. If the argument is deleted immediately after it is used, it will not be processed as the next input file.

7.10 awk Built−In Functions

7.10.1 String Functions

The sub and gsub Functions. The sub function matches the regular expression for the largest and leftmost substring in the record, and then replaces that substring with the substitution string. If a target string is specified, the regular expression is matched for the largest and leftmost substring in the target string, and the substring is replaced with the substitution string. If a target string is not specified, the entire record is used.

FORMAT

```
sub (regular expression, substitution string);
sub (regular expression, substitution string, target string)
```

Example 7.61

```
1  % nawk '{sub(/Mac/, "MacIntosh"); print}' filename
2  % nawk '{sub(/Mac/, "MacIntosh", $1); print}' filename
```

EXPLANATION

1. The first time the regular expression Mac is matched in the record ($0), it will be replaced with the string MacIntosh. The replacement is made only on the first occurrence of a match on the line. (See gsub for multiple occurrences.)
2. The first time the regular expression Mac is matched in the first field of the record, it will be replaced with the string MacIntosh. The replacement is made only on the first occurrence of a match on the line for the target string. The gsub function substitutes a regular expression with a string globally, that is, for every occurrence where the regular expression is matched in each record ($0).

FORMAT

```
gsub(regular expression, substitution string)
gsub(regular expression, substitution string, target string)
```

Example 7.62

```
1  % nawk '{ gsub(/CA/, "California"); print }' datafile
2  % nawk '{ gsub(/[Tt]om/, "Thomas", $1 ); print }' filename
```

EXPLANATION

1. Everywhere the regular expression CA is found in the record ($0), it will be replaced with the string California.
2. Everywhere the regular expression Tom or tom is found in the first field, it will be replaced with the string Thomas.

The index Function. The index function returns the first position where a substring is found in a string. Offset starts at position 1.

FORMAT

```
index(string, substring)
```

Example 7.63

```
% nawk '{ print index("hollow", "low") }' filename
4
```

EXPLANATION

The number returned is the position where the substring low is found in hollow, with the offset starting at one.

The length Function. The length function returns the number of characters in a string. Without an argument, the length function returns the number of characters in a record.

FORMAT

```
length ( string )
length
```

Example 7.64

```
% nawk '{ print length("hello") }' filename
5
```

EXPLANATION

The length function returns the number of characters in the string hello.

The substr Function. The substr function returns the substring of a string starting at a position where the first position is one. If the length of the substring is given, that part of the string is returned. If the specified length exceeds the actual string, the string is returned.

FORMAT

```
substr(string, starting position)
substr(string, starting position, length of string)
```

Example 7.65

```
% nawk ' { print substr("Santa Claus", 7, 6 )} ' filename
Claus
```

EXPLANATION

In the string Santa Claus, print the substring starting at position 7 with a length of 6 characters.

The match Function. The match function returns the index where the regular expression is found in the string, or zero if not found. The match function sets the built−in variable RSTART to the starting position of the substring within the string, and RLENGTH to the number of characters to the end of the substring. These variables can be used with the substr function to extract the pattern. (Works only with nawk.)

FORMAT

```
match(string, regular expression)
```

Example 7.66

```
% nawk 'END{start=match("Good ole USA", /[A–Z]+$/); print start}'\
  filename
10
```

EXPLANATION

The regular expression /[A–Z]+$/ says search for consecutive uppercase letters at the end of the string. The substring USA is found starting at the tenth character of the string Good ole USA. If the string cannot be matched, 0 is returned.

Example 7.67

```
1   % nawk 'END{start=match("Good ole USA", /[A–Z]+$/);\
      print RSTART, RLENGTH}' filename
    10 3
2   % nawk 'BEGIN{ line="Good ole USA"}; \
      END{ match( line, /[A–Z]+$/);\
      print substr(line, RSTART,RLENGTH)}' filename
    USA
```

EXPLANATION

1. The RSTART variable is set by the match function to the starting position of the regular expression matched. The RLENGTH variable is set to the length of the substring.
2. The substr function is used to find a substring in the variable line, and uses the RSTART and RLENGTH values (set by the match function) as the beginning position and length of the substring.

The split Function. The split function splits a string into an array using whatever field separator is designated as the third parameter. If the third parameter is not provided, awk will use the current value of FS.

FORMAT

```
split (string, array, field separator)
split (string, array)
```

Example 7.68

```
% awk 'BEGIN{split("12/25/2001",date,"/");print date[2]}' filename
25
```

EXPLANATION

The split function splits the string 12/25/2001 into an array, called date, using the forward slash as the separator. The array subscript starts at 1. The second element of the date array is printed.

The sprintf Function. The sprintf function returns an expression in a specified format. It allows you to apply the format specifications of the printf function.

FORMAT

```
variable=sprintf("string with format specifiers ", expr1, expr2, \
... , expr2)
```

Example 7.69

```
% awk '{line = sprintf ( "%-15s %6.2f ", $1 , $3 );\
  print line}'  filename
```

EXPLANATION

The first and third fields are formatted according to the printf specifications (a left−justified, 15−space string and a right−justified, 6−character floating point number). The result is assigned to the user−defined variable line. See "The printf Function".

7.11 Built−In Arithmetic Functions

Table 7.3 lists the built−in arithmetic functions, where x and y are arbitrary expressions.

Table 7.3. Arithmetic Functions

Name Value Returnedatan2(x,y)Arctangent of y/x in the range.cos(x)Cosine of x, with x in radians.exp(x)Exponential function of x, e.int(x)Integer part of x; truncated toward 0 when x > 0.log(x)Natural (base e) logarithm of x.rand( )Random number r, where 0 < r < 1.sin(x)Sine of x, with x in radians.sqrt(x)Square root of x.srand(x)x is a new seed for rand( ).[a]

[a] From Alfred V. Aho, Brian W. Kernighan, and Peter J. Weinberger, *The AWK Programming Language* (Boston: Addison−Wesley, 1988).© 1988 Bell Telephone Laboratories, Inc. Reprinted by permission of Pearson Education, Inc.

7.11.1 Integer Function

The int function truncates any digits to the right of the decimal point to create a whole number. There is no rounding off.

Example 7.70

```
1   % awk 'END{print 31/3}' filename
    10.3333
2   % awk 'END{print int(31/3})' filename
    10
```

EXPLANATION

1. In the END block, the result of the division is to print a floating point number.
2. In the END block, the int function causes the result of the division to be truncated at the decimal point. A whole number is displayed.

7.11.2 Random Number Generator

The rand Function. The rand function generates a pseudorandom floating point number greater than or equal to zero and less than one.

Example 7.71

```
% nawk '{print rand()}' filename
0.513871
0.175726
0.308634

% nawk '{print rand()}' filename
0.513871
0.175726
0.308634
```

EXPLANATION

Each time the program runs, the same set of numbers is printed. The srand function can be used to seed the rand function with a new starting value. Otherwise, as in this example, the same sequence is repeated each time rand is called.

The srand Function. The srand function without an argument uses the time of day to generate the seed for the rand function. Srand(x) uses x as the seed. Normally, x should vary during the run of the program.

Example 7.72

```
% nawk 'BEGIN{srand()};{print rand()}' filename
0.508744
0.639485
0.657277

% nawk 'BEGIN{srand()};{print rand()}' filename
0.133518
0.324747
0.691794
```

EXPLANATION

The srand function sets a new seed for rand. The starting point is the time of day. Each time rand is called, a new sequence of numbers is printed.

Example 7.73

```
% nawk 'BEGIN{srand()};{print 1 + int(rand() * 25)}' filename
6
24
14
```

EXPLANATION

The srand function sets a new seed for rand. The starting point is the time of day. The rand function selects a random number between 0 and 25 and casts it to an integer value.

7.12 User−Defined Functions (nawk)

A user−defined function can be placed anywhere in the script that a pattern action rule can.

FORMAT

```
function name ( parameter, parameter, parameter, ... ) {
   statements
   return expression
(The return statement and expression are optional)
}
```

Variables are passed by value and are local to the function where they are used. Only copies of the variables are used. Arrays are passed by address or by reference, so array elements can be directly changed within the function. Any variable used within the function that has not been passed in the parameter list is considered a global variable; that is, it is visible to the entire awk program, and if changed in the function, is changed throughout the program. The only way to provide local variables within a function is to include them in the parameter list. Such parameters are usually placed at the end of the list. If there is not a formal parameter provided in the function call, the parameter is initially set to null. The return statement returns control and possibly a value to the caller.

Example 7.74

```
(The Command Line Display of grades File before Sort)
% cat  grades
44 55 66 22 77 99
100 22 77 99 33 66
55 66 100 99 88 45

(The Script)
% cat sorter.sc
    # Script is called sorter
    # It sorts numbers in ascending order
1   function sort ( scores, num_elements, temp, i, j ) {
        # temp, i, and j will be local and private,
        # with an initial value of null.
2       for( i = 2; i <= num_elements ; ++i ) {
3          for ( j = i; scores [j−1] > scores[j]; −−j ){
```

```
              temp = scores[j]
              scores[j] = scores[j-1]
              scores[j-1] = temp
           }
4       }
5   }
6   {for ( i = 1; i <= NF; i++)
       grades[i]=$i
7   sort(grades, NF)    # Two arguments are passed
8   for( j = 1; j <= NF; ++j )
       printf( "%d ", grades[j] )
       printf("\n")
    }

(After the Sort)
% nawk -f sorter.sc grades
22 44 55 66 77 99
22 33 66 77 99 100
45 55 66 88 99 100
```

EXPLANATION

1. The function called sort is defined. The function can be defined anywhere in the script. All variables, except those passed as parameters, are global in scope. If changed in the function, they will be changed throughout the awk script. Arrays are passed by reference. Five formal arguments are enclosed within the parentheses. The array scores will be passed by reference, so that if any of the elements of the array are modified within the function, the original array will be modified. The variable num_elements is a local variable, a copy of the original. The variables temp, i, and j are local variables in the function.
2. The outer for loop will iterate through an array of numbers, as long as there are at least two numbers to compare.
3. The inner for loop will compare the current number with the previous number, scores[j –1]). If the previous array element is larger than the current one, temp will be assigned the value of the current array element, and the current array element will be assigned the value of the previous element.
4. The outer loop block ends.
5. This is the end of the function definition.
6. The first action block of the script starts here. The for loop iterates through each field of the current record, creating an array of numbers.
7. The sort function is called, passing the array of numbers from the current record and the number of fields in the current record.
8. When the sort function has completed, program control starts here. The for loop prints the elements in the sorted array.

7.13 Review

```
% cat datafile
northwest          NW   Joel Craig          3.0    .98    3    4
western            WE   Sharon Kelly        5.3    .97    5    23
southwest          SW   Chris Foster        2.7    .8     2    18
southern           SO   May Chin            5.1    .95    4    15
southeast          SE   Derek Johnson       4.0    .7     4    17
eastern            EA   Susan Beal          4.4    .84    5    20
northeast          NE   TJ Nichols          5.1    .94    3    13
north              NO   Val Shultz          4.5    .89    5    9
```

```
central             CT   Sheri Watson        5.7    .94    5    13
```

Example 7.75

```
% nawk '{if ( $8 > 15 ){ print $3 " has a high rating"}\
  else print $3 "---NOT A COMPETITOR---"}' datafile

Joel---NOT A COMPETITOR---
Sharon has a high rating
Chris has a high rating
May---NOT A COMPETITOR---
Derek has a high rating
Susan has a high rating
TJ---NOT A COMPETITOR---
Val---NOT A COMPETITOR---
Sheri---NOT A COMPETITOR---
```

EXPLANATION

The if statement is an action statement. If there is more than one statement following the expression, it must be enclosed in curly braces. (Curly braces are not required in this example, since there is only one statement following the expression.) The expression reads—if the eighth field is greater than 15, print the third field and the string has a high rating; else print the third field and −−−NOT A COMPETITOR−−−.

Example 7.76

```
% nawk '{i=1; while(i<=NF && NR < 2){print $i; i++}}' datafile
northwest
NW
Joel
Craig
3.0
.98
3
4
```

EXPLANATION

The user−defined variable i is assigned 1. The while loop is entered and the expression tested. If the expression evaluates true, the print statement is executed; the value of the ith field is printed. The value of i is printed, next the value is incremented by 1, and the loop is reentered. The loop expression will become false when the value of i is greater than NF and the value of NR is two or more. The variable i will not be reinitialized until the next record is entered.

```
% cat datafile
northwest           NW   Joel Craig          3.0    .98    3    4
western             WE   Sharon Kelly        5.3    .97    5    23
southwest           SW   Chris Foster        2.7    .8     2    18
southern            SO   May Chin            5.1    .95    4    15
southeast           SE   Derek Johnson       4.0    .7     4    17
eastern             EA   Susan Beal          4.4    .84    5    20
northeast           NE   TJ Nichols          5.1    .94    3    13
north               NO   Val Shultz          4.5    .89    5    9
central             CT   Sheri Watson        5.7    .94    5    13
```

Example 7.77

```
% nawk '{ for( i=3 ; i <= NF && NR == 3 ; i++ ){ print $i }}' datafile
Chris
Foster
2.7
.8
2
18
```

EXPLANATION

This is similar to the while loop in functionality. The initialization, test, and loop control statements are all in one expression. The value of i (i = 3) is initialized once for the current record. The expression is then tested. If i is less than or equal to NF, and NR is equal to 3, the print block is executed. After the value of the ith field is printed, control is returned to the loop expression. The value of i is incremented and the test is repeated.

Example 7.78

```
(The Command Line)
% cat nawk.sc4
# Awk script illustrating arrays
BEGIN{OFS="\t"}
{ list[NR] = $1 }   # The array is called list. The index in the
                    # number of the current record. The value of the
                    # first field is assigned to the array element.
END{ for( n = 1; n <= NR; n++){
         print list[n]} # for loop is used to loop
                        # through the array.
}
(The Command Line)
% nawk −f nawk.sc4 datafile
northwest
western
southwest
southern
southeast
eastern
northeast
north
central
```

EXPLANATION

The array, list, uses NR as an index value. Each time a line of input is processed, the first field is assigned to the list array. In the END block, the for loop iterates through each element of the array.

Example 7.79

```
(The Command Line)
% cat nawk.sc5
# Awk script with special for loop
/north/{name[count++]=$3}
END{ print "The number living in a northern district: " count
     print "Their names are: "
     for ( i in name )       # Special nawk for loop is used to
           print name[i]     # iterate through the array.
}
```

```
% nawk −f nawk.sc5 datafile
The number living in a northern district: 3
Their names are:
Joel
TJ
Val
```

EXPLANATION

Each time the regular expression north appears on the line, the name array is assigned the value of the third field. The index count is incremented each time a new record is processed, thus producing another element in the array. In the END block, the special for loop is used to iterate through the array.

```
% cat datafile
northwest          NW   Joel Craig          3.0    .98    3    4
western            WE   Sharon Kelly        5.3    .97    5    23
southwest          SW   Chris Foster        2.7    .8     2    18
southern           SO   May Chin            5.1    .95    4    15
southeast          SE   Derek Johnson       4.0    .7     4    17
eastern            EA   Susan Beal          4.4    .84    5    20
northeast          NE   TJ Nichols          5.1    .94    3    13
north              NO   Val Shultz          4.5    .89    5    9
central            CT   Sheri Watson        5.7    .94    5    13
```

Example 7.80

```
(The Command Line)
% cat nawk.sc6
# Awk and the special for loop
{region[$1]++}   # The index is the first field of each record

END{for(item in region){
        print region[item], item
    }
}

% nawk −f nawk.sc6 datafile
1 central
1 northwest
1 western
1 southeast
1 north
1 southern
1 northeast
1 southwest
1 eastern

% nawk −f nawk.sc6 datafile3
4 Mary
2 Tom
1 Alax
1 Bob
1 Sean
```

EXPLANATION

The region array uses the first field as an index. The value stored is the number of times each region was found. The END block uses the special awk for loop to iterate through the array called region.

UNIX TOOLS LAB EXERCISE

Lab 6: nawk Exercise

Mike Harrington:(510) 548−1278:250:100:175

Christian Dobbins:(408) 538−2358:155:90:201

Susan Dalsass:(206) 654−6279:250:60:50

Archie McNichol:(206) 548−1348:250:100:175

Jody Savage:(206) 548−1278:15:188:150

Guy Quigley:(916) 343−6410:250:100:175

Dan Savage:(406) 298−7744:450:300:275

Nancy McNeil:(206) 548−1278:250:80:75

John Goldenrod:(916) 348−4278:250:100:175

Chet Main:(510) 548−5258:50:95:135

Tom Savage:(408) 926−3456:250:168:200

Elizabeth Stachelin:(916) 440−1763:175:75:300

(Refer to the database called lab6.data on the CD.)

The database above contains the names, phone numbers, and money contributions to the party campaign for the past three months.

1. Write a `nawk` script that will produce the following report:

```
                    ***FIRST QUARTERLY REPORT***
                  ***CAMPAIGN 1998 CONTRIBUTIONS***
----------------------------------------------------------------------
   NAME                 PHONE     Jan  |  Feb  |  Mar  |  Total Donated
----------------------------------------------------------------------
Mike Harrington     (510) 548−1278  250.00  100.00  175.00   525.00
Christian Dobbins   (408) 538−2358  155.00   90.00  201.00   446.00
Susan Dalsass       (206) 654−6279  250.00   60.00   50.00   360.00
Archie McNichol     (206) 548−1348  250.00  100.00  175.00   525.00
Jody Savage         (206) 548−1278   15.00  188.00  150.00   353.00
Guy Quigley         (916) 343−6410  250.00  100.00  175.00   525.00
Dan Savage          (406) 298−7744  450.00  300.00  275.00  1025.00
```

```
Nancy McNeil        (206) 548−1278  250.00   80.00   75.00   405.00
John Goldenrod      (916) 348−4278  250.00  100.00  175.00   525.00
Chet Main           (510) 548−5258   50.00   95.00  135.00   280.00
Tom Savage          (408) 926−3456  250.00  168.00  200.00   618.00
Elizabeth Stachelin (916) 440−1763  175.00   75.00  300.00   550.00
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
                                    SUMMARY
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
The campaign received a total of $6137.00 for this quarter.
The average donation for the 12 contributors was $511.42.
The highest total contribution was $1025.00 made by Dan Savage.
                      ***THANKS Dan***
The following people donated over $500 to the campaign.
They are eligible for the quarterly drawing!!
Listed are their names (sorted by last names) and phone numbers:
   John Goldenrod−−(916) 348−4278
   Mike Harrington−−(510) 548−1278
   Archie McNichol−−(206) 548−1348
   Guy Quigley−−(916) 343−6410
   Dan Savage−−(406) 298−7744
   Tom Savage−−(408) 926−3456
   Elizabeth Stachelin−−(916) 440−1763
      Thanks to all of you for your continued support!!
```

7.14 Odds and Ends

Some data (e.g., that read in from tape or from a spreadsheet) may not have obvious field separators but may instead have fixed−width columns. To preprocess this type of data, the substr function is useful.

7.14.1 Fixed Fields

In the following example, the fields are of a fixed width, but are not separated by a field separator. The substr function is used to create fields.

Example 7.81

```
% cat fixed
031291ax5633(408)987−0124
021589bg2435(415)866−1345
122490de1237(916)933−1234
010187ax3458(408)264−2546
092491bd9923(415)134−8900
112990bg4567(803)234−1456
070489qr3455(415)899−1426

% nawk '{printf substr($0,1,6)" ";printf substr($0,7,6)" ";\
  print substr($0,13,length)}' fixed
031291  ax5633  (408)987−0124
021589  bg2435  (415)866−1345
122490  de1237  (916)933−1234
010187  ax3458  (408)264−2546
092491  bd9923  (415)134−8900
112990  bg4567  (803)234−1456
070489  qr3455  (415)899−1426
```

EXPLANATION

The first field is obtained by getting the substring of the entire record, starting at the first character, offset by 6 places. Next, a space is printed. The second field is obtained by getting the substring of the record, starting at position 7, offset by 6 places, followed by a space. The last field is obtained by getting the substring of the entire record, starting at position 13 to the position represented by the length of the line. (The length function returns the length of the current line, $0, if it does not have an argument.)

Empty Fields. If the data is stored in fixed−width fields, it is possible that some of the fields are empty. In the following example, the substr function is used to preserve the fields, regardless of whether they contain data.

Example 7.82

```
1   % cat db
    xxx xxx
    xxx abc xxx
    xxx a   bbb
    xxx     xx

    % cat awkfix
    # Preserving empty fields. Field width is fixed.
    {
2   f[1]=substr($0,1,3)
3   f[2]=substr($0,5,3)
4   f[3]=substr($0,9,3)
5   line=sprintf("%−4s%−4s%−4s\n", f[1],f[2], f[3])
6   print line
    }
    % nawk –f awkfix db
    xxx xxx
    xxx abc xxx
    xxx a   bbb
    xxx     xx
```

EXPLANATION

1. The contents of the file db are printed. There are empty fields in the file.
2. The first element of the f array is assigned the substring of the record, starting at position 1 and offset by 3.
3. The second element of the f array is assigned the substring of the record, starting at position 5 and offset by 3.
4. The third element of the f array is assigned the substring of the record, starting at position 9 and offset by 3.
5. The elements of the array are assigned to the user−defined variable line after being formatted by the sprintf function.
6. The value of line is printed and the empty fields are preserved.

Numbers with $, Commas, or Other Characters. In the following example, the price field contains a dollar sign and comma. The script must eliminate these characters to add up the prices to get the total cost. This is done using the gsub function.

Example 7.83

```
% cat vendor
access tech:gp237221:220:vax789:20/20:11/01/90:$1,043.00
alisa systems:bp262292:280:macintosh:new updates:06/30/91:$456.00
alisa systems:gp262345:260:vax8700:alisa talk:02/03/91:$1,598.50
apple computer:zx342567:240:macs:e–mail:06/25/90:$575.75
caci:gp262313:280:sparc station:network11.5:05/12/91:$1,250.75
datalogics:bp132455:260:microvax2:pagestation maint:07/01/90:$1,200.00
dec:zx354612:220:microvax2:vms sms:07/20/90:$1,350.00

% nawk –F: '{gsub(/\$/,"");gsub(/,/,""); cost +=$7};\

END{print "The total is $" cost}' vendor
$7474
```

EXPLANATION

The first gsub function globally substitutes the literal dollar sign (\$) with the null string, and the second gsub function substitutes commas with a null string. The user−defined cost variable is then totalled by adding the seventh field to cost and assigning the result back to cost. In the END block, the string The total cost is $ is printed, followed by the value of cost.[1]

7.14.2 Bundling and Unbundling Files

The Bundle Program. In *The AWK Programming Language*, the program to bundle files together is very short and to the point. We are trying to combine several files into one file to save disk space, to send files through electronic mail, and so forth. The following awk command will print every line of each file, preceded with the filename.

Example 7.84

```
% nawk '{ print FILENAME, $0 }' file1 file2 file3 > bundled
```

EXPLANATION

The name of the current input file, FILENAME, is printed, followed by the record ($0) for each line of input in file1. After file1 has reached the end of file, awk will open the next file, file2, and do the same thing, and so on. The output is redirected to a file called bundled.

Unbundle. The following example displays how to unbundle files, or put them back into separate files.

Example 7.85

```
%  nawk '$1 != previous { close(previous); previous=$1};\
   {print substr($0, index($0, " ") + 1) > $1}' bundled
```

EXPLANATION

The first field is the name of the file. If the name of the file is not equal to the value of the user−defined variable previous (initially null), the action block is executed. The file assigned to previous is closed, and previous is assigned the value of the first field. Then the substr of the record, the starting position returned from the index function (the position of the first space + 1), is redirected to the filename contained in the first field.

To bundle the files so that the filename appears on a line by itself, above the contents of the file use, the following command:

```
% nawk '{if(FNR==1){print FILENAME;print $0}\
  else print $0}'  file1 file2 file3 > bundled
```

The following command will unbundle the files:

```
% nawk 'NF==1{filename=$NF} ;\
  NF != 1{print $0 > filename}' bundled
```

7.14.3 Multiline Records

In the sample data files used so far, each record is on a line by itself. In the following sample datafile, called checkbook, the records are separated by blank lines and the fields are separated by newlines. To process this file, the record separator (RS) is assigned a value of null, and the field separator (FS) is assigned the newline.

Example 7.86

```
(The Input File)
% cat checkbook
1/1/01
#125
-695.00
Mortgage

1/1/01
#126
-56.89
PG&E
1/2/01
#127
-89.99
Safeway

1/3/01
+750.00
Pay Check

1/4/01
#128
-60.00
Visa

(The Script)
   % cat awkchecker
   BEGIN{RS=""; FS="\n";ORS="\n\n"}
   {print  NR, $1,$2,$3,$4}

(The Output)
% nawk -f awkchecker checkbook
1 1/1/01  #125  -695.00  Mortgage

2 1/1/01  #126  -56.89  PG&E

3 1/2/01  #127  -89.99  Safeway

4 1/3/01  +750.00  Pay Check

5 1/4/01  #128  -60.00  Visa
```

EXPLANATION

1. In the BEGIN block, the record separator (RS) is assigned null, the field separator (FS) is assigned a newline, and the output record separator (ORS) is assigned two newlines. Now each line is a field and each output record is separated by two newlines.
2. The number of the record is printed, followed by each of the fields.

7.14.4 Generating Form Letters

The following example is modified from a program in *The AWK Programming Language*.[2] The tricky part of this is keeping track of what is actually being processed. The input file is called data.form. It contains just the data. Each field in the input file is separated by colons. The other file is called form.letter. It is the actual form that will be used to create the letter. This file is loaded into awk's memory with the getline function. Each line of the form letter is stored in an array. The program gets its data from data.form, and the letter is created by substituting real data for the special strings preceded by # and @ found in form.letter. A temporary variable, temp, holds the actual line that will be displayed after the data has been substituted. This program allows you to create personalized form letters for each person listed in data.form.

Example 7.87

```
(The Awk Script)
% cat form.awk
# form.awk is an awk script that requires access to 2 files: The
# first file is called "form.letter." This file contains the
# format for a form letter. The awk script uses another file,
# "data.form," as its input file. This file contains the
# information that will be substituted into the form letters in
# the place of the numbers preceded by pound signs. Today's date
# is substituted in the place of "@date" in "form.letter."
1   BEGIN{ FS=":"; n=1
2   while(getline < "form.letter" >  0)
3       form[n++] = $0   # Store lines from form.letter in an array
4   "date" | getline d; split(d, today, " ")
        # Output of date is Fri Mar 2 14:35:50   PST 2001
5   thisday=today[2]". "today[3]", "today[6]
6   }
7   { for( i = 1; i < n; i++ ){
8       temp=form[i]
9       for ( j = 1; j <=NF; j++ ){
           gsub("@date", thisday, temp)
10         gsub("#" j, $j , temp )
        }
11  print temp
    }
    }

% cat form.letter
   The form letter, form.letter, looks like this:
*********************************************************
   Subject: Status Report for Project "#1"
   To: #2
   From: #3
   Date: @date
   This letter is to tell you, #2, that project "#1" is up to
   date.
   We expect that everything will be completed and ready for
   shipment as scheduled on #4.
```

```
   Sincerely,

   #3
*********************************************************
The file, data.form, is awk's input file containing the data that will
replace the #1–4 and the @date in form.letter.

% cat data.form
   Dynamo:John Stevens:Dana Smith, Mgr:4/12/2001
   Gallactius:Guy Sterling:Dana Smith, Mgr:5/18/2001

(The Command Line)

   % nawk  –f form.awk  data.form
   *********************************************************
   Subject: Status Report for Project "Dynamo"
   To: John Stevens
   From: Dana Smith, Mgr
   Date: Mar. 2, 2001
   This letter is to tell you, John Stevens, that project
   "Dynamo" is up to date.
   We expect that everything will be completed and ready for
   shipment as scheduled on 4/12/2001.

   Sincerely,

   Dana Smith, Mgr
   Subject: Status Report for Project "Gallactius"
   To: Guy Sterling
   From: Dana Smith, Mgr
   Date: Mar. 2, 2001
   This letter is to you, Guy Sterling, that project "Gallactius"
   is up to date.
   We expect that everything will be completed and ready for
   shipment as scheduled on 5/18/2001.

   Sincerely,

   Dana Smith, Mgr
```

EXPLANATION

1. In the BEGIN block, the field separator (FS) is assigned a colon; a user−defined variable n is assigned 1.
2. In the while loop, the getline function reads a line at a time from the file called form.letter. If getline fails to find the file, it returns a –1. When it reaches the end of file, it returns zero. Therefore, by testing for a return value of greater than one, we know that the function has read in a line from the input file.
3. Each line from form.letter is assigned to an array called form.
4. The output from the UNIX date command is piped to the getline function and assigned to the user−defined variable d. The split function then splits up the variable d with whitespace, creating an array called today.
5. The user−defined variable thisday is assigned the month, day, and year.
6. The BEGIN block ends.
7. The for loop will loop n times.
8. The user−defined variable temp is assigned a line from the form array.

9. The nested for loop is looping through a line from the input file, data.form, NF number of times. Each line stored in the temp variable is checked for the string @date. If @date is matched, the gsub function replaces it with today's date (the value stored in this day).
10. If a # and a number are found in the line stored in temp, the gsub function will replace the # and number with the value of the corresponding field in the input file, data.form. For example, if the first line stored is being tested, #1 would be replaced with Dynamo, #2 with John Stevens, #3 with Dana Smith, #4 with 4/12/2001, and so forth.
11. The line stored in temp is printed after the substitutions.

7.14.5 Interaction with the Shell

Now that you have seen how awk works, you will find that awk is a very powerful utility when writing shell scripts. You can embed one−line awk commands or awk scripts within your shell scripts. The following is a sample of a Korn shell program embedded with awk commands.

Example 7.88

```
!#/bin/ksh
# This korn shell script will collect data for awk to use in
# generating form letter(s). See above.
print "Hello $LOGNAME. "
print "This report is for the month and year:"
1   cal | nawk 'NR==1{print $0}'

    if [[ -f data.form  || -f formletter? ]]
    then
       rm data.form formletter?  2> /dev/null
    fi
    integer num=1
    while true
    do
       print "Form letter #$num:"
       read project?"What is the name of the project? "
       read sender?"Who is the status report from? "
       read recipient?"Who is the status report to? "
       read due_date?"What is the completion date scheduled? "
       echo $project:$recipient:$sender:$due_date > data.form
       print -n "Do you wish to generate another form letter? "
       read answer
       if [[ "$answer" != [Yy]* ]]
       then
              break
       else
2             nawk -f form.awk  data.form  > formletter$num
       fi
       (( num+=1 ))
    done
    nawk -f form.awk data.form > formletter$num
```

EXPLANATION

1. The UNIX cal command is piped to awk. The first line that contains the current month and year is printed.
2. The nawk script form.awk generates form letters, which are redirected to a UNIX file.

7.15 Review

7.15.1 String Functions

```
% cat datafile
northwest          NW   Joel Craig         3.0    .98    3    4
western            WE   Sharon Kelly       5.3    .97    5    23
southwest          SW   Chris Foster       2.7    .8     2    18
southern           SO   May Chin           5.1    .95    4    15
southeast          SE   Derek Johnson      4.0    .7     4    17
eastern            EA   Susan Beal         4.4    .84    5    20
northeast          NE   TJ Nichols         5.1    .94    3    13
north              NO   Val Shultz         4.5    .89    5    9
central            CT   Sheri Watson       5.7    .94    5    13
```

Example 7.89

```
% nawk 'NR==1{gsub(/northwest/,"southeast", $1) ;print}' datafile
southeast     NW     Joel Craig         3.0  .98  3   4
```

> **EXPLANATION**
>
> If this is the first record (NR == 1), globally substitute the regular expression northwest with southeast, if northwest is found in the first field.

Example 7.90

```
% nawk 'NR==1{print substr($3, 1, 3)}' datafile
Joe
```

> **EXPLANATION**
>
> If this is the first record, display the substring of the third field, starting at the first character, and extracting a length of 3 characters. The substring Joe is printed.

Example 7.91

```
% nawk 'NR==1{print length($1)}' datafile
9
```

> **EXPLANATION**
>
> If this is the first record, the length (number of characters) in the first field is printed.

Example 7.92

```
% nawk 'NR==1{print index($1,"west")}' datafile
6
```

> **EXPLANATION**
>
> If this is the first record, print the first position where the substring west is found in the first field. The string west starts at the sixth position (index) in the string northwest.

Example 7.93

```
% nawk '{if(match($1,/^no/)){print substr($1,RSTART,RLENGTH)}}'\
  datafile
no
no
no
```

EXPLANATION

If the match function finds the regular expression /^no/ in the first field, the index position of the leftmost character is returned. The built−in variable RSTART is set to the index position and the RLENGTH variable is set to the length of the matched substring. The substr function returns the string in the first field starting at position RSTART, RLENGTH number of characters.

Example 7.94

```
% nawk 'BEGIN{split("10/14/01",now,"/");print now[1],now[2],now[3]}'
10 14 01
```

EXPLANATION

The string 10/14/01 is split into an array called now. The delimiter is the forward slash. The elements of the array are printed, starting at the first element of the array.

```
% cat datafile2
Joel Craig:northwest:NW:3.0:.98:3:4
Sharon Kelly:western:WE:5.3:.97:5:23
Chris Foster:southwest:SW:2.7:.8:2:18
May Chin:southern:SO:5.1:.95:4:15
Derek Johnson:southeast:SE:4.0:.7:4:17
Susan Beal:eastern:EA:4.4:.84:5:20
TJ Nichols:northeast:NE:5.1:.94:3:13
Val Shultz:north:NO:4.5:.89:5:9
Sheri Watson:central:CT:5.7:.94:5:13
```

Example 7.95

```
% nawk −F: '/north/{split($1, name, " ");\
  print "First name: "name[1];\
  print "Last name: " name[2];\
  print "\n−−−−−−−−−−−−−−−−−−−−"}' datafile2

First name: Joel
Last name: Craig
−−−−−−−−−−−−−−−−−−−−
First name: TJ
Last name: Nichols
−−−−−−−−−−−−−−−−−−−−
First name: Val
last name: Shultz
−−−−−−−−−−−−−−−−−−−−
```

EXPLANATION

The input field separator is set to a colon (–F:). If the record contains the regular expression north, the first field is split into an array called name, where a space is the delimiter. The elements of the array are printed.

```
% cat datafile
northwest          NW   Joel Craig          3.0    .98    3    4
western            WE   Sharon Kelly        5.3    .97    5    23
southwest          SW   Chris Foster        2.7    .8     2    18
southern           SO   May Chin            5.1    .95    4    15
southeast          SE   Derek Johnson       4.0    .7     4    17
eastern            EA   Susan Beal          4.4    .84    5    20
northeast          NE   TJ Nichols          5.1    .94    3    13
north              NO   Val Shultz          4.5    .89    5    9
central            CT   Sheri Watson        5.7    .94    5    13
```

Example 7.96

```
% nawk '{line=sprintf("%10.2f%5s\n",$7,$2); print line}' datafile
3.00   NW
5.00   WE
2.00   SW
4.00   SO
4.00   SE
5.00   EA
3.00   NE
5.00   NO
5.00   CT
```

EXPLANATION

The sprintf function formats the seventh and the second fields ($7, $2) using the formatting conventions of the printf function. The formatted string is returned and assigned to the user−defined variable line and printed.

7.15.2 Command Line Arguments

Example 7.97

```
% cat argvs.sc
# Testing command line arguments with ARGV and ARGC using a for loop.

BEGIN{
    for(i=0;i < ARGC;i++)
       printf("argv[%d] is %s\n", i, ARGV[i])
       printf("The number of arguments, ARGC=%d\n", ARGC)
}

% nawk −f argvs.sc datafile
argv[0] is nawk
argv[1] is datafile
The number of arguments, ARGC=2
```

EXPLANATION

The BEGIN block contains a for loop to process the command line arguments. ARGC is the number of arguments and ARGV is an array that contains the actual arguments. Nawk does not count options as arguments. The only valid arguments in this example are the nawk command and the input file, datafile.

Example 7.98

```
% nawk 'BEGIN{name=ARGV[1]};\
  $0 ~ name {print $3 , $4}'  "Derek" datafile
nawk: can't open Derek
source line number 1


% nawk 'BEGIN{name=ARGV[1]; delete ARGV[1]};\
  $0 ~ name {print $3, $4}'  "Derek" datafile
Derek Johnson
```

EXPLANATION

1. The name "Derek" was set to the variable name in the BEGIN block. In the pattern−action block, nawk attempted to open "Derek" as an input file and failed.
2. After assigning "Derek" to the variable name, ARGV[1] is deleted. When starting the pattern−action block, nawk does not try to open "Derek" as the input file, but opens datafile instead.

```
% cat datafile
northwest          NW   Joel Craig         3.0    .98    3    4
western            WE   Sharon Kelly       5.3    .97    5    23
southwest          SW   Chris Foster       2.7    .8     2    18
southern           SO   May Chin           5.1    .95    4    15
southeast          SE   Derek Johnson      4.0    .7     4    17
eastern            EA   Susan Beal         4.4    .84    5    20
northeast          NE   TJ Nichols         5.1    .94    3    13
north              NO   Val Shultz         4.5    .89    5    9
central            CT   Sheri Watson       5.7    .94    5    13
```

7.15.3 Reading Input (getline)

Example 7.99

```
% nawk 'BEGIN{ "date" | getline d; print d}' datafile
Mon Jan 15 11:24:24 PST 2001
```

EXPLANATION

The UNIX date command is piped to the getline function. The results are stored in the variable d and printed.

Example 7.100

```
% nawk 'BEGIN{ "date " | getline d; split( d, mon) ;print mon[2]}'\
  datafile
Jan
```

EXPLANATION

The UNIX date command is piped to the getline function and the results are stored in d. The split function splits the string d into an array called mon. The second element of the array is printed.

Example 7.101

```
% nawk 'BEGIN{ printf "Who are you looking for?" ; \
  getline name < "/dev/tty"};\
```

EXPLANATION

Input is read from the terminal, /dev/tty, and stored in the array called name.

Example 7.102

```
% nawk 'BEGIN{while(getline < "/etc/passwd"  > 0 ){lc++}; print lc}'\
  datafile
16
```

EXPLANATION

The while loop is used to loop through the /etc/passwd file one line at a time. Each time the loop is entered, a line is read by getline and the value of the variable lc is incremented. When the loop exits, the value of lc is printed, i.e., the number of lines in the /etc/passwd file. As long as the return value from getline is not 0, i.e., a line has been read, the looping continues.

7.15.4 Control Functions

Example 7.103

```
% nawk '{if ( $5 > 4.5) next; print $1}' datafile
northwest
southwest
southeast
eastern
north
```

EXPLANATION

If the fifth field is greater than 4.5, the next line is read from the input file (datafile) and processing starts at the beginning of the awk script (after the BEGIN block). Otherwise, the first field is printed.

Example 7.104

```
% nawk '{if ($2 ~ /S/){print ; exit 0}}' datafile
southwest       SW      Chris   Foster  2.7     .8      2       18

% echo $status ( csh ) or echo $? (sh or ksh)
0
```

EXPLANATION

If the second field contains an S, the record is printed and the awk program exits. The C shell status variable contains the exit value. If using the Bourne or Korn shells, the $? variable contains the exit status.

```
% cat datafile
northwest          NW   Joel Craig          3.0    .98    3    4
western            WE   Sharon Kelly        5.3    .97    5    23
southwest          SW   Chris Foster        2.7    .8     2    18
southern           SO   May Chin            5.1    .95    4    15
southeast          SE   Derek Johnson       4.0    .7     4    17
eastern            EA   Susan Beal          4.4    .84    5    20
northeast          NE   TJ Nichols          5.1    .94    3    13
north              NO   Val Shultz          4.5    .89    5    9
central            CT   Sheri Watson        5.7    .94    5    13
```

7.15.5 User−Defined Functions

Example 7.105

```
(The Command Line)
% cat nawk.sc7
1  BEGIN{largest=0}
2  {maximum=max($5)}

3  function max ( num ) {
4     if ( num > largest){ largest=num }
      return largest
5  }
6  END{ print "The maximum is " maximum "."}

% nawk −f nawk.sc7 datafile
The maximum is 5.7.
```

EXPLANATION

1. In the BEGIN block, the user−defined variable largest is initialized to zero.
2. For each line in the file, the variable maximum is assigned the value returned from the function max. The function max is given $5 as its argument.
3. The user−defined function max is defined. The function statements are enclosed in curly braces. Each time a new record is read from the input file, datafile, the function max will be called.
4. It will compare the values in num and largest and return the larger of the two numbers.
5. The function definition block ends.
6. The END block prints the final value in maximum.

UNIX TOOLS LAB EXERCISE

Lab 7: nawk Exercise

Mike Harrington:(510) 548−1278:250:100:175

Christian Dobbins:(408) 538−2358:155:90:201

Susan Dalsass:(206) 654−6279:250:60:50

Archie McNichol:(206) 548−1348:250:100:175

Jody Savage:(206) 548−1278:15:188:150

Guy Quigley:(916) 343−6410:250:100:175

Dan Savage:(406) 298−7744:450:300:275

Nancy McNeil:(206) 548−1278:250:80:75

John Goldenrod:(916) 348−4278:250:100:175

Chet Main:(510) 548−5258:50:95:135

Tom Savage:(408) 926−3456:250:168:200

Elizabeth Stachelin:(916) 440−1763:175:75:300

(Refer to the database called lab7.data on the CD.)

The database above contains the names, phone numbers, and money contributions to the party campaign for the past three months.

1: Write a user−defined function to return the average of all the contributions for a given month. The month will be passed in at the command line.

[1] For details on how commas are added back into the program, see Alfred V. Aho, Brian W. Kernighan, and Peter J. Weinberger, *The AWK Programming Language* (Boston: Addison−Wesley, 1988), p. 72.

[2] Alfred V. Aho, Brian W. Kernighan, and Peter J. Weinberger, *The AWK Programming Language* (Boston: Addison−Wesley, 1988). © 1988 Bell Telephone Laboratories, Inc. Reprinted by permission of Pearson Education, Inc.

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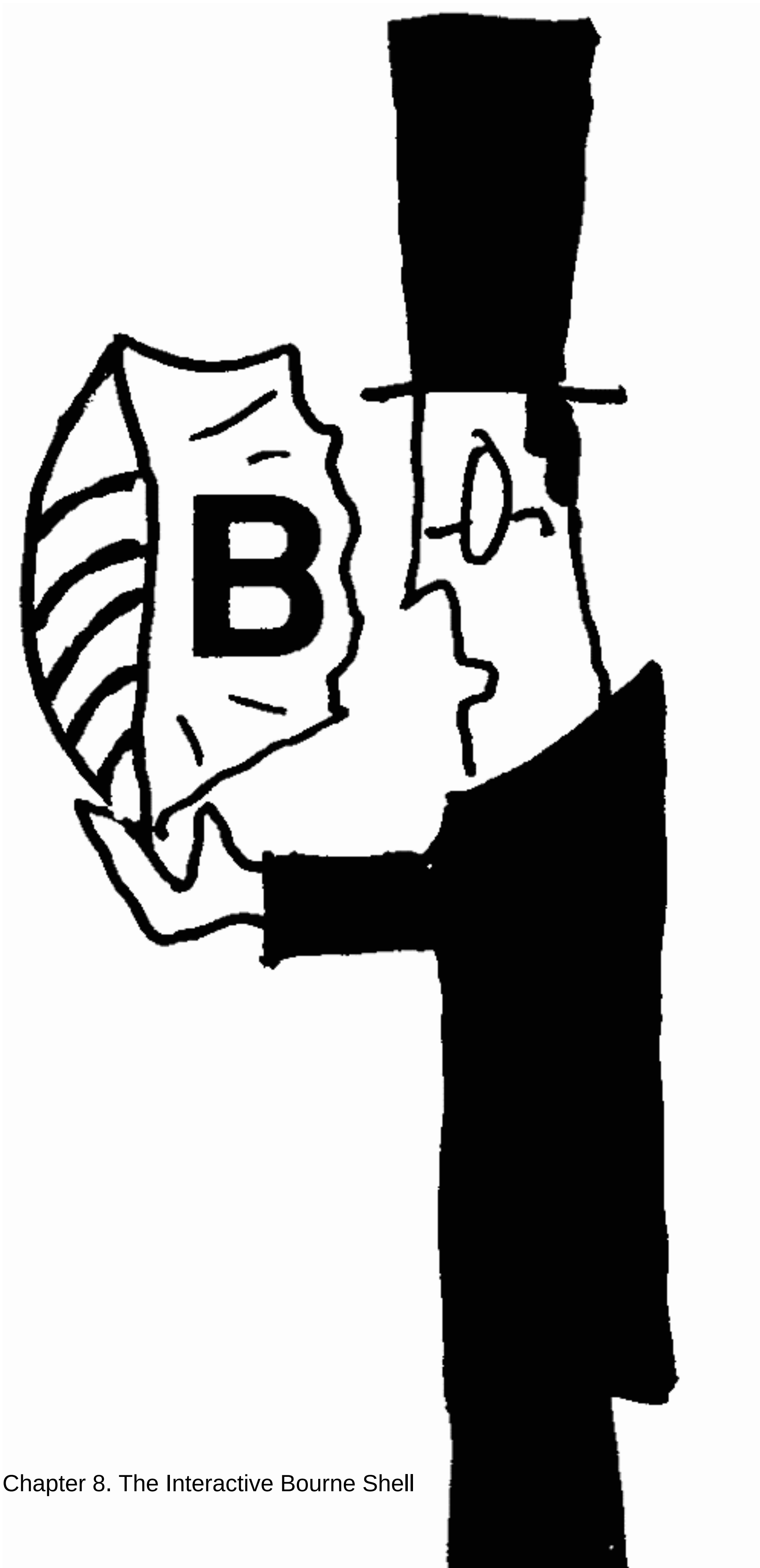
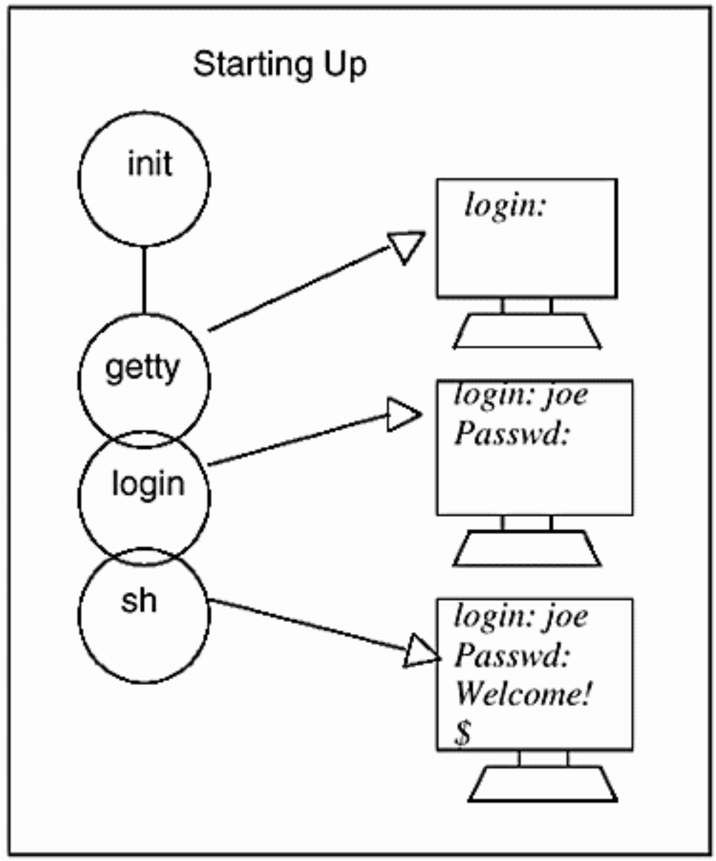
Chapter 8. The Interactive Bourne Shell


B

8.1 Startup

If the Bourne shell is your login shell, it follows a chain of processes before you see a shell prompt.

Figure 8.1. Starting the Bourne shell.



The first process to run is called init, PID 1. It gets instructions from a file called inittab (System V), or it spawns a getty process (BSD). These processes open up the terminal ports, providing a place where standard input comes from and a place where standard output and error go, and they put a login prompt on your screen. The /bin/login program is then executed. The login program prompts for a password, encrypts and verifies the password, sets up an initial environment, and starts up the login shell, /bin/sh, the last entry in the passwd file. The sh process looks for the system file, /etc/profile, and executes its commands. It then looks in the user's home directory for an initialization file called .profile. After executing commands from .profile, the default dollar sign ($) prompt appears on your screen and the Bourne shell awaits commands.

8.1.1 The Environment

The environment of a process consists of variables, open files, the current working directory, functions, resource limits, signals, and so forth. It defines those features that are inherited from one shell to the next and the configuration for the working environment. The configuration for the user's shell is defined in the shell initialization files.

The Initialization Files. After the Bourne shell program starts up, it first checks for the system file /etc/profile. After executing the commands in that file, the initialization file, .profile, in the user's home directory, is executed. Skeleton files for initial setup can be found in /etc/skel (SVR4).

The /etc/profile File. The /etc/profile file is a systemwide initialization file set up by the system administrator to perform tasks when the user logs on. It is executed when the Bourne shell starts up. It is available to all Bourne and Korn shell users on the system and normally performs such tasks as checking the mail spooler for new mail and displaying the message of the day from the /etc/motd file. (The following examples will make more sense after you have completed this chapter.)

Example 8.1

```
(Sample /etc/profile)
# The profile that all logins get before using their own .profile
1   trap " " 2 3
2   export LOGNAME PATH
3   if [ "$TERM" = " " ]
    then
        if /bin/i386
        then
             TERM=AT386   # Sets the terminal
        else
             TERM=sun
        fi
        export TERM
    fi
    # Login and −su shells get /etc/profile services.
    # −rsh is given its environment in its own .profile.
4      case "$0" in
       −sh | −ksh | −jsh )
5          if [ ! −f .hushlogin ]
           then
              /usr/sbin/quota
              # Allow the user to break the Message−Of−The−
              # Day only.
6             trap "trap ' ' 2" 2
7             /bin/cat −s /etc/motd
              # Message of the day displayed
              trap " " 2
8             /bin/mail −E      # Checks for new mail
9             case $? in
              0)
                   echo "You have new mail. "
              ;  ;
              2)
                   echo "You have mail. "
                   ;;
              esac
           fi
       esac
10     umask 022
11     trap 2 3
```

EXPLANATION

1. The trap command controls signals coming into this program while it is running. If signals 2 (Control−C) or 3 (Control−\) are sent while the program is in execution, those signals will be ignored.
2. The variables LOGNAME and PATH are exported so that their values will be known in subshells started from this process.
3. The command /bin/i386 is executed. If the exit status of the command is zero, the terminal

variable, TERM, is assigned the value AT386; if not, the TERM variable is assigned sun.

4. If the value of $0, the name of the program running the /etc/profile file, is either a login or Bourne, Korn, or job shell, the following commands will be executed.
5. If the .hushlogin file does not exist, quota will be run to display the disk usage warnings if usage is over the quota.
6. The trap is reset so that the user can terminate the message of the day with Control−C.
7. After the message of the day has been displayed, the trap is reset to ignore Control−C.
8. The mail program checks for new incoming mail.
9. If the exit status ($?) of the mail program is 0 or 2, the message "You have new mail." or "You have mail.", respectively, is displayed.
10. The umask command is set to determine the initial permissions of files and directories when they are created.
11. The trap command sets signals 2 and 3 back to their defaults; i.e., to kill the program if either Control−C or Control−\ arrive.

The .profile File. The .profile file is a user−defined initialization file executed once at login and found in your home directory. It gives you the ability to customize and modify the shell environment. Environment and terminal settings are normally put here, and if a window application or database application is to be initiated, it is started here. The settings in this file will be discussed in detail as the chapter progresses, but a brief synopsis of each line in the file is explained here.

Example 8.2

```
(Sample .profile)

1   TERM=vt102
2   HOSTNAME='uname −n'
3   EDITOR=/usr/ucb/vi
4   PATH=/bin:/usr/ucb:/usr/bin:/usr/local:/etc:/bin:/usr/bin:
5   PS1="$HOSTNAME $ > "
6   export TERM HOSTNAME EDITOR PATH PS1
7   stty erase ^h
8   go () { cd $1; PS1='pwd'; PS1='basename $PS1'; }
9   trap '$HOME/.logout' EXIT
10  clear
```

EXPLANATION

1. The TERM variable is assigned the value of the terminal type, vt102.
2. Because the uname –n command is enclosed in backquotes, the shell will perform command substitution, i.e., the output of the command (the name of the host machine) will be assigned to the variable HOSTNAME.
3. The EDITOR variable is assigned /usr/ucb/vi. Programs such as mail will now have this variable available when defining an editor.
4. The PATH variable is assigned the directory entries that the shell searches in order to find a UNIX program. If, for example, you type ls, the shell will search the PATH until it finds that program in one of the listed directories. If it never finds the program, the shell will tell you so.
5. The primary prompt is assigned the value of HOSTNAME, the machine name, and the $ and > symbols.
6. All of the variables listed are exported. They will be known by child processes started from this shell.

7. The stty command sets terminal options. The erase key is set to ^h, so that when you press the Backspace key, the letter typed preceding the cursor is erased.
8. A function called go is defined. The purpose of this function is to take one argument, a directory name, cd to that directory, and set the primary prompt to the present working directory. The basename command removes all but the last entry of the path. The prompt will show you the current directory.
9. The trap command is a signal handling command. When you exit the shell, that is, log out, the .logout file will be executed.
10. The clear command clears the screen.

The Prompts. When used interactively, the shell prompts you for input. When you see the prompt, you know that you can start typing commands. The Bourne shell provides two prompts: the primary prompt, a dollar sign ($), and the secondary prompt, a right angle bracket symbol (>). The prompts are displayed when the shell is running interactively. You can change these prompts. The variable PS1 is the primary prompt set initially to a dollar sign ($). The primary prompt appears when you log on and the shell waits for you to type commands. The variable PS2 is the secondary prompt, initially set to the right angle bracket character. It appears if you have partially typed a command and then pressed the carriage return. You can change the primary and secondary prompts.

The Primary Prompt. The dollar sign is the default primary prompt. You can change your prompt. Normally prompts are defined in .profile, the user initialization file.

Example 8.3

```
1   $ PS1="'uname –n > '"
2   chargers >
```

EXPLANATION

1. The default primary prompt is a dollar sign ($). The PS1 prompt is being reset to the name of the machine (uname –n) and a > symbol. (Don't confuse backquotes and single quotes.)
2. The new prompt is displayed.

The Secondary Prompt. The PS2 prompt is the secondary prompt. Its value is displayed to standard error, which is the screen by default. This prompt appears when you have not completed a command and have pressed the carriage return.

Example 8.4

```
1   $ echo "Hello
2   > there"
3   Hello
    there
4   $

5   $ PS2="----> "
6   $ echo 'Hi
7   ------>
    ------>
    ------> there'
    Hi


    there
    $
```

EXPLANATION

1. The double quotes must be matched after the string "Hello.
2. When a newline is entered, the secondary prompt appears. Until the closing double quotes are entered, the secondary prompt will be displayed.
3. The output of the echo command is displayed.
4. The primary prompt is displayed.
5. The secondary prompt is reset.
6. The single quote must be matched after the string 'Hi.
7. When a newline is entered, the new secondary prompt appears. Until the closing single quote is entered, the secondary prompt will be displayed.

The Search Path. The path variable is used by the Bourne shell to locate commands typed at the command line. The path is a colon−separated list of directories used by the shell when searching for commands. The search is from left to right. The dot at the end of the path represents the current working directory. If the command is not found in any of the directories listed in the path, the Bourne shell sends to standard error the message filename: not found. It is recommended that the path be set in the .profile file.

If the dot is not included in the path and you are executing a command or script from the current working directory, the name of the script must be preceded with a ./, such as ./program_name, so that shell can find the program.

Example 8.5

```
(Printing the PATH)
1   $ echo $PATH
/home/gsa12/bin:/usr/ucb:/usr/bin:/usr/local/bin:/usr/bin:/usr/local/bin:.

(Setting the PATH)
2   $ PATH=$HOME:/usr/ucb:/usr:/usr/bin:/usr/local/bin:.
3   $ export PATH
```

EXPLANATION

1. By echoing $PATH, the value of the PATH variable is displayed. The path consists of a list of colon−separated elements and is searched from left to right. The dot at the end of the path represents the user's current working directory.
2. To set the path, a list of colon−separated directories are assigned to the PATH variable.
3. By exporting the path, child processes will have access to it.

The hash Command. The hash command controls the internal hash table used by the shell to improve efficiency in searching for commands. Instead of searching the path each time a command is entered, the first time you type a command, the shell uses the search path to find the command, and then stores it in a table in the shell's memory. The next time you use the same command, the shell uses the hash table to find it. This makes it much faster to access a command than having to search the complete path. If you know that you will be using a command often, you can add the command to the hash table. You can also remove commands from the table. The output of the hash command displays both the number of times the shell has used the table to find a command (hits) and the relative cost (cost) of looking up the command, that is, how far down the search path it had to go before it found the command. The hash command with the –r option clears the hash table.

Example 8.6

```
1   $ hash
    hits  cost   command
    3     8      /usr/bin/date
    1     8      /usr/bin/who
    1     8      /usr/bin/ls
2   $ hash vi
    3     8      /usr/bin/date
    1     8      /usr/bin/who
    1     8      /usr/bin/ls
    0     6      /usr/ucb/vi
3   $ hash –r
```

EXPLANATION

1. The hash command displays the commands currently stored in the internal hash table. The shell will not have to search the search path to find the commands listed when they are entered at the command line. This saves time. Otherwise, the shell has to go out to the disk to search the path. When you type a new command, the shell will search the path first, and then place it on the hash table. The next time you use that command, the shell finds it in memory.
2. The hash command can take arguments; the names of commands you want to guarantee get stored on the hash table ahead of time.
3. The hash command with the –r option clears the hash table.

The dot Command. The dot command is a built−in Bourne shell command. It takes a script name as an argument.The script will be executed in the environment of the current shell; that is, a child process will not be started. All variables set in the script will become part of the current shell's environment. Likewise, all variables set in the current shell will become part of the script's environment. The dot command is normally used to re−execute the .profile file if it has been modified. For example, if one of the settings, such as the EDITOR or TERM variable, has been changed since you logged on, you can use the dot command to re−execute the .profile without logging out and then logging back in.

Example 8.7

```
$ . .profile
```

EXPLANATION

The dot command executes the initialization file, .profile, within this shell. Local and global variables are redefined within this shell. The dot command makes it unnecessary to log out and then log back in again.[1]

8.1.2 The Command Line

After logging on, the shell displays its primary prompt, a dollar sign, by default. The shell is your command interpreter. When the shell is running interactively, it reads commands from the terminal and breaks the command line into words. A command line consists of one or more words (tokens), separated by whitespace (blanks and/or tabs), and terminated with a newline, which is generated by pressing Enter. The first word is the command and subsequent words are the command's arguments. The command may be a UNIX executable program such as ls or pwd, a built−in command such as cd or test, or a shell script. The command may contain special characters, called metacharacters, that the shell must interpret while parsing the command line. If a command line is long and you want to continue typing on the next line, the backslash character, followed by a newline, will allow you to continue typing on the next line. The secondary prompt will appear until the command line is terminated.

The Exit Status. After a command or program terminates, it returns an exit status to the parent process. The exit status is a number between 0 and 255. By convention, when a program exits, if the status returned is zero, the command was successful in its execution. When the exit status is nonzero, the command failed in some way. The shell status variable, ?, is set to the value of the exit status of the last command that was executed. Success or failure of a program is determined by the programmer who wrote the program.

Example 8.8

```
1   $ grep "john" /etc/passwd
    john:MgVyBsZJavd16s:9496:40:John Doe:/home/falcon/john:/bin/sh
2   $ echo $?
    0
3   $ grep "nicky" /etc/passwd
4   $ echo $?
    1
5   $ grep "scott" /etc/passsswd
    grep: /etc/passsswd: No such file or directory
6   $ echo $?
    2
```

EXPLANATION

1. The grep program searches for the pattern john in the /etc/passwd file and is successful. The line from /etc/passwd is displayed.
2. The ? variable is set to the exit value of the grep command. Zero indicates success.
3. The grep program cannot find user nicky in the /etc/passwd file.
4. If the grep program cannot find the pattern, it returns an exit status of 1.
5. The grep fails because the /etc/passsswd file cannot be opened.
6. If grep cannot find the file, it returns an exit status of 2.

Multiple Commands at the Command Line. A command line can consist of multiple commands. Each command is separated by a semicolon, and the command line is terminated with a newline.

Example 8.9

```
$ ls; pwd; date
```

EXPLANATION

The commands are executed from left to right, one after the other, until the newline is reached.

Grouping Commands. Commands may also be grouped so that all of the output is either piped to another command or redirected to a file.

Example 8.10

```
$ ( ls ; pwd; date ) > outputfile
```

EXPLANATION

The output of each of the commands is sent to the file called outputfile. The spaces inside the parentheses are necessary.

Conditional Execution of Commands. With conditional execution, two command strings are separated by the special metacharacters, double ampersands (&&) and double vertical bars (||). The command on the right of either of these metacharacters will or will not be executed based on the exit condition of the command on the left.

Example 8.11

```
$ cc prgm1.c –o prgm1 && prgm1
```

EXPLANATION

If the first command is successful (has a zero exit status), the command after the && is executed; i.e., if the cc program can successfully compile prgm1.c, the resulting executable program, prgm1, will be executed.

Example 8.12

```
$ cc prog.c >& err || mail bob < err
```

EXPLANATION

If the first command fails (has a nonzero exit status), the command after the || is executed; i.e., if the cc program cannot compile prog.c, the errors are sent to a file called err, and user bob will be mailed the err file.

Commands in the Background. Normally, when you execute a command, it runs in the foreground, and the prompt does not reappear until the command has completed execution. It is not always convenient to wait for the command to complete. By placing an ampersand (&) at the end of the command line, the shell will return the shell prompt immediately and execute the command in the background concurrently. You do not have to wait to start up another command. The output from a background job will be sent to the screen as it processes. Therefore, if you intend to run a command in the background, the output of that command might be redirected to a file or piped to another device, such as a printer, so that the output does not interfere with what you are doing.

The $! variable contains the PID number of the last job put in the background.

Example 8.13

```
1   $ man sh | lp&
2   [1] 1557
3   $ kill −9 $!
```

EXPLANATION

1. The output of the man command (the manual pages for the sh command) is piped to the printer. The ampersand at the end of the command line puts the job in the background.

2. There are two numbers that appear on the screen: the number in square brackets indicates that this is the first job to be placed in the background; the second number is the PID, or the process identification number of this job.
3. The shell prompt appears immediately. While your program is running in the background, the shell is waiting for another command in the foreground.
4. The ! variable evaluates to the PID of the job most recently put in the background. If you get it in time, you will kill this job before it goes to the print queue.

8.1.3 Metacharacters (Wildcards)

Metacharacters are special characters used to represent something other than themselves. Shell metacharacters are called wildcards. Table 8.1 lists metacharacters and what they do.

Table 8.1. Shell Metacharacters

Metacharacter Meaning\Literally interprets the following character.&Processes in the background.;Separates commands.$Substitutes variables.?Matches for a single character.[abc]Matches for one character from a set of characters.[!abc]Matches for one character not from the set of characters.*Matches for zero or more characters.(cmds)Executes commands in a subshell.{cmds}Executes commands in current shell.

8.1.4 Filename Substitution

When evaluating the command line, the shell uses metacharacters to abbreviate filenames or pathnames that match a certain set of characters. The filename substitution metacharacters listed in Table 8.2 are expanded into an alphabetically listed set of filenames. The process of expanding the metacharacter into filenames is also called filename substitution, or globbing. If a metacharacter is used and there is no filename that matches it, the shell treats the metacharacter as a literal character.

Table 8.2. Shell Metacharacters and Filename Substitution

Metacharacter Meaning*Matches zero or more characters.?Matches exactly one character.[abc]Matches one character in the set a, b, or c.[a–z]Matches one character in the range from a to z.[! a–z]Matches one character not in the range from a to z.\Escapes or disables the metacharacter.

The Asterisk. The asterisk is a wildcard that matches for zero or more of any characters in a filename.

Example 8.14

```
1   $ ls  *
    abc abc1 abc122 abc123 abc2 file1 file1.bak file2 file2.bak none
    nonsense nobody nothing nowhere one
2   $ ls  *.bak
    file1.bak file2.bak
3   $ echo a*
    ab abc1 abc122 abc123 abc2
```

EXPLANATION

1. The asterisk expands to all of the files in the present working directory. All of the files are passed as arguments to is and displayed.
2. All files starting with zero or more characters and ending with .bak are matched and listed.

3. All files starting with a, followed by zero or more characters, are matched and passed as arguments to the echo command.

The Question Mark. The question mark represents a single character in a filename. When a filename contains one or more question marks, the shell performs filename substitution by replacing the question mark with the character it matches in the filename.

Example 8.15

```
1   $ ls
    abc  abc122  abc2  file1.bak  file2.bak  nonsense  nothing  one
    abc1  abc123  file1  file2  none  noone  nowhere

2   $ ls a?c?
    abc1 abc2

3   $ ls ??
    ?? not found

4   $ echo  abc???
    abc122 abc123

5   $ echo ??
    ??
```

EXPLANATION

1. The files in the current directory are listed.
2. Filenames starting with a, followed by a single character, followed by c and a single character, are matched and listed.
3. Filenames containing exactly two characters are listed if found. Since there are no two−character files, the question marks are treated as a literal filename.
4. Filenames starting with abc and followed by exactly three characters are expanded and displayed by the echo command.
5. There are no files in the directory that contain exactly two characters. The shell treats the question mark as a literal question mark if it cannot find a match.

The Square Brackets. The brackets are used to match filenames containing one character in a set or range of characters.

Example 8.16

```
1   $ ls
    abc  abc122 abc2 file1.bak file2.bak nonsense nothing
    one  abc1 abc123 file1 file2 none noone nowhere

2   $ ls abc[123]
    abc1  abc2

3   $ ls abc[1–3]
    abc1  abc2

4   $ ls [a–z][a–z][a–z]
    abc one

5   $ ls [!f–z] ???
    abc1  abc2
```

```
6   $ ls abc12[23]
    abc122 abc123
```

EXPLANATION

1. All of the files in the present working directory are listed.
2. All filenames containing four characters are matched and listed if the filename starts with abc, followed by 1, 2, or 3. Only one character from the set in the brackets is matched.
3. All filenames containing four characters are matched and listed if the filename starts with abc and is followed by a number in the range from 1 to 3.
4. All filenames containing three characters are matched and listed, if the filename contains exactly three lowercase alphabetic characters.
5. All filenames containing four characters are listed if the first character is not a lowercase letter between f and z ([!f–z], followed by three of any character (e.g., ???).
6. Files are listed if the filenames contain abc12 followed by 2 or 3.

Escaping Metacharacters. To use a metacharacter as a literal character, the backslash may be used to prevent the metacharacter from being interpreted.

Example 8.17

```
1   $ ls
    abc file1 youx
2   $ echo How are you?
    How are youx
3   $ echo How are you\?
    How are you?
4   $ echo  When does this line \
    > ever end\?
    When does this line ever end?
```

EXPLANATION

1. The files in the present working directory are listed. (Note the file youx.)
2. The shell will perform filename expansion on the ?. Any files in the current directory starting with y−o−u and followed by exactly one character are matched and substituted in the string. The filename youx will be substituted in the string to read How are youx (probably not what you wanted to happen).
3. By preceding the question mark with a backslash, it is escaped, meaning that the shell will not try to interpret it as a wildcard.
4. The newline is escaped by preceding it with a backslash. The secondary prompt is displayed until the string is terminated with a newline. The question mark (?) is escaped to protect it from filename expansion.

8.1.5 Variables

There are two types of variables, local and environment variables. Some variables are created by the user and others are special shell variables.

Local Variables. Local variables are given values that are known only to the shell in which they are created. Variable names must begin with an alphabetic or underscore character. The remaining characters can be alphabetic, decimal digits zero to nine, or an underscore character. Any other characters mark the termination of the variable name. When assigning a value, there can be no whitespace surrounding the equal sign. To set the variable to null, the equal sign is followed by a newline.[2]

A dollar sign is used in front of a variable to extract the value stored there.

Setting Local Variables

Example 8.18

```
1   $ round=world
    $ echo $round
    world

2   $ name="Peter Piper"
    $ echo $name
    Peter Piper

3   $ x=
    $ echo $x

4   $ file.bak="$HOME/junk"
    file.bak=/home/jody/ellie/junk: not found
```

EXPLANATION

1. The variable round is assigned the value world. When the shell encounters the dollar sign preceding a variable name, it performs variable substitution. The value of the variable is displayed.
2. The variable name is assigned the value "Peter Piper". The quotes are needed to hide the whitespace so that the shell will not split the string into separate words when it parses the command line. The value of the variable is displayed.
3. The variable x is not assigned a value. It will be assigned null. The null value, an empty string, is displayed.
4. The period in the variable name is illegal. The only characters allowed in a variable name are numbers, letters, and the underscore. The shell tries to execute the string as a command.

The Scope of Local Variables. A local variable is known only to the shell in which it was created. It is not passed on to subshells. The double dollar sign variable is a special variable containing the PID of the current shell.

Example 8.19

```
1   $ echo $$
    1313
2   $ round=world
    $ echo $round
    world
3   $ sh           # Start a subshell

4   $ echo $$
    1326
5   $ echo $round

6   $ exit         # Exits this shell, returns to parent shell

7   $ echo $$
    1313
```

```
8   $ echo $round
    world
```

EXPLANATION

1. The value of the double dollar sign variable evaluates to the PID of the current shell. The PID of this shell is 1313.
2. The local variable round is assigned the string value world, and the value of the variable is displayed.
3. A new Bourne shell is started. This is called a subshell, or child shell.
4. The PID of this shell is 1326. The parent shell's PID is 1313.
5. The variable round is not defined in this shell. A blank line is printed.
6. The exit command terminates this shell and returns to the parent shell. (Control−D will also exit this shell.)
7. The parent shell returns. Its PID is displayed.
8. The value of the variable round is displayed.

Setting Read−Only Variables. A read−only variable cannot be redefined or unset.

Example 8.20

```
1   $ name=Tom
2   $ readonly name
    $ echo $name
    Tom
3   $ unset name
    name: readonly
4   $ name=Joe
    name: readonly
```

EXPLANATION

1. The local variable name is assigned the value Tom.
2. The variable is made readonly.
3. A read−only variable cannot be unset.
4. A read−only variable cannot be redefined.

Environment Variables. Environment variables are available to the shell in which they are created and any subshells or processes spawned from that shell. By convention, environment variables are capitalized. Environment variables are variables that have been exported.

The shell in which a variable is created is called the parent shell. If a new shell is started from the parent shell, it is called the child shell. Some of the environment variables, such as HOME, LOGNAME, PATH, and SHELL, are set before you log on by the /bin/login program. Normally, environment variables are defined and stored in the .profile file in the user's home directory. See Table 8.3 for a list of environment variables.

Table 8.3. Bourne Shell Environment Variables

ENV Variable ValuePATHThe search path for commands.HOMEHome directory; used by cd when no directory is specified.IFSInternal field separators, normally space, tab, and newline.LOGNAMEThe user's login name.MAILIf this parameter is set to the name of a mail file and the MAILPATH parameter is not set, the shell informs the user of the arrival of mail in the specified file.MAILCHECKThis parameter specifies how often (in seconds) the shell will check for the arrival of mail in the files specified by the MAILPATH or MAIL parameters. The default value is 600 seconds (10 minutes). If set to zero, the shell will check before issuing each primary prompt.MAILPATHA colon−separated list of filenames. If this parameter is set, the shell informs the user of the arrival of mail in any of the specified files. Each filename can be followed by a percent sign and a message that will be printed when the modification time changes. The default message is You have mail.PWDPresent working directory.PS1Primary prompt string, which is a dollar sign by default.PS2Secondary prompt string, which is a right angle bracket by default.SHELLWhen the shell is invoked, it scans the environment for this name. The shell gives default values to PATH, PS1, PS2, MAILCHECK, and IFS. HOME and MAIL are set by login.

Setting Environment Variables. To set environment variables, the export command is used either after assigning a value or when the variable is set. (Do not use the dollar sign on a variable when exporting it.)

Example 8.21

```
1   $ TERM=wyse    $ export TERM
2   $ NAME= "John Smith"
    $ export NAME
    $ echo $NAME
    John Smith
3   $ echo $$
    319              # pid number for parent shell
4   $ sh
                     # Start a subshell
5   $ echo $$
    340              # pid number for new shell
6   $ echo $NAME
    John Smith
7   $ NAME="April Jenner"
    $ export NAME
    $ echo $NAME
    April Jenner
8   $ exit           # Exit the subshell and go back to parent shell
9   $ echo $$
    319              # pid number for parent shell
10  $ echo $NAME
    John Smith
```

EXPLANATION

1. The TERM variable is assigned wyse. The variable is exported. Now, processes started from this shell will inherit the variable.
2. The variable is defined and exported to make it available to subshells started from the shell.
3. The value of this shell's PID is printed.
4. A new Bourne shell is started. The new shell is called the child. The original shell is its parent.
5. The PID of the new Bourne shell is stored in the $$ variable and its value is echoed.
6. The variable, set in the parent shell, was exported to this new shell and is displayed.
7. The variable is reset to April Jenner. It is exported to all subshells, but will not affect the parent shell. Exported values are not propagated upward to the parent shell.
8. This Bourne child shell is exited.
9. The PID of the parent is displayed again.

10. The variable NAME contains its original value. Variables retain their values when exported from parent to child shell. The child cannot change the value of a variable for its parent.

Listing Set Variables. There are two built−in commands that print the value of a variable: set and env. The set command prints all variables, local and global. The env command prints just the global variables.

Example 8.22

```
1   $ env     (Partial list)
    LOGNAME=ellie
    TERMCAP=sun-cmd
    USER=ellie
    DISPLAY=:0.0
    SHELL=/bin/sh
    HOME=/home/jody/ellie
    TERM=sun-cmd
    LD_LIBRARY_PATH=/usr/local/OW3/lib
    PWD=/home/jody/ellie/perl

2   $ set
    DISPLAY=:0.0
    FMHOME=/usr/local/Frame-2.1X
    FONTPATH=/usr/local/OW3/lib/fonts
    HELPPATH=/usr/local/OW3/lib/locale:/usr/local/OW3/lib/help
    HOME=/home/jody/ellie
    HZ=100
    IFS=
    LANG=C
    LD_LIBRARY_PATH=/usr/local/OW3/lib
    LOGNAME=ellie
    MAILCHECK=600
    MANPATH=/usr/local/OW3/share/man:/usr/local/OW3/man:/
    usr/local/man:/usr/local/doctools/man:/usr/man
    OPTIND=1
    PATH=/home/jody/ellie:/usr/local/OW3/bin:/usr/ucb:/usr/local/
    doctools/bin:/usr/bin:/usr/local:/usr/etc:/etc:/usr/spool/
    news/bin:/home/jody/ellie/bin:/usr/lo
    PS1=$
    PS2=>
    PWD=/home/jody/ellie/kshprog/joke
    SHELL=/bin/sh
    TERM=sun-cmd
    TERMCAP=sun-cmd:te=\E[>4h:ti=\E[>4l:tc=sun:
    USER=ellie
    name=Tom
    place="San Francisco"
```

EXPLANATION

1. The env command lists all environment (exported) variables. These variables are, by convention, named with all uppercase letters. They are passed from the process in which they are created to any of its child processes.
2. The set command, without options, prints all set variables, local and exported (including variables set to null).

Unsetting Variables. Both local and environment variables can be unset by using the unset command, unless the variables are set as read−only.

Example 8.23

```
unset name; unset TERM
```

EXPLANATION

The unset command removes the variable from the shell's memory.

Printing the Values of Variables: The echo Command. The echo command prints its arguments to standard output and is used primarily in Bourne and C shells. The Korn shell has a built−in print command. There are different versions of the echo command; for example, the Berkeley (BSD) echo is different from the System V echo. Unless you specify a full pathname, you will use the built−in version of the echo command. The built−in version will reflect the version of UNIX you are using. The System V echo allows the use of numerous escape sequences, whereas the BSD version does not. Table 8.4 lists the BSD echo option and escape sequences.

Table 8.4. BSD echo Option and System V Escape Sequences

Option Meaning BSD:–nSuppress newline at the end of a line of output. System V:\bBackspace.\cPrint the line without a newline.\fForm feed.\nNewline.\rReturn.\tTab.\vVertical tab.\\Backslash.

Example 8.24

```
1   $ echo The username is $LOGNAME.
    The username is ellie.

2   $ echo "\t\tHello there\c"   # System V
    Hello there$

3   $ echo −n "Hello there"      # BSD
    Hello there$
```

EXPLANATION

1. The echo command prints its arguments to the screen. Variable substitution is performed by the shell before the echo command is executed.
2. The System V version of the echo command supports escape sequences similar to those of the C programming language. The $ is the shell prompt.
3. The –n option to the echo command indicates the BSD version of the echo command is being used. The line is printed without the newline. The escape sequences are not supported by this version of echo.

Variable Expansion Modifiers. Variables can be tested and modified by using special modifiers. The modifier provides a shortcut conditional test to check if a variable has been set, and then assigns a value to the variable based on the outcome of the test. See Table 8.5 for a list of variable modifiers.

Table 8.5. Variable Modifiers

Modifier Value ${variable:−word}If variable is set and is non−null, substitute its value; otherwise, substitute word. ${variable:=word}If variable is set or is non−null, substitute its value; otherwise, set it to word. The value of variable is substituted permanently. Positional parameters may not be assigned in this way.${variable:+word}If parameter is set and is non−null, substitute word; otherwise, substitute nothing.${variable:?word}If variable is set and is non−null, substitute its value; otherwise, print word and exit from the shell. If word is omitted, the message parameter null or not set is printed.

Using the colon with any of the modifiers (−, =, +, ?) checks whether the variable is not set or is null; without the colon, a variable set to null is considered to be set.

Example 8.25

```
(Assigning Temporary Default Values)
1   $ fruit=peach
2   $ echo ${fruit:–plum}
    peach

3   $ echo ${newfruit:–apple}
    apple
4   $ echo $newfruit

5   $ echo $EDITOR       # More realistic example
6   $ echo ${EDITOR:–/bin/vi}
    /bin/vi
7   $ echo $EDITOR

8   $ name=
    $ echo ${name−Joe}
9   $ echo ${name:−Joe}
    Joe
```

EXPLANATION

1. The variable fruit is assigned the value peach.
2. The special modifier will check to see if the variable fruit has been set. If it has, the value is printed; if not, plum is substituted for fruit and its value is printed.
3. The variable newfruit has not been set. The value apple will be temporarily substituted for newfruit.
4. The setting was only temporary. The variable newfruit is not set.
5. The environment variable EDITOR has not been set.
6. The :– modifier substitutes EDITOR with /bin/vi.
7. The EDITOR was never set. Nothing prints.
8. The variable name is set to null. By not prefixing the modifier with a colon, the variable is considered to be set, even if to null, and the new value Joe is not assigned to name.
9. The colon causes the modifier to check that a variable is either not set or is set to null. In either case, the value Joe will be substituted for name.

Example 8.26

```
(Assigning Permanent Default Values)
1   $ name=
2   $ echo  ${name:=Patty}
    Patty
3   $ echo $name
    Patty
4   $ echo ${EDITOR:=/bin/vi}
    /bin/vi
5   $ echo $EDITOR
    /bin/vi
```

EXPLANATION

1. The variable name is assigned the value null.
2. The special modifier := will check to see if the variable name has been set. If it has been set, it will not be changed; if it is either null or not set, it will be assigned the value to the right of the equal sign. Patty is assigned to name since the variable is set to null. The setting is permanent.
3. The variable name still contains the value Patty.
4. The value of the variable EDITOR is set to /bin/vi.
5. The value of the variable EDITOR is displayed.

Example 8.27

```
(Assigning Temporary Alternate Value)
1   $ foo=grapes
2   $ echo ${foo:+pears}
    pears
3   $ echo $foo
    grapes
    $
```

EXPLANATION

1. The variable foo has been assigned the value grapes.
2. The special modifier :+ will check to see if the variable has been set. If it has been set, pears will temporarily be substituted for foo; if not, null is returned.
3. The variable foo now has its original value.

Example 8.28

```
(Creating Error Messages Based On Default Values)
1   $ echo ${namex:?"namex is undefined"}
    namex: namex is undefined
2   $ echo ${y?}
    y: parameter null or not set
```

EXPLANATION

1. The :? modifier will check to see if the variable has been set. If not, the string to the right of the ? is printed to standard error, after the name of the variable. If in a script, the script exits.
2. If a message is not provided after the ?, the shell sends a default message to standard error.

Positional Parameters. Normally, the special built−in variables, often called positional parameters, are used in shell scripts when passing arguments from the command line, or used in functions to hold the value of arguments passed to the function. See Table 8.6. The variables are called positional parameters because they are denoted by their position on the command line. The Bourne shell allows up to nine positional parameters. The name of the shell script is stored in the $0 variable. The positional parameters can be set and reset with the set command.

Table 8.6. Positional Parameters

Positional Parameter Meaning$0References the name of the current shell script.$1–$9Denotes positional parameters 1 through 9.$#Evaluates to the number of positional parameters.$*Evaluates to all the positional parameters.$@Means the same as $*, except when double quoted."$*"Evaluates to "$1 $2 $3"."$@"Evaluates to "$1" "$2" "$3".

Example 8.29

```
1   $ set tim bill ann fred
    $ echo $*      # Prints all the positional parameters
                   # tim bill ann fred.


2   $ echo $1      # Prints the first positional parameter.
    tim
3   $ echo $2 $3   # Prints the second and third
    bill ann       # positional parameters.
4   $ echo $#      # Prints the total number of
    4              # positional parameters.

5   $ set a b c d e f g h i j k l m
    $ echo  $10    # Prints the first positional parameter
    a0             # followed by a zero.
6   $ echo  $*
   a b c d e f g h i j k l m

7   $ set file1 file2 file3
    $ echo  \$$#
    $3
8   $ eval echo  \$$#
    file3
```

EXPLANATION

1. The set command assigns values to positional parameters. The $* special variable contains all of the parameters set.
2. The value of the first positional parameter, tim, is displayed.
3. The value of the second and third parameters, bill and ann, are displayed.
4. The $# special variable contains the number of positional parameters currently set.
5. The set command resets all of the positional parameters. The original set is destroyed. Positional parameters cannot be numbered beyond nine. The value of the first positional parameter is printed, followed by the number zero.
6. The $* allows you to print all of the parameters, even past nine.
7. The positional parameters are reset to file1, file2, and file3. The dollar sign is escaped; $# is the number of arguments. The echo command displays $3.
8. The eval command parses the command line a second time before executing the command. The first time parsed, the shell substitutes \$$# with $3, and the second time, the shell substitutes the value of $3 with file3.

Other Special Variables. The shell has special variables consisting of a single character. The dollar sign preceding the character allows you to access the value stored in the variable. See Table 8.7.

Table 8.7. Special Variables

Variable Meaning$The PID of the shell–The sh options currently set?The exit value of last executed command!The PID of the last job put in the background

Example 8.30

```
1   $ echo The pid of this shell is $$
    The pid of this shell is 4725

2   $ echo The options for this shell are $–
    The options for this shell are s

3   $ grep dodo /etc/passwd
    $ echo $?
    1

4   $ sleep 25&
    4736
    $ echo $!
    4736
```

EXPLANATION

1. The $ variable holds the value of the PID for this process.
2. The – variable lists all options for this interactive Bourne shell.
3. The grep command searches for the string dodo in the /etc/passwd file. The ? variable holds the exit status of the last command executed. Since the value returned from grep is 1, grep is assumed to have failed in its search. An exit status of zero indicates a successful exit.
4. The ! variable holds the PID number of the last command placed in the background. The & appended to the sleep command sends the command to the background.

8.1.6 Quoting

Quoting is used to protect special metacharacters from interpretation. There are three methods of quoting: the backslash, single quotes, and double quotes. The characters listed in Table 8.8 are special to the shell and must be quoted.

Table 8.8. Special Metacharacters Requiring Quotes

Metacharacter Meaning;Command separator&Background processing( )Command grouping; creates a subshell{ }Command grouping; does not create a subshell|Pipe<Input redirection>Output redirectionnewlineCommand terminationspace/tabWord delimiter$Variable substitution character* [ ] ?Shell metacharacters for filename expansion

Single and double quotes must be matched. Single quotes protect special metacharacters, such as $, *, ?, |, >, and <, from interpretation. Double quotes also protect special metacharacters from being interpreted, but allow variable and command substitution characters (the dollar sign and backquotes) to be processed. Single quotes will protect double quotes and double quotes will protect single quotes.

The Bourne shell does not let you know if you have mismatched quotes. If running interactively, a secondary prompt appears when quotes are not matched. If in a shell script, the file is scanned and if the quote is not matched, the shell will attempt to match it with the next available quote; if the shell cannot match it with the next available quote, the program aborts and the message 'end of file' unexpected appears on the terminal. Quoting can be a real hassle for even the best of shell programmers! See Appendix C for shell quoting rules.

The Backslash. The backslash is used to quote (or escape) a single character from interpretation. The backslash is not interpreted if placed in single quotes. The backslash will protect the dollar sign ($), backquotes (' '), and the backslash from interpretation if enclosed in double quotes.

Example 8.31

```
1   $ echo Where are you going\?
    Where are you going?

2   $ echo Start on this line and \
    >  go to the next line.
   Start on this line and go to the next line.

3   $ echo \\
    \

4   $ echo '\\'
    \\

5   $ echo '\$5.00'
    \$5.00

6   $ echo  "\$5.00"
    $5.00
```

EXPLANATION

1. The backslash prevents the shell from performing filename substitution on the question mark.
2. The backslash escapes the newline, allowing the next line to become part of this line.
3. Since the backslash itself is a special character, it prevents the backslash following it from interpretation.
4. The backslash is not interpreted when enclosed in single quotes.
5. All characters in single quotes are treated literally. The backslash does not serve any purpose here.
6. When enclosed in double quotes, the backslash prevents the dollar sign from being interpreted for variable substitution.

Single Quotes. Single quotes must be matched. They protect all metacharacters from interpretation. To print a single quote, it must be enclosed in double quotes or escaped with a backslash.

Example 8.32

```
1   $ echo 'hi there
    > how are you?
    > When will this end?
    > When the quote is matched
    > oh'
    hi there
    how are you?
    When will this end?
    When the quote is matched
    oh
```

```
2   $ echo 'Don\'t  you need $5.00?'
    Don't you need $5.00?

3   $ echo 'Mother yelled, "Time to eat!"'
    Mother yelled, "Time to eat!"
```

EXPLANATION

1. The single quote is not matched on the line. The Bourne shell produces a secondary prompt. It is waiting for the quote to be matched.
2. The single quotes protect all metacharacters from interpretation. The apostrophe in Don't is escaped with a backslash. Otherwise, it would match the first quote, and the single quote at the end of the string would not have a mate. In this example, the $ and the ? are protected from the shell and will be treated as literals.
3. The single quotes protect the double quotes in this string.

Double Quotes. Double quotes must be matched, will allow variable and command substitution, and protect any other special metacharacters from being interpreted by the shell.

Example 8.33

```
1   $ name=Jody
2   $ echo "Hi $name, I'm glad to meet you!"
    Hi Jody, I'm glad to meet you!

3   $ echo "Hey $name, the time is 'date'"
    Hey Jody, the time is Wed Dec 14 14:04:11 PST 1998
```

EXPLANATION

1. The variable name is assigned the string Jody.
2. The double quotes surrounding the string will protect all special metacharacters from interpretation, with the exception of $ in $name. Variable substitution is performed within double quotes.
3. Variable substitution and command substitution are both performed when enclosed within double quotes. The variable name is expanded, and the command in backquotes, date, is executed.

8.1.7 Command Substitution

Command substitution is used when assigning the output of a command to a variable or when substituting the output of a command within a string. All three shells use backquotes to perform command substitution.[3]

Example 8.34

```
1   $ name='nawk –F:  '{print $1}' database'
    $ echo $name
    Ebenezer Scrooge

2   $ set 'date'
3   $ echo $*
    Fri Oct 19 09:35:21 PDT 2001

4   $ echo  $2 $6
    Oct 2001
```

EXPLANATION

1. The nawk command is enclosed in backquotes. It is executed and its output is assigned to the variable name, as a string, and displayed.
2. The set command assigns the output of the date command to positional parameters. Whitespace separates the list of words into its respective parameters.
3. The $* variable holds all of the positional parameters. The output of the date command was stored in the $* variable. Each parameter is separated by whitespace.
4. The second and sixth parameters are printed.

8.1.8 An Introduction to Functions

Although the Bourne shell does not have an alias mechanism for abbreviating commands, it does support functions (introduced to the shell in SVR2). Functions are used to execute a group of commands with a name. They are like scripts, only more efficient. Once defined, they become part of the shell's memory so that when the function is called, the shell does not have to read it in from the disk as it does with a file. Often functions are used to improve the modularity of a script (discussed in the programming section of this chapter). Once defined, they can be used again and again. Functions are often defined in the user's initialization file, .profile. They must be defined before they are invoked, and cannot be exported.

Defining Functions. The function name is followed by a set of empty parentheses. The definition of the function consists of a set of commands separated by semicolons and enclosed in curly braces. The last command is terminated with a semicolon. Spaces around the curly braces are required.

FORMAT

```
function_name () { commands ; commands; }
```

Example 8.35

```
1   $ greet () { echo "Hello $LOGNAME, today is 'date'; }
2   $ greet
    Hello ellie, today is Thu Oct 4 19:56:31 PDT  2001
```

EXPLANATION

1. The function is called greet.
2. When the greet function is invoked, the command(s) enclosed within the curly braces are executed.

Example 8.36

```
1   $ fun () { pwd; ls; date; }
2   $ fun
    /home/jody/ellie/prac
    abc    abc123   file1.bak  none      nothing   tmp
    abc1   abc2     file2      nonsense  nowhere   touch
    abc122 file1    file2.bak noone      one
    Sat Feb 24 11:15:48 PST 2001

3   $ welcome () { echo "Hi $1 and $2"; }
4   $ welcome tom joe
    Hi tom and joe
```

```
5   $ set jane nina lizzy
6   $ echo $*
    jane nina lizzy

7   $ welcome tom joe
    hi tom and joe

8   $ echo  $1 $2
    jane nina
```

EXPLANATION

1. The function fun is named and defined. The name is followed by a list of commands enclosed in curly braces. Each command is separated by a semicolon. A space is required after the first curly brace or you will get a syntax error. A function must be defined before it can be used.
2. The function behaves just like a script when invoked. Each of the commands in the function definition are executed in turn.
3. There are two positional parameters used in the function welcome. When arguments are given to the function, the positional parameters are assigned those values.
4. The arguments to the function, tom and joe, are assigned to $1 and $2, respectively. The positional parameters in a function are private to the function and will not interfere with any used outside the function.
5. The positional parameters are set at the command line. These variables have nothing to do with the ones set in the function.
6. $* displays the values of the currently set positional parameters.
7. The function welcome is called. The values assigned to the positional parameters are tom and joe.
8. The positional variables assigned at the command line are unaffected by those set in the function.

Listing and Unsetting Functions. To list functions and their definitions, use the set command. The function and its definition will appear in the output, along with the exported and local variables. Functions and their definitions are unset with the unset command.

8.1.9 Standard I/O and Redirection

When the shell starts up, it inherits three files: stdin, stdout, and stderr. Standard input normally comes from the keyboard. Standard output and standard error normally go to the screen. There are times when you want to read input from a file or send output or error to a file. This can be accomplished by using I/O redirection. See Table 8.9 for a list of redirection operators.

Table 8.9. Redirection Operators

Redirection OperatorWhat It Does<Redirect input.>Redirect output.>>Append output.2>Redirect error.1>&2Redirect output to where error is going.2>&1Redirect error to where output is going.

Example 8.37

```
1   $ tr '[A-Z]'  '[a-z]' < myfile
                             # Redirect  input

2   $ ls > lsfile            # Redirect output
```

```
    $ cat lsfile
    dir1
    dir2
    file1
    file2
    file3

3   $ date >> lsfile         # Redirect and append otuput
    $ cat lsfile
    dir1
    dir2
    file1
    file2
    file3
    Mon Sept 17 12:57:22 PDT 2001


4   $ cc prog.c 2> errfile   Redirect error

5   $ find . –name \*.c –print > foundit 2> /dev/null
    # Redirect output to foundit, and error to /dev/null.

6   $ find . –name \*.c –print > foundit 2>&1
    # Redirect output and send standard error to where output is going

7   $ echo "File needs an argument" 1>&2
    # Send standard output to error
```

EXPLANATION

1. Instead of getting input from the keyboard, standard input is redirected from the file myfile to the UNIX tr command. All uppercase letters are converted to lowercase letters.
2. Instead of sending output to the screen, the ls command redirects its output to the file lsfile.
3. The output of the date command is redirected and appended to lsfile.
4. The file prog.c is compiled. If the compile fails, the standard error is redirected to the file errfile. Now you can take your error file to the local guru for an explanation (of sorts)!
5. The find command starts searching in the current working directory for filenames ending in .c, and prints the filenames to a file named foundit. Errors from the find command are sent to /dev/null.
6. The find command starts searching in the current working directory for filenames ending in .c, and prints the filenames to a file named foundit. The errors are also sent to foundit.
7. The echo command sends its message to standard error. Its standard output is merged with standard error.

The exec Command and Redirection. The exec command can be used to replace the current program with a new one without starting a new process. Standard output or input can be changed with the exec command without creating a subshell (see Table 8.10). If a file is opened with exec, subsequent read commands will move the file pointer down the file a line at a time until the end of the file. The file must be closed to start reading from the beginning again. However, if using UNIX utilities such as cat and sort, the operating system closes the file after each command has completed. For examples on how to use exec commands in scripts, see "Looping Commands".

Table 8.10. The exec Command

exec CommandWhat It Doesexec lsls will execute in place of the shell. When ls is finished, the shell in which it was started does not return.exec < fileaOpen filea for reading standard input.exec > filexOpen filex for writing standard output.exec 3< datfileOpen datfile as file descriptor 3 for reading input.sort <&3Datfile is sorted.exec 4>newfileOpen newfile as file descriptor (fd) 4 for writing.ls >&4Output of ls is redirected to newfile.exec 5<&4Make fd 5 a copy of fd 4.exec 3<&–Close fd 3.

Example 8.38

```
1   $ exec date
    Sun Oct 14 10:07:34  PDT 2001
     <Login prompt appears if you are in your login shell >
2   $ exec > temp
    $ ls
    $ pwd
    $ echo Hello
3   $ exec > /dev/tty
4   $ echo Hello
    Hello
```

EXPLANATION

1. The exec command executes the date command in the current shell (it does not fork a child shell). Since the date command is executed in place of the current shell, when the date command exits, the shell terminates. If a Bourne shell had been started from the C shell, the Bourne shell would exit and the C shell prompt would appear. If you are in your login shell when you try this, you will be logged out. If you are working interactively in a shell window, the window exits.
2. The exec command opens standard output for the current shell to the temp file. Output from ls, pwd, and echo will no longer go to the screen, but to temp.
3. The exec command reopens standard output to the terminal. Now, output will go to the screen as shown in line 4.
4. Standard output has been directed back to the terminal (/dev/tty).

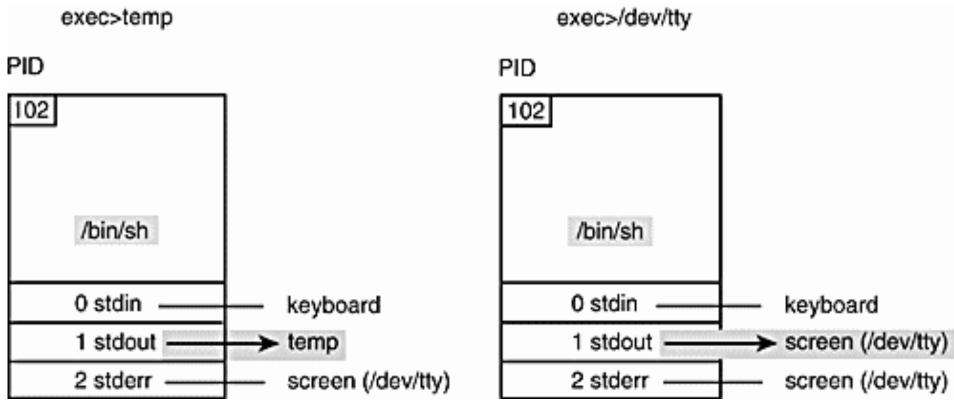
Example 8.39

```
1   $ cat doit
    pwd
    echo hello
    date
2   $ exec < doit
    /home/jody/ellie/shell
    hello
    Sun Oct 14 10:07:34  PDT 2001
3   %
```

EXPLANATION

1. The contents of a file called doit are displayed.
2. The exec command opens standard input to the file called doit. Input is read from the file instead of from the keyboard. The commands from the file doit are executed in place of the current shell. When the last command exits, so does the shell. See Figure 8.2.

Figure 8.2. The exec command.



3. The Bourne shell exited when the exec command completed. The C shell prompt appeared. It was the parent shell. If you had been in your login shell when the exec finished, you would be logged out; if in a window, the window would have disappeared.

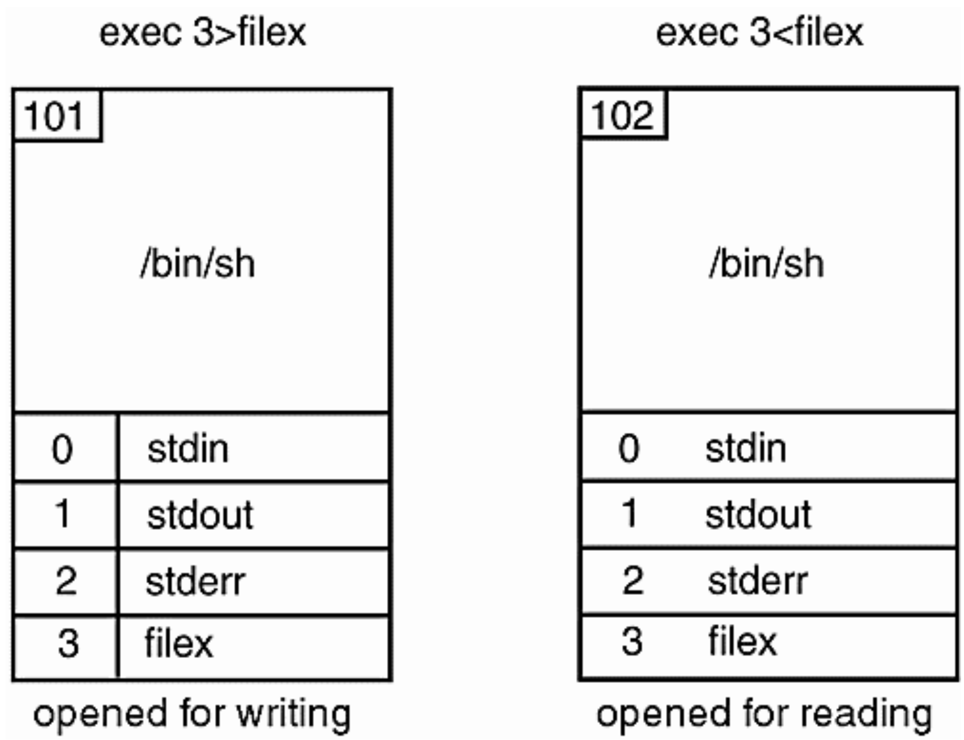
Example 8.40

```
1   $ exec 3> filex
2   $ who >& 3
3   $ date >& 3
4   $ exec 3>&-
5   $ exec 3< filex
6   $ cat <&3
    ellie  console  Oct 7     09:53
    ellie  ttyp0    Oct 7     09:54
    ellie  ttyp1    Oct 7     09:54
    ellie  ttyp2    Oct 11    15:42
    Sun Oct 14 13:31:31  PDT 2001
7   $ exec 3<&-
8   $ date >& 3
    Sun Oct 14 13:41:14  PDT 2001
```

EXPLANATION

1. File descriptor 3 (fd 3) is assigned to filex and opened for redirection of output. See Figure 8.3.

Figure 8.3. exec and file descriptors.



2. The output of the who command is sent to fd 3, filex.
3. The output of the date command is sent to fd 3; filex is already opened, so the output is appended to filex.
4. Fd 3 is closed.
5. The exec command opens fd 3 for reading input. Input will be redirected from filex.
6. The cat program reads from fd 3, assigned to filex.
7. The exec command closes fd 3. (Actually, the operating system will close the file once end of file is reached.)
8. When attempting to send the output of the date command to fd 3, the output goes to the screen, since the file descriptor was closed.

8.1.10 Pipes

A pipe takes the output from the command on the left−hand side of the pipe symbol and sends it to the input of the command on the right−hand side of the pipe symbol. A pipeline can consist of more than one pipe.

The purpose of the next three commands is to count the number of people logged on (who), save the output of the command in a file (tmp), use the wc –l to count the number of lines in the tmp file (wc –l), and then remove the tmp file (i.e., find the number of people logged on). See Figures 8.4 and 8.5.

Figure 8.4. The pipe.

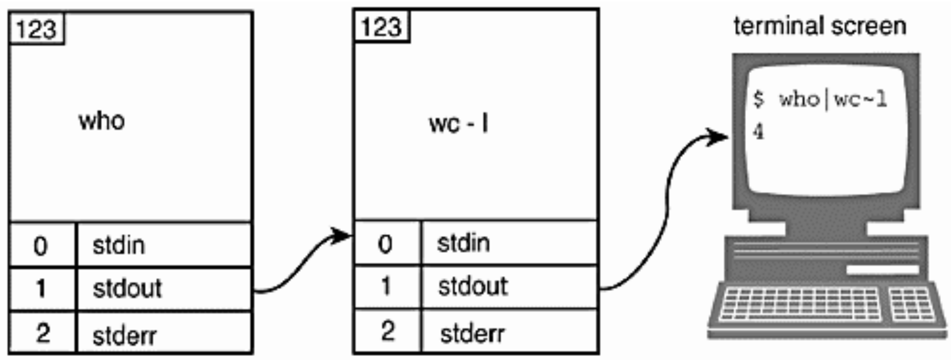
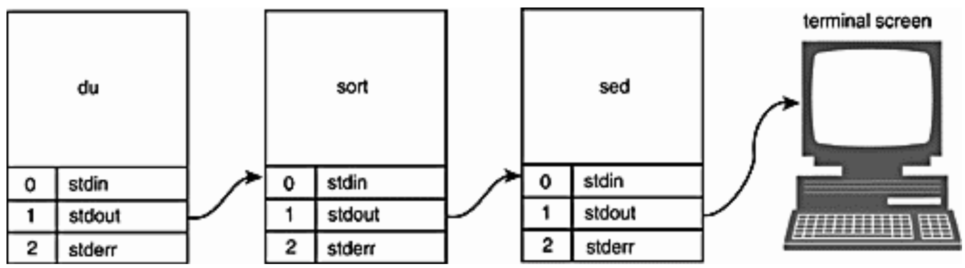


Figure 8.5. Multiple pipes (filter).



Example 8.41

```
1   $ who > tmp
2   $ wc –l tmp
    4 tmp
3   $ rm tmp

# Using a pipe saves disk space and time.

4   $ who | wc –l
    4


5   $ du . | sort –n | sed –n '$p'
    72388   /home/jody/ellie
```

EXPLANATION

1. The output of the who command is redirected to the tmp file.
2. The wc –l command displays the number of lines in tmp.
3. The tmp file is removed.
4. With the pipe facility, you can perform all three of the preceding steps in one step. The output of the who command is sent to an anonymous kernel buffer; the wc –l command reads from the buffer and sends its output to the screen.
5. The output of the du command, the number of disk blocks used per directory, is piped to the sort command and sorted numerically. It is then piped to the sed command, which prints the last line of the output it receives.

8.1.11 The here document and Redirecting Input

The here document accepts inline text for a program expecting input, such as mail, sort, or cat, until a user−defined terminator is reached. It is often used in shell scripts for creating menus. The command receiving the input is appended with a << symbol, followed by a user−defined word or symbol, and a newline. The next lines of text will be the lines of input to be sent to the command. The input is terminated when the user−defined word or symbol is then placed on a line by itself in the leftmost column (it cannot have spaces surrounding it). The word is used in place of Control−D to stop the program from reading input.

If the terminator is preceded by the <<– operator, leading tabs, and only tabs, may precede the final terminator. The user−defined terminating word or symbol must match exactly from "here" to "here." The following examples illustrate the use of the here document at the command line to demonstrate the syntax. It is much more practical to use them in scripts.

Example 8.42

```
1   $ cat << FINISH                         # FINISH is a user-defined
2   > Hello there $LOGNAME                    terminator
3   > The time is 'date'
    > I can't wait to see you!!!
4   > FINISH                                # terminator matches first

5   Hello there ellie                       # FINISH on line 1.
    The time is Thu Feb 8 19:42:16 PST 2001
    I can't wait to see you!!!
6   $
```

EXPLANATION

1. The UNIX cat program will accept input until the word FINISH appears on a line by itself.
2. A secondary prompt appears. The following text is input for the cat command. Variable substitution is performed within the here document.
3. Command substitution, `'date'`, is performed within the here document.
4. The user−defined terminator FINISH marks the end of input for the cat program. It cannot have any spaces before or after it and is on a line by itself.
5. The output from the cat program is displayed.
6. The shell prompt reappears.

Example 8.43

```
1   $ cat <<– DONE
    >   Hello there
    >   What's up?
    >   Bye now The time is 'date'.
2   >   DONE
    Hello there
    What's up?
    Bye now The time is Thu Feb 8 19:48:23 PST 2001.
    $
```

EXPLANATION

1. The cat program accepts input until DONE appears on a line by itself. The <<– operator allows the input and final terminator to be preceded by one or more tabs.
2. The final matching terminator, DONE, is preceded by a tab. The output of the cat program is displayed on the screen.

8.2 Programming with the Bourne Shell

8.2.1 The Steps in Creating a Shell Script

A shell script is normally written in an editor and consists of commands interspersed with comments. Comments are preceded by a pound sign and consist of text used to document what is going on.

The First Line. The first line at the top left corner of the script will indicate the program that will be executing the lines in the script. This line is commonly written as

```
#!/bin/sh
```

The #! is called a magic number and is used by the kernel to identify the program that should be interpreting the lines in the script. This line must be the top line of your script.

Comments. Comments are lines preceded by a pound sign (#) and can be on a line by themselves or on a line following a script command. They are used to document your script. It is sometimes difficult to understand what the script is supposed to do if it is not commented. Although comments are important, they are often too sparse or not used at all. Try to get used to commenting what you are doing not only for someone else, but also for yourself. Two days from now you may not recall exactly what you were trying to do.

Executable Statements and Bourne Shell Constructs. A Bourne shell program consists of a combination of UNIX commands, Bourne shell commands, programming constructs, and comments.

Making the Script Executable. When you create a file, it is not given the execute permission. You need this permission to run your script. Use the chmod command to turn on the execute permission.

Example 8.44

```
1   $ chmod +x myscript
2   $ ls −lF  myscript
    −rwxr−xr−x    1  ellie   0 Jul  13:00 myscript*
```

EXPLANATION

1. The chmod command is used to turn on the execute permission for the user, group, and others.
2. The output of the ls command indicates that all users have execute permission on the myscript file. The asterisk at the end of the filename also indicates that this is an executable program.

A Scripting Session. In the following example, the user will create a script in the editor. After saving the file, the execute permissions are turned on, and the script is executed. If there are errors in the program, the shell will respond immediately.

Example 8.45

```
(The Script)
% cat greetings
1   #!/bin/sh
2   # This is the first Bourne shell program of the day.
    # Scriptname: greetings
    # Written by:  Barbara Born
3   echo "Hello $LOGNAME, it's nice talking to you."
4   echo "Your present working directory is 'pwd'."
    echo "You are working on a machine called 'uname −n'."
    echo "Here is a list of your files."
5   ls      # List files in the present working directory
6   echo  "Bye for now $LOGNAME. The time is 'date +%T'!"

(The Command Line)
    $ chmod +x greetings
    $ greetings
3   Hello barbara, it's nice talking to you.
4   Your present working directory is /home/lion/barbara/prog
    You are working on a machine called lion.
    Here is a list of your files.
5   Afile      cplus   letter          prac
    Answerbook cprog   library  prac1
    bourne     joke    notes    perl5
6   Bye for now barbara.  The time is 18:05:07!
```

EXPLANATION

1. The first line of the script, #!/bin/sh, lets the kernel know what interpreter will execute the lines in this program, in this case the sh (Bourne shell) interpreter.
2. The comments are nonexecutable lines preceded by a pound sign. They can be on a line by themselves or appended to a line after a command.
3. After variable substitution is performed by the shell, the echo command displays the line on the screen.
4. After command substitution is performed by the shell, the echo command displays the line on the screen.
5. The ls command is executed. The comment will be ignored by the shell.
6. The echo command displays the string enclosed within double quotes. Variables and command substitution (backquotes) are expanded when placed within double quotes. In this case, the quotes were really not necessary.

8.2.2 Reading User Input

The read command is a built−in command used to read input from the terminal or from a file (see Table 8.11). The read command takes a line of input until a newline is reached. The newline at the end of a line will be translated into a null byte when read. You can also use the read command to cause a program to stop until the user enters a carriage return. To see how the read command is most effectively used for reading lines of input from a file, see "Looping Commands".

Table 8.11. The read Command

Format	**Meaning**
read answer	Reads a line from standard input and assigns it to the variable answer.
read first last	Reads a line from standard input to the first whitespace or newline, putting the first word typed into the variable first and the rest of the line into the variable last.

Example 8.46

```
(The Script)
$ cat nosy
    #!/bin/sh
    # Scriptname: nosy
    echo "Are you happy? \c"
1   read answer
    echo "$answer is the right response."
    echo "What is your full name? \c"
2   read first middle last
    echo "Hello  $first"
------------------------------------------------------------
(The Output)
    $ nosy
    Are you happy? Yes
1   Yes is the right response.
2   What is your full name? Jon Jake Jones
    Hello Jon
```

EXPLANATION

1. The read command accepts a line of user input and assigns the input to the variable answer.
2. The read command accepts input from the user and assigns the first word of input to the variable first, the second word of input to the variable middle, and all the rest of the words up to the end of the line to the variable last.

Example 8.47

```
(The Script)
$ cat printer_check
    #!/bin/sh
    # Scriptname: printer_check
    # Script to clear a hung up printer for SVR4
1   if [ $LOGNAME != root ]
    then
       echo "Must have root privileges to run this program"
       exit 1
    fi
2   cat << EOF
    Warning: All jobs in the printer queue will be removed.
    Please turn off the printer now. Press return when you
    are ready to continue. Otherwise press Control C.
    EOF
3   read ANYTHING      # Wait until the user turns off the printer
    echo
4   /etc/init.d/lp stop       # Stop the printer
5   rm -f /var/spool/lp/SCHEDLOCK /var/spool/lp/temp*
    echo
    echo "Please turn the printer on now."
6   echo "Press return to continue"
7   read ANYTHING            # Stall until the user turns the printer
                             # back on
    echo                     # A blank line is printed
8   /etc/init.d/lp start     # Start the printer
```

EXPLANATION

1. Checks to see if user is root. If not, sends an error and exits.
2. Creates a here document. Warning message is displayed on the screen.
3. The read command waits for user input. When the user presses Enter, the variable ANYTHING accepts whatever is typed. The variable is not used for anything. The read in this case is used to wait until the user turns off the printer, comes back, and presses Enter.
4. The lp program stops the printer daemon.
5. The SCHEDLOCK file must be removed before the scheduler can start again, as well as temporary files in /var/spool/lp.
6. The user is asked to press Return when ready.
7. Whatever the user types is read into the variable ANYTHING, and when Enter is pressed, the program will resume execution.
8. The lp program starts the print daemons.

8.2.3 Arithmetic

Arithmetic is not built into the Bourne shell. If you need to perform simple integer arithmetic calculations, the UNIX expr command is most commonly used in Bourne shell scripts. For floating point arithmetic, the awk or bc programs can be used. Because arithmetic was not built in, the performance of the shell is degraded when iterating through loops a number of times. Each time a counter is incremented or decremented in a looping mechanism, it is necessary to fork another process to handle the arithmetic.

Integer Arithmetic and the expr Command. The expr command is an expression−handling program. When used to evaluate arithmetic expressions, it can perform simple integer operations (see Table 8.12). Each of its arguments must be separated by a space. The +, −, *, /, and % operators are supported, and the normal programming rules of associativity and precedence apply.

Table 8.12. The expr Command Arithmetic Operators

Operator	Function
* / %	Multiplication, division, modulus.
+ −	Addition, substraction.

Example 8.48

```
1   $ expr 1 + 4
    5

2   $ expr 1+4
    1+4

3   $ expr 5 + 9  /  3
    8

4   $ expr 5 * 4
    expr: syntax error

5   $ expr 5 \* 4  −  2
    18

6   $ expr 11 % 3
    2

7   $ num=1
    $ num='expr $num + 1'
```

```
$ echo $num
2
```

EXPLANATION

1. The expr command evaluates the expression. The two numbers are added.
2. Since there are no spaces between the operator, the expression is evaluated as a string.
3. Addition and division are combined. The division is performed first and then the addition.
4. The asterisk (*) is evaluated by the shell as one of its wildcards, causing the expr command to fail.
5. The asterisk (*) is escaped with a backslash to prevent shell interpretation. The expr command performs arithmetic.
6. The modulus operator (%) returns the remainder after division is performed.
7. The variable num is assigned 1. The expr command adds one to the value of the variable and assigns the result to num. The value of num is echoed to the screen.

Floating Point Arithmetic. The bc, awk, and nawk utilities are useful if you need to perform more complex calculations.

Example 8.49

```
(The Command Line)
1   $ n='echo "scale=3; 13 / 2" | bc'
    $ echo $n
    6.500

2   product='nawk –v x=2.45 –v y=3.123 'BEGIN{printf "%.2f\n",x*y}''
    $ echo $product
    7.65
```

EXPLANATION

1. The output of the echo command is piped to the bc program. The scale is set to 3, which is the number of significant digits to the right of the decimal point that will be printed. The calculation is to divide 13 by 2. The entire pipeline is enclosed in backquotes. Command substitution will be performed and the output assigned to the variable n.
2. The nawk program gets its values from the argument list passed in at the command line, x=2.45 y=3.123. (The –v switch works with nawk, not awk.) After the numbers are multiplied, the printf function formats and prints the result with a precision of two places to the right of the decimal point. The output is assigned to the variable product.

8.2.4 Positional Parameters and Command Line Arguments

Information can be passed into a script via the command line. Each word (separated by whitespace) following the script name is called an argument.

Command line arguments can be referenced in scripts with positional parameters; for example, $1 for the first argument, $2 for the second argument, $3 for the third argument, and so on. The $# variable is used to test for the number of parameters, and $* is used to display all of them. Positional parameters can be set or reset with the set command. When the set command is used, any positional parameters previously set are cleared out. See Table 8.13.

Table 8.13. Positional Parameters

Positional ParameterWhat It References$0References the name of the script.$#Holds the value of the number of positional parameters.$*Lists all of the positional parameters.$@Means the same as $*, except when enclosed in double quotes."$*"Expands to a single argument (e.g., "$1 $2 $3")."$@"Expands to separate arguments (e.g., "$1" "$2" 3").$1 … $9References up to nine positional parameters.

Example 8.50

```
(The Script)
    #!/bin/sh
    # Scriptname: greetings
    echo "This script is called $0."
1   echo "$0  $1 and $2"
    echo "The number of positional parameters is $#"
    -----------------------------------------------------------
(The Command Line)
    $ chmod +x greetings
2   $ greetings
    This script is called  greetings.
    greetings  and
    The number of positional paramters is

3   $ greetings Tommy
    This script is called greetings.
    greetings Tommy and
    The number of positional parameters is 1

4   $ greetings Tommy  Kimberly
    This script is called greetings.
    greetings Tommy and Kimberly
    The number of positional parameters is 2
```

EXPLANATION

1. In the script greetings, positional parameter $0 references the script name, $1 the first command line agreement, and $2 the second command line agreement.
2. The greetings script is executed without any arguments passed. The output illustrates that the script is called greetings ($0 in the script) and that $1 and $2 were never assigned anything; therefore, their values are null and nothing is printed.
3. This time, one argument is passed, Tommy. Tommy is assigned to positional parameter 1.
4. Two arguments are entered, Tommy and Kimberly. Tommy is assigned to $1 and Kimberly is assigned to $2.

The set Command and Positional Parameters. The set command with arguments resets the positional parameters.[4] Once reset, the old parameter list is lost. To unset all of the positional parameters, use set – –. $0 is always the name of the script.

Example 8.51

```
(The Script)
    $ cat args
    #!/bin/sh
    # Scriptname: args
    # Script to test command line arguments
1   echo The name of this script is $0.
2   echo The arguments are $*.
```

```
3   echo The first argument is $1.
4   echo The second argument is $2.
5   echo The number of arguments is $#.
6   oldargs=$*             # Save parameters passed in from the
                           # command line
7   set Jake Nicky Scott   # Reset the positional parameters
8   echo All the positional parameters are $*.
9   echo The number of postional parameters is $#.
10  echo "Good–bye for now, $1 "
11  set 'date'          #  Reset the positional parameters
12  echo The date is $2 $3, $6.
13  echo "The value of \$oldargs is $oldargs."
14  set $oldargs
15  echo $1 $2 $3

(The Output)
     $ args a b c d
1   The name of this script is args.
2   The arguments are a b c d.
3   The first argument is a.
4   The second argument is b.
5   The number of arguments is 4.
8   All the positional parameters are Jake Nicky Scott.
9   The number of positional parameters is 3.
10  Good–bye for now, Jake
12  The date is Mar 25, 2001.
13  The value of $oldargs is a b c d.
```

EXPLANATION

1. The name of the script is stored in the $0 variable.
2. $* represents all of the positional parameters.
3. $1 represents the first positional parameter (command line argument).
4. $2 represents the second positional parameter.
5. $# is the total number of positional parameters (command line arguments).
6. All positional parameters are saved in a variable called oldargs.
7. The set command allows you to reset the positional parameters, clearing out the old list. Now, $1 is Jake, $2 is Nicky, and $3 is Scott.
8. $* represents all of the parameters, Jake, Nicky, and Scott.
9. $# represents the number of parameters, 3.
10. $1 is Jake.
11. After command substitution is performed, i.e., date is executed, the positional parameters are reset to the output of the date command.
12. The new values of $2, $3, and $6 are displayed.
13. The values saved in oldargs are printed.
14. The set command creates positional parameters from the value stored in oldargs.
15. The first three positional parameters are displayed.

Example 8.52

```
(The Script)
    $ cat checker
    #!/bin/sh
    # Scriptname: checker
    # Script to demonstrate the use of special variable
    # modifiers and arguments
1   name=${1:?"requires an argument" }
    echo Hello $name
```

```
(The Command Line)
2   $ checker
    ./checker: 1: requires an argument
3   $ checker Sue
    Hello Sue
```

EXPLANATION

1. The special variable modifier :? will check whether $1 has a value. If not, the script exits and the message is printed.
2. The program is executed without an argument. $1 is not assigned a value; an error is displayed.
3. The checker program is given a command line argument, Sue. In the script, $1 is assigned Sue. The program continues.

How $* and $@ Differ. The $* and $@ differ only when enclosed in double quotes. When $* is enclosed within double quotes, the parameter list becomes a single string. When $@ is enclosed within double quotes, each of the parameters is quoted; that is, each word is treated as a separate string.

Example 8.53

```
1   $ set 'apple pie' pears peaches
2   $ for i in $*
    > do
    > echo $i
    > done
    apple
    pie
    pears
    peaches

3   $ set 'apple pie' pears peaches
4   $ for i in "$*"
    > do
    > echo $i
    > done
    apple pie pears peaches

5   $ set 'apple pie' pears peaches
6   $ for i in $@
    > do
    > echo $i
    > done
    apple
    pie
    pears
    peaches

7   $ set 'apple pie' pears peaches
8   $ for i in "$@"          # At last!!
    > do
    > echo $i
    > done
    apple pie
    pears
    peaches
```

EXPLANATION

1. The positional parameters are set.
2. When $* is expanded, the quotes surrounding apple pie are stripped; apple and pie become two separate words. The for loop assigns each of the words, in turn, to the variable i, and then prints the value of i. Each time through the loop, the word on the left is shifted off, and the next word is assigned to the variable i.
3. The positional parameters are set.
4. By enclosing $* in double quotes, the entire parameter list becomes one string, "apple pie pears peaches". The entire list is assigned to i as a single word. The loop makes one iteration.
5. The positional parameters are set.
6. Unquoted, $@ and $* behave the same way (see line 2 of this explanation).
7. The positional parameters are set.
8. By surrounding $@ with double quotes, each of the positional parameters is treated as a quoted string. The list would be "apple pie," "pears," "peaches." The desired result is finally achieved.

8.2.5 Conditional Constructs and Flow Control

Conditional commands allow you to perform some task(s) based on whether a condition succeeds or fails. The if command is the simplest form of decision−making; the if/else commands allow a two−way decision; and the if/elif/else commands allow a multiway decision.

The Bourne shell expects a command to follow an if. The command can be a system command or a built−in command. The exit status of the command is used to evaluate the condition.

To evaluate an expression, the built−in test command is used. This command is also linked to the bracket symbol. Either the test command is used, or the expression can be enclosed in set of single brackets. Shell metacharacters (wildcards) are not expanded by the test command. The result of a command is tested, with zero status indicating success and nonzero status indicating failure. See Table 8.14.

Testing Exit Status. The following examples illustrate how the exit status is tested.

Example 8.54

```
(At the Command Line)
1   $ name=Tom
2   $ grep "$name"  /etc/passwd
    Tom:8ZKX2F:5102:40:Tom Savage:/home/tom:/bin/ksh
3   $ echo $?
    0             Success!

4   $ test $name != Tom
5   $ echo $?
    1             Failure

6   $ [ $name = Tom ]       # Brackets replace the test command
7   $ echo $?
    0             Success

8   $ [ $name =  [Tt]?m ]   # Wildcards are not evaluated
9   $ echo  $?              # by the test command
    1
```

EXPLANATION

1. The variable name is assigned the string Tom.
2. The grep command will search for string Tom in the passwd file.
3. The ? variable contains the exit status of the last command executed, in this case, the exit status of grep. If grep is successful in finding the string Tom, it will return an exit status of zero. The grep command was successful.
4. The test command is used to evaluate strings, numbers, and perform file testing. Like all commands, it returns an exit status. If the exit status is zero, the expression is true; if the exit status is one, the expression evaluates to false. There must be spaces surrounding the equal sign. The value of name is tested to see if it is not equal to Tom.
5. The test fails and returns an exit status of one.
6. The brackets are an alternate notation for the test command. There must be spaces after the first bracket. The expression is tested to see if $name evaluates to the string Tom.
7. The exit status of the test is zero. The test was successful because $name is equal to Tom.
8. The test command does not allow wildcard expansion. Since the question mark is treated as a literal character, the test fails. Tom and [Tt]?m are not equal.
9. The exit status is one indicating that the text in line 8 failed.

The test Command. The test command is used to evaluate conditional expressions, returning true or false. It will return a zero exit status for true and a nonzero exit status for false. The test command or brackets can be used.

Table 8.14. String, Integer, and File Testing

Test OperatorTest For String Test:string1 = string2String1 is equal to String2 (space surrounding = required).string1 != string2String1 is not equal to String2 (space surrounding != required).stringString is not null.–z stringLength of string is zero.–n stringLength of string is nonzero.Example:test –n $word or [–n $word].test tom = sue or [tom = sue]. Integer Test:int1 –eq int2Int1 is equal to int2.int1 –ne int2Int1 is not equal to int2.int1 –gt int2Int1 is greater than int2.int1 –ge int2Int1 is greater than or equal to int2.int1 –lt int2Int1 is less than int2.int1 –le int2Int1 is less than or equal to int2. File Test:–b filenameBlock special file.–c filenameCharacter special file.–d filenameDirectory existence.–f filenameRegular file existence and not a directory.–g filenameSet−group−ID is set.–k filenameSticky bit is set.–p filenameFile is a named pipe.–r filenameFile is readable.–s filenameFile is nonzero size.–u filenameSet−user−ID bit is set.–w filenameFile is writeable.–x filenameFile is executable.

The if Command. The simplest form of conditional is the if command. The command or UNIX utility following the if construct is executed and its exit status is returned. The exit status is usually determined by the programmer who wrote the utility. If the exit status is zero, the command succeeded and the statement(s) after the then keyword are executed. In the C shell, the expression following the if command is a Boolean−type expression as in C. But in the Bourne and Korn shells, the statement following the if is a command or group of commands. If the exit status of the command being evaluated is zero, the block of statements after the then is executed until fi is reached. The fi terminates the if block. If the exit status is nonzero, meaning that the command failed in some way, the statement(s) after the then keyword are ignored and control goes to the line directly after the fi statement. It is important that you know the exit status of the commands being tested. For example, the exit status of grep is reliable in letting you know whether grep found the pattern it was searching for in a file. If grep is successful in its search, it returns a zero exit status; if not, it returns one. The sed and awk programs also search for patterns, but they will report a successful exit status regardless of whether they find the pattern. The criteria for success with sed and awk is correct syntax, not functionality.[5]

FORMAT

```
if commandthen
then
    command
    command
fi
---------------------------------

if test expression
then
    command
fi

        or

if [ expression ]
then
    command
fi
-------------------------------
```

Example 8.55

```
1   if ypmatch "$name" passwd > /dev/null 2>&1
2   then
         echo Found $name!
3   fi
```

EXPLANATION

1. The ypmatch command is an NIS (Sun's Network Information Services) command that searches for its argument, name, in the NIS passwd database on the server machine. Standard output and standard error are redirected to /dev/null, the UNIX bit bucket. If ypmatch is not supported on your system, try

   ```
   if grep "$name" /etc/passwd > /dev/null 2>&1
   ```
2. If the exit status of the ypmatch command is zero, the program goes to the then statement and executes commands until fi is reached.
3. The fi terminates the list of commands following the then statement.

Example 8.56

```
1   echo  "Are you okay (y/n) ?"
    read answer
2   if [ "$answer" = Y -o "$answer" = y  ]
    then
       echo  "Glad to hear it."
3   fi
```

EXPLANATION

1. The user is asked the question and told to respond. The read command waits for a response.
2. The test command, represented by square brackets, is used to test expressions. It returns

an exit status of zero if the expression is true and nonzero if the expression is false. If the variable answer evaluates to Y or y, the commands after the then statement are executed. (The test command does not allow the use of wildcards when testing expressions, and spaces must surround the square brackets. (and the = operators.) See Table 8.14.

$answer is double quoted to hold it together as a single string. The test command fails if more than one word appears before the = operator. For example, if the user entered yes, you betcha, the answer variable would evaluate to three words, causing the test to fail, unless $answer is enclosed in double quotes.

3. The fi terminates the list of commands following the then statement.

The exit Command and the ? Variable. The exit command is used to terminate the script and return to the command line. You may want the script to exit if some condition occurs. The argument given to the exit command is a number ranging from 0 to 255. If the program exits with zero as an argument, the program exited with success. A nonzero argument indicates some kind of failure. The argument given to the exit command is stored in the shell's ? variable.

Example 8.57

```
(The Script)
$ cat bigfiles
    # Name: bigfiles
    # Purpose: Use the find command to find any files in the root
    # partition that have not been modified within the past n (any
    # number within 30 days) days and are larger than 20 blocks
    # (512−byte blocks)

1   if  [ $# −ne 2 ]
    then
        echo  "Usage: $0 mdays size " 1>&2
        exit 1
2   fi
3   if  [ $1 −lt 0 −o $1 −gt 30 ]
    then

        echo "mdays is out of range"
        exit 2
4   fi
5   if [ $2 −le 20 ]
    then
        echo "size is out of range"
        exit 3
6   fi
7   find / −xdev −mtime $1 −size +$2 −print

(The Command Line)
$ bigfiles
Usage: bigfiles mdays size

$ echo $?
1

$ bigfiles 400 80
mdays is out of range

$ echo $?
2

$ bigfiles 25 2
```

```
size is out of range

$ echo $?
3

$ bigfiles 2 25
(Output of find prints here)
```

EXPLANATION

1. The statement reads: If the number of arguments is not equal to 2, print the error message and send it to standard error, then exit the script with an exit status of 1.
2. The fi marks the end of the block of statements after then.
3. The statement reads: If the value of the first positional parameter passed in from the command line is less than 0 or greater than 30, then print the message and exit with a status of 2. See Table 8.14 for numeric operators.
4. The fi ends the if block.
5. The statement reads: If the value of the second positional parameter passed in at the command line is less than or equal to 20 (512−byte blocks), then print the message and exit with a status of 3.
6. The fi ends the if block.
7. The find command starts its search in the root directory.The –x dev option prevents find from searching other partitions. The –mtime option takes a number argument, which is the number of days since the file was modified, and the –size option takes a number argument, which is the size of the file in 512−byte blocks.

Checking for Null Values. When checking for null values in a variable, use double quotes to hold the null value or the test command will fail.

Example 8.58

```
(The Script)

1   if [ "$name" = "" ]
        # Alternative to  [ ! "$name" ]  or  [ −z "$name" ]
    then
       echo The name variable is null
    fi

(From System showmount program, which displays all remotely mounted
systems)

    remotes='/usr/sbin/showmount'
2   if [ "X${remotes}" != "X" ]
    then
       /usr/sbin/wall ${remotes}
                    ...
3   fi
```

EXPLANATION

1. If the name variable evaluates to null, the test is true. The double quotes are used to represent null.
2. The showmount command lists all clients remotely mounted from a host machine. The command will list either one or more clients, or nothing. The variable remotes will either

have a value assigned or will be null. The letter X precedes the variable remotes when being tested. If remotes evaluates to null, no clients are remotely logged on and X will be equal to X, causing the program to start execution again on line 3. If the variable has a value, for example, the hostname pluto, the expression would read if Xpluto != X, and the wall command would be executed. (All users on remote machines will be sent a message.) The purpose of using X in the expression is to guarantee that even if the value of remotes is null, there will always be a placeholder on either side of the != operator in the expression.
3. The fi terminates the if.

The if/else Command. The if/else commands allow a two−way decision−making process. If the command after the if fails, the commands after the else are executed.

FORMAT

```
if  command
then
    command(s)
else
    command(s)
fi
```

Example 8.59

```
(The Script)
    #!/bin/sh
1   if ypmatch "$name" passwd > /dev/null 2>&1[6]
2   then
        echo Found $name!
3   else
4       echo  "Can't find $name."
        exit 1
5   fi
```

EXPLANATION

1. The ypmatch command searches for its argument, name, in the NIS passwd database. Since the user does not need to see the output, standard output and standard error are redirected to /dev/null, the UNIX bit bucket.
2. If the exit status of the ypmatch command is zero, program control goes to the then statement and executes commands until else is reached.
3. The commands under the else statement are executed if the ypmatch command fails to find $name in the passwd database; that is, the exit status of ypmatch must be nonzero for the commands in the else block to be executed.
4. If the value in $name is not found in the passwd database, this echo statement is executed and the program exits with a value of one, indicating failure.
5. The fi terminates the if.

Example 8.60

```
(The Script)
$ cat idcheck
#!/bin/sh
# Scriptname: idcheck
# purpose:check user ID to see if user is root.
```

```
# Only root has a uid of 0.
# Format for id output:uid=9496(ellie) gid=40 groups=40
# root's uid=0

1   id='id | nawk –F'[=(]'  '{print $2}''     # Get user ID
    echo your user id is: $id
2   if [ $id –eq 0 ]
    then
3       echo "you are superuser."
4   else
        echo "you are not superuser."
5   fi

    (The Command Line)
6   $ idcheck
    your user id is: 9496
    you are not superuser.
7   $ su
    Password:
8   # idcheck
    your user id is: 0
    you are superuser
```

EXPLANATION

1. The id command is piped to the nawk command. Nawk uses an equal sign and open parenthesis as field separators, extracts the user ID from the output, and assigns the output to the variable id.
2. If the value of id is equal to zero, then line 3 is executed
3. If ID is not equal to zero, the else statements are executed.
4. The fi marks the end of the if command.
5. The idcheck script is executed by the current user, whose UID is 9496.
6. The su command switches the user to root.
7. The # prompt indicates that the superuser (root) is the new user. The UID for root is 0.

The if/elif/else Command. The if/elif/else commands allow a multiway decision− making process. If the command following the if fails, the command following the elif is tested. If that command succeeds, the commands under its then statement are executed. If the command after the elif fails, the next elif command is checked. If none of the commands succeeds, the else commands are executed. The else block is called the default.

FORMAT

```
if  command
then
    command(s)
elif command
then
    commands(s)
elif command
then
    command(s)
else
    command(s)
fi
```

Example 8.61

```
(The Script)
$ cat tellme
    #!/bin/sh
    # Scriptname: tellme
1   echo −n "How old are you? "
    read age
2   if  [  $age −lt  0 −o $age −gt 120 ]
    then
        echo  "Welcome to our planet! "
        exit 1
    fi

3   if [ $age −ge 0 −a  $age −lt 13 ]
    then
        echo "A child is a garden of verses"
    elif [ $age −ge 12 −a $age −lt  20 ]
    then
        echo "Rebel without a cause"
    elif [ $age  −gt 20 −a  $age −lt  30 ]
    then
        echo "You got the world by the tail!!"
    elif [ $age −ge  30 −a  $age −lt 40 ]
    then
        echo "Thirty something..."
4   else
        echo "Sorry I asked"
5   fi

(The Output)
$ tellme
How old are you? 200
Welcome to our planet!

$ tellme
How old are you? 13
Rebel without a cause

$ tellme
How old are you? 55
Sorry I asked
```

EXPLANATION

1. The user is asked for input. The input is assigned to the variable age.
2. A numeric test is performed within the square brackets. If age is less than 0 or greater than 120, the echo command is executed and the program terminates with an exit status of one. The interactive shell prompt will appear.
3. A numeric test is performed within the square brackets. If age is greater than 0 and less than 13, the test command returns exit status zero, true, and the statement after the then is executed. Otherwise, program control goes to the elif. If that test is false, the next elif is tested.
4. The else construct is the default. If none of the above statements are true, the else commands will be executed.
5. The fi terminates the initial if statement.

File Testing. Often when writing scripts, your script will require that there are certain files available and that those files have specific permissions, are of a certain type, or have other attributes. (See Table 8.14.) You will find file testing a necessary part of writing dependable scripts.

When if statements are nested, the fi statement always goes with the nearest if statement. Indenting the nested ifs makes it easier to see which if statement goes with which fi statement.

Example 8.62

```
(The Script)
   #!/bin/sh
   file=./testing

1  if [ -d $file ]
   then
      echo "$file is a directory"
2  elif [ -f $file ]
   then
3     if [  -r $file -a -w $file -a -x $file ]
      then    # nested if command
         echo "You have read, write, and execute \
         permission on $file."
4     fi
5  else
      echo "$file is neither a file nor a directory."
6  fi
```

EXPLANATION

1. If the file testing is a directory, print testing is a directory.
2. If the file testing is not a directory, else if the file is a plain file, then…
3. If the file testing is readable, writeable, and executable, then…
4. The fi terminates the innermost if command.
5. The else commands are executed if lines 1 and 2 are not true.
6. This fi goes with the first if.

The null Command. The null command, represented by a colon, is a built−in, do−nothing command that returns an exit status of zero. It is used as a placeholder after an if command when you have nothing to say, but need a command or the program will produce an error message because it requires something after the then statement. Often the null command is used as an argument to the loop command to make the loop a forever loop.

Example 8.63

```
(The Script)
1   name=Tom
2   if grep "$name" databasefile > /dev/null 2>&1
    then
3       :
4   else
        echo  "$1 not found in databasefile"
        exit 1
    fi
```

EXPLANATION

1. The variable name is assigned the string Tom.
2. The if command tests the exit status of the grep command. If Tom is found in the database file, the null command, a colon, is executed and does nothing.
3. The colon is the null command. It does nothing other than returning a 0 exit status.
4. What we really want to do is print an error message and exit if Tom is not found. The commands after the else will be executed if the grep command fails.

Example 8.64

```
(The Command Line)
1   $ DATAFILE=
2   $ : ${DATAFILE:=$HOME/db/datafile}
    $ echo $DATAFILE
    /home/jody/ellie/db/datafile
3   $ : ${DATAFILE:=$HOME/junk}
    $ echo $DATAFILE
    /home/jody/ellie/db/datafile
```

EXPLANATION

1. The variable DATAFILE is assigned null.
2. The colon command is a "do−nothing" command. The modifier (:=) returns a value that can be assigned to a variable or used in a test. In this example, the expression is passed as an argument to the do−nothing command. The shell will perform variable substitution; that is, assign the pathname to DATAFILE if DATAFILE does not already have a value. The variable DATAFILE is permanently set.
3. Since the variable has already been set, it will not be reset with the default value provided on the right of the modifier.

Example 8.65

```
(The Script)
$ cat wholenum
    #!/bin/sh
1   # Name:wholenum
    # Purpose:The expr command tests that the user enters an integer
    echo "Enter a number."
    read number
2   if expr "$number" + 0 > /dev/null 2>&1
    then
3      :
    else
4       echo "You did not enter an integer value."
        exit 1
5   fi
```

EXPLANATION

1. The user is asked to enter an integer. The number is assigned to the variable number.
2. The expr command evaluates the expression. If addition can be performed, the number is a whole number and expr returns a successful exit status. All output is redirected to the bit bucket /dev/null.
3. If expr is successful, it returns a zero exit status, and the colon command does nothing.

4. If the expr command fails, it returns a nonzero exit status, the echo command displays the message, and the program exits.
5. The fi ends the if block.

8.2.6 The case Command

The case command is a multiway branching command used as an alternative to if/elif commands. The value of the case variable is matched against value1, value2, and so forth, until a match is found. When a value matches the case variable, the commands following the value are executed until the double semicolons are reached. Then execution starts after the word esac (case spelled backwards).

If the case variable is not matched, the program executes the commands after the *), the default value, until ;; or esac is reached. The *) value functions the same as the else statement in if/else conditionals. The case values allow the use of shell wildcards and the vertical bar (pipe symbol) for oring two values.

FORMAT

```
case variable in
value1)
    command(s)
    ;;
value2)
    command(s)
    ;;
*)
command(s)
    ;;
esac
```

Example 8.66

```
(The Script)
$ cat colors
    #!/bin/sh
    # Scriptname: colors
1   echo -n "Which color do you like?"
    read color
2   case "$color" in
3   [Bb]l??)
4       echo I feel $color
        echo The sky is $color
5       ;;
6   [Gg]ree*)
        echo  $color is for trees
        echo  $color is for seasick;;
7   red | orange)             # The vertical bar means "or"
        echo  $color is very warm!;;
8   *)
        echo  No such color as $color;;
9   esac
10  echo  "Out of case"
```

EXPLANATION

1. The user is asked for input. The input is assigned to the variable color.
2. The case command evaluates the expression $color.
3. If the color begins with a B or b, followed by the letter l and any two characters, the case expression matches the first value. The value is terminated with a single closed parenthesis. The wildcards are shell metacharacters used for filename expansion.
4. The statements are executed if the value in line number 3 matches the case expression.
5. The double semicolons are required after the last command in this block of commands. Control branches to line 10 when the semicolons are reached. The script is easier to debug if the semicolons are on their own line.
6. If the case expression matches a G or g, followed by the letters ree and ending in zero or more of any other characters, the echo commands are executed. The double semicolons terminate the block of statements and control branches to line 10.
7. The vertical bar is used as an or conditional operator. If the case expression matches either red or orange, the echo command is executed.
8. This is the default value. If none of the above values match the case expression, the commands after the *) are executed.
9. The esac statement terminates the case command.
10. After one of the case values are matched, execution continues here.

Creating Menus with the here document and case Command. The here document and case command are often used together. The here document is used to create a menu of choices that will be displayed to the screen. The user will be asked to select one of the menu items, and the case command will test against the set of choices to execute the appropriate command.

Example 8.67

```
(The .profile File)
    echo "Select a terminal type: "
1   cat << ENDIT
        1) vt 120
        2) wyse50
        3) sun
2   ENDIT
3   read choice
4   case "$choice" in
5   1)  TERM=vt120
        export TERM
        ;;
    2)  TERM=wyse50
        export TERM
        ;;
6   3)  TERM=sun
        export TERM
        ;;
7   esac
8   echo "TERM is $TERM."

(The Output)
$ . .profile
Select a terminal type:
1) vt120
2) wyse50
3) sun
3               <-- User input
TERM is sun.
```

EXPLANATION

1. If this segment of script is put in the .profile, when you log on, you will be given a chance to select the proper terminal type. The here document is used to display a menu of choices.
2. The user−defined ENDIT terminator marks the end of the here document.
3. The read command stores the user input in the variable TERM.
4. The case command evaluates the variable TERM and compares that value with one of the values preceding the closing parenthesis: 1, 2, or *.
5. The first value tested is 1. If there is a match, the terminal is set to a vt120. The TERM variable is exported so that subshells will inherit it.
6. A default value is not required. The TERM variable is normally assigned in /etc/profile at login time. If the choice is 3, the terminal is set to a sun.
7. The esac terminates the case command.
8. After the case command has finished, this line is executed.

8.2.7 Looping Commands

Looping commands are used to execute a command or group of commands a set number of times or until a certain condition is met. The Bourne shell has three types of loops: the for loop, the while loop, and the until loop.

The for Command. The for looping command is used to execute commands a finite number of times on a list of items. For example, you might use this loop to execute the same commands on a list of files or usernames. The for command is followed by a user−defined variable, the keyword in, and a list of words. The first time in the loop, the first word from the wordlist is assigned to the variable, and then shifted off the list. Once the word is assigned to the variable, the body of the loop is entered, and commands between the do and done keywords are executed. The next time around the loop, the second word is assigned to the variable, and so on. The body of the loop starts at the do keyword and ends at the done keyword. When all of the words in the list have been shifted off, the loop ends and program control continues after the done keyword.

FORMAT

```
for variable in word_list
do
    command(s)
done
```

Example 8.68

```
(The Script)
$ cat forloop
    #!/bin/sh
    # Scriptname: forloop
1   for pal in Tom Dick Harry Joe
2   do
3       echo "Hi $pal"
4   done
5   echo "Out of loop"

(The Output)
$ forloop
Hi Tom
Hi Dick
```

```
Hi Harry
Hi Joe
Out of loop
```

EXPLANATION

1. This for loop will iterate through the list of names, Tom, Dick, Harry, and Joe, shifting each one off (to the left and assigning its value to the user−defined variable, pal) after it is used. As soon as all of the words are shifted and the wordlist is empty, the loop ends and execution starts after the done keyword. The first time in the loop, the variable pal will be assigned the word Tom. The second time through the loop, pal will be assigned Dick, the next time pal will be assigned Harry, and the last time pal will be assigned Joe.
2. The do keyword is required after the wordlist. If it is used on the same line, the list must be terminated with a semicolon. Example:

   ```
   for pal in Tom Dick Harry Joe; do
   ```
3. This is the body of the loop. After Tom is assigned to the variable pal, the commands in the body of the loop (i.e., all commands between the do and done keywords) are executed.
4. The done keyword ends the loop. Once the last word in the list (Joe) has been assigned and shifted off, the loop exits.
5. Control resumes here when the loop exits.

Example 8.69

```
(The Command Line)
1   $ cat mylist
   tom
   patty
   ann
   jake
(The Script)
$ cat mailer
    #!/bin/sh
    # Scriptname: mailer
2   for person in 'cat mylist'
    do
3       mail $person < letter
        echo  $person was sent a letter.
4   done
5   echo "The letter has been sent."
```

EXPLANATION

1. The contents of a file, called mylist, are displayed.
2. Command substitution is performed and the contents of mylist becomes the wordlist. The first time in the loop, tom is assigned to the variable person, then it is shifted off to be replaced with patty, and so forth.
3. In the body of the loop, each user is mailed a copy of a file called letter.
4. The done keyword marks the end of this loop iteration.
5. When all of the users in the list have been sent mail and the loop has exited, this line is executed.

Example 8.70

```
(The Script)
    #!/bin/sh
    # Scriptname: backup
    # Purpose:
    # Create backup files and store them in a backup directory
1   dir=/home/jody/ellie/backupscripts
2   for file in memo[1-5]
    do
        if [ -f $file ]
        then
             cp $file $dir/$file.bak
             echo "$file is backed up in $dir"
        fi
    done

(The Output)
memo1 is backed up in /home/jody/ellie/backupscripts
memo2 is backed up in /home/jody/ellie/backupscripts
memo3 is backed up in /home/jody/ellie/backupscripts
memo4 is backed up in /home/jody/ellie/backupscripts
memo5 is backed up in /home/jody/ellie/backupscripts
```

EXPLANATION

1. The variable dir is assigned.
2. The wordlist will consist of all files in the current working directory with names starting with memo and ending with a number between 1 and 5. Each filename will be assigned, one at time, to the variable file for each iteration of the loop.
3. When the body of the loop is entered, the file will be tested to make sure it exists and is a real file. If so, it will be copied into the directory /home/jody/ellie/backupscripts with the .bak extension appended to its name.

The $* and $@ Variables in Wordlists. When expanded, the $* and $@ are the same unless enclosed in double quotes. $* evaluates to one string, whereas $@ evaluates to a list of separate words.

Example 8.71

```
(The Script)
$ cat greet
    #!/bin/sh
    # Scriptname: greet
1   for name in $*      # Same as for name in $@
2   do
       echo Hi $name
3   done

(The Command Line)
$ greet Dee Bert Lizzy Tommy
Hi Dee
Hi Bert
Hi Lizzy
Hi Tommy
```

EXPLANATION

1. $* and $@ expand to a list of all the positional parameters, in this case, the arguments passed in from the command line: Dee, Bert, Lizzy, and Tommy. Each name in the list will be assigned, in turn, to the variable name in the for loop.
2. The commands in the body of the loop are executed until the list is empty.
3. The done keyword marks the end of the loop body.

Example 8.72

```
(The Script)
$ cat permx
    #!/bin/sh
    # Scriptname:permx
1   for file         # Empty wordlist
    do
2      if [ −f $file −a ! −x $file ]
       then
3               chmod +x $file
                echo $file now has execute permission
       fi
    done

(The Command Line)
4   $ permx *
    addon now has execute permission
    checkon now has execute permission
    doit now has execute permission
```

EXPLANATION

1. If the for loop is not provided with a wordlist, it iterates through the positional parameters. This is the same as for file in $*.
2. The filenames are coming in from the command line. The shell expands the asterisk (*) to all filenames in the current working directory. If the file is a plain file and does not have execute permission, line 3 is executed.
3. Execute permission is added for each file being processed.
4. At the command line, the asterisk will be evaluated by the shell as a wildcard and all files in the current directory will be replaced for the *. The files will be passed as arguments to the permx script.

The while Command. The while evaluates the command immediately following it and, if its exit status is zero, the commands in the body of the loop (commands between do and done) are executed. When the done keyword is reached, control is returned to the top of the loop and the while command checks the exit status of the command again. Until the exit status of the command being evaluated by the while becomes nonzero, the loop continues. When the exit status reaches nonzero, program execution starts after the done keyword.

FORMAT

```
while command
do
    command(s)
done
```

Example 8.73

```
(The Script)
$ cat num
    #!/bin/sh
    # Scriptname: num
1   num=0       # Initialize num
2   while  [ $num −lt 10 ]          # Test num with test command
    do
       echo  −n $num
3      num='expr  $num + 1          # Increment num
    done
    echo "\nAfter loop exits, continue running here"

(The Output)
0123456789
After loop exits, continue running here
```

EXPLANATION

1. This is the initialization step. The variable num is assigned 0.
2. The while command is followed by the test (square brackets) command. If the value of num is less than 10, the body of the loop is entered.
3. In the body of the loop, the value of num is incremented by one. If the value of num never changes, the loop would iterate infinitely or until the process is killed.

Example 8.74

```
(The Script)
    #!/bin/sh
    # Scriptname: quiz
1   echo "Who was the chief defense lawyer in the OJ case?"
    read answer
2   while [ "$answer" != "Johnny" ]
3   do
         echo  "Wrong try again!"
4        read answer
5   done
6   echo You got it!

(The Output)
$ quiz
Who was the chief defense lawyer in the OJ case? Marcia
Wrong try again!
Who was the chief defense lawyer in the OJ case?  I give up
Wrong try again!
Who was the chief defense lawyer in the OJ case?  Johnny
You got it!
```

EXPLANATION

1. The echo command prompts the user, Who was the chief defense lawyer in the OJ case? The read command waits for input from the user. The input will be stored in the variable answer.
2. The while loop is entered and the test command, the bracket, tests the expression. If the variable answer does not equal the string Johnny, the body of the loop is entered and commands between the do and done are executed.

3. The do keyword is the start of the loop body.
4. The user is asked to re−enter input.
5. The done keyword marks the end of the loop body. Control is returned to the top of the while loop, and the expression is tested again. As long as $answer does not evaluate to Johnny, the loop will continue to iterate. When the user enters Johnny, the loop ends. Program control goes to line 6.
6. When the body of the loop ends, control starts here.

Example 8.75

```
(The Script)
$ cat sayit
    #!/bin/sh
    # Scriptname: sayit
    echo Type q to quit.
    go=start
1   while [ −n "$go" ]    # Make sure to double quote the variable
    do
2       echo −n I love you.
3       read word
4       if [ "$word" = q −o "$word" = Q ]
        then
                echo "I'll always love you!"
                go=
        fi
    done

(The Output)
$ sayit
Type q to quit.
I love you.     When user presses the Enter key, the program continues
I love you.
I love you.
I love you.
I love you.q
I'll always love you!
$
```

EXPLANATION

1. The command after the while is executed and its exit status tested. The –n option to the test command tests for a nonnull string. Since go initially has a value, the test is successful, producing a zero exit status. If the variable go is not enclosed in double quotes and the variable is null, the test command would complain:

   ```
   go: test: argument expected
   ```
2. The loop is entered. The string I love you. is echoed to the screen.
3. The read command waits for user input.
4. The expresson is tested. If the user enters a q or Q, the string I'll always love you! is displayed, and the variable go is set to null. When the while loop is re−entered, the test is unsuccessful since the variable is null. The loop terminates. Control goes to the line after the done statement. In this example, the script will terminate since there are no more lines to execute.

The until Command. The until command is used like the while command, but executes the loop statements only if the command after until fails, i.e., if the command returns an exit status of nonzero. When the done keyword is reached, control is returned to the top of the loop and the until command checks the exit status of the command again. Until the exit status of the command being evaluated by until becomes zero, the loop continues. When the exit status reaches zero, the loop exits, and program execution starts after the done keyword.

FORMAT

```
until command
do
    command(s)
done
```

Example 8.76

```
    #!/bin/sh
1   until who | grep linda
2   do
        sleep 5
3   done
    talk linda@dragonwings
```

EXPLANATION

1. The until loop tests the exit status of the last command in the pipeline, grep. The who command lists who is logged on this machine and pipes its output to grep. The grep command will return a zero exit status (success) only when it finds user linda.
2. If user linda has not logged on, the body of the loop is entered and the program sleeps for five seconds.
3. When linda logs on, the exit status of the grep command will be zero and control will go to the statements following the done keyword.

Example 8.77

```
(The Script)
$ cat hour
    #!/bin/sh
    # Scriptname: hour
1   hour=1
2   until [ $hour  -gt 24 ]
    do
3       case "$hour" in
        [0-9] |1[0-1])  echo  "Good morning!"
             ;;
        12) echo  "Lunch time."

            ;;
        1[3-7]) echo  "Siesta time."
            ;;
        *)      echo  "Good night."
           ;;
        esac
4       hour='expr $hour + 1'
5   done

(The Output)
$ hour
Good morning!
Good morning!
```

```
    ...
Lunch time.
Siesta time.
    ...
Good night.
    ...
```

EXPLANATION

1. The variable hour is initialized to 1.
2. The test command tests if the hour is greater than 24. If the hour is not greater than 24, the body of the loop is entered. The until loop is entered if the command following it returns a nonzero exit status. Until the condition is true, the loop continues to iterate.
3. The case command evaluates the hour variable and tests each of the case statements for a match.
4. The hour variable is incremented before control returns to the top of the loop.
5. The done command marks the end of the loop body.

Looping Commands. If some condition occurs, you may want to break out of a loop, return to the top of the loop, or provide a way to stop an infinite loop. The Bourne shell provides loop control commands to handle these kinds of situations.

The shift Command. The shift command shifts the parameter list to the left a specified number of times. The shift command without an argument shifts the parameter list once to the left. Once the list is shifted, the parameter is removed permanently. Often, the shift command is used in a while loop when iterating through a list of positional parameters.

FORMAT

```
shift [n]
```

Example 8.78

```
(Without a Loop)
(The Script)
1   set joe mary tom sam
2   shift
3   echo $*
4   set 'date'
5   echo  $*
6   shift 5
7   echo  $*
8   shift 2

(The Output)
3   mary tom sam
5   Fri Sep 9 10:00:12 PDT 2001
7   2001
8   cannot shift
```

EXPLANATION

1. The set command sets the positional parameters. $1 is assigned joe, $2 is assigned mary, $3 is assigned tom, and $4 is assigned sam. $* represents all of the parameters.
2. The shift command shifts the positional parameters to the left; joe is shifted off.
3. The parameter list is printed after the shift.
4. The set command resets the positional parameters to the output of the UNIX date command.
5. The new parameter list is printed.
6. This time the list is shifted 5 times to the left.
7. The new parameter list is printed.
8. By attempting to shift more times than there are parameters, the shell sends a message to standard error.

Example 8.79

```
(With a Loop)
(The Script)
$ cat doit
    #!/bin/sh
    # Name: doit
    # Purpose: shift through command line arguments
    # Usage: doit [args]
1    while [  $# -gt  0 ]
     do
2       echo  $*
3       shift
4    done

(The Command Line)
$ doit a b c d e
a b c d e
b c d e
c d e
d e
e
```

EXPLANATION

1. The while command tests the numeric expression. If the number of positional parameters ($#) is greater than 0, the body of the loop is entered. The positional parameters are coming from the command line as arguments. There are five.
2. All positional parameters are printed.
3. The parameter list is shifted once to the left.
4. The body of the loop ends here; control returns to the top of the loop. Each time the loop is entered, the shift command causes the parameter list to be decreased by one. After the first shift, $# (number of positional parameters) is four. When $# has been decreased to zero, the loop ends.

Example 8.80

```
(The Script)
$ cat dater
    #!/bin/sh
    # Scriptname: dater
    # Purpose: set positional parameters with the set command
```

```
    # and shift through the parameters.
1   set 'date'
2   while [ $# -gt 0 ]
    do
3      echo $1
4      shift
    done

(The Output)
$ dater
Sat
Oct
13
12:12:13
PDT
2001
```

EXPLANATION

1. The set command takes the output of the date command and assigns the output to positional parameters $1 through $6.
2. The while command tests whether the number of positional parameters ($#) is greater than 0. If true, the body of the loop is entered.
3. The echo command displays the value of $1, the first positional parameter.
4. The shift command shifts the parameter list once to the left. Each time through the loop, the list is shifted until the list is empty. At that time, $# will be zero and the loop terminates.

The break Command. The built−in break command is used to force immediate exit from a loop, but not from a program. (To leave a program, the exit command is used.) After the break command is executed, control starts after the done keyword. The break command causes an exit from the innermost loop, so if you have nested loops, the break command takes a number as an argument, allowing you to break out of a specific outer loop. If you are nested in three loops, the outermost loop is loop number 3, the next nested loop is loop number 2, and the innermost nested loop is loop number 1. The break is useful for exiting from an infinite loop.

FORMAT

```
break [n]
```

Example 8.81

```
1   while true; do
2      echo Are you ready to move on\?
       read answer
3      if [  "$answer"  =  Y -o "$answer" = y  ]
       then
4          break
5      else
           ....commands...
       fi
6   done
7   print "Here we are"
```

EXPLANATION

1. The true command is a UNIX command that always exits with zero status. It is often used to start an infinite loop. It is okay to put the do statement on the same line as the while command, as long as a semicolon separates them. The body of the loop is entered.
2. The user is asked for input. The user's input is assigned to the variable answer.
3. If $answer evaluates to Y or y, control goes to line 4.
4. The break command is executed, the loop is exited, and control goes to line 7. The line Here we are is printed. Until the user answers with a Y or y, the program will continue to ask for input. This could go on forever!
5. If the test fails in line 3, the else commands are executed. When the body of the loop ends at the done keyword, control starts again at the top of the while at line 1.
6. This is the end of the loop body.
7. Control starts here after the break command is executed.

The continue Command. The continue command returns control to the top of the loop if some condition becomes true. All commands below the continue will be ignored. If nested within a number of loops, the continue command returns control to the innermost loop. If a number is given as its argument, control can then be started at the top of any loop. If you are nested in three loops, the outermost loop is loop number 3, the next nested loop is loop number 2, and the innermost nested loop is loop number 1.[7]

FORMAT

```
continue [n]
```

Example 8.82

```
(The mailing List)
$ cat mail_list
ernie
john
richard
melanie
greg
robin


(The Script)
    #!/bin/sh
    # Scriptname: mailem
    # Purpose: To send a list
1   for name in 'cat  mail_list'
    do
2       if [   "$name" = "richard" ] ; then
3           continue
        else
4           mail $name < memo
         fi
5   done
```

EXPLANATION

1. After command substitution, cat mail_list, the for loop will iterate through the list of names from the file called mail_list.
2. If the name matches richard, the continue command is executed and control goes back to top of the loop where the loop expression is evalutated. Since richard has already been shifted off the list, the next user, melanie, will be assigned to the variable name. The string richard does not need to be quoted here because it is only one word. But, it is good practice to quote the string after the test's = operator because if the string consisted of more than one word, for example, richard jones, the test command would produce an error message:

   ```
   test: unknown operator richard
   ```
3. The continue command returns control to the top of the loop, skipping any commands in the rest of the loop body.
4. All users in the list, except richard, will be mailed a copy of the file memo.
5. This is the end of the loop body.

Nested Loops and Loop Control. When using nested loops, the break and continue commands can be given a numeric, integer argument so that control can go from the inner loop to an outer loop.

Example 8.83

```
(The Script)
$ cat months
    #!/bin/sh
    # Scriptname: months
1   for month in Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
    do
2       for week in  1 2 3 4
        do
              echo -n "Processing the month of $month. Okay? "
              read ans
3             if [ "$ans" = n  -o -z "$ans" ]
              then
4                   continue 2
              else
                    echo -n "Process week $week of $month? "
                    read ans
                    if [ "$ans" = n -o -z "$ans" ]
                    then
5                         continue
                    else
                          echo "Now processing week $week of $month."
                          sleep 1
                                # Commands go here
                          echo "Done processing..."
                    fi
              fi
6       done
7   done

(The Output)
$ months
Processing the month of Jan. Okay?
Processing the month of Feb. Okay? y
Process week 1 of Feb? y
Now processing week 1 of Feb.
Done processing...
Processing the month of Feb. Okay? y
Process week 2 of Feb? y
Now processing week 2 of Feb.
Done processing...
Processing the month of Feb. Okay? n
Processing the month of Mar. Okay? n

Processing the month of Apr. Okay? n
Processing the month of May. Okay? n
```

EXPLANATION

1. The outer for loop is started. The first time in the loop, Jan is assigned to month.
2. The inner for loop starts. The first time in this loop, 1 is assigned to week. The inner loop iterates completely before going back to the outer loop.
3. If the user enters either an n or presses Enter, line 4 is executed.
4. The continue command with an argument of 2 starts control at the top of the second outermost loop. The continue without an argument returns control to the top of the innermost loop.
5. Control is returned to the innermost for loop.
6. This done terminates the innermost loop.
7. This done terminates the outermost loop.

I/O Redirection and Subshells. Input can be piped or redirected to a loop from a file. Output can also be piped or redirected to a file from a loop. The shell starts a subshell to handle I/O redirection and pipes. Any variables defined within the loop will not be known to the rest of the script when the loop terminates.

Redirecting the Output of the Loop to a File

Example 8.84

```
(The Command Line)
1   $ cat memo
    abc
    def
    ghi

(The Script)
$ cat numbers
    #!/bin/sh
    # Program name: numberit
    # Put line numbers on all lines of memo
2   if [ $# −lt  1 ]
    then
3       echo  "Usage: $0 filename " >&2
        exit 1
    fi
4   count=1                     # Initialize count
5   cat $1 | while read line
    # Input is coming from file on command line
    do
6       [ $count −eq 1 ] && echo "Processing file $1..." > /dev/tty
7       echo $count $line
8       count='expr $count + 1'
9   done > tmp$$                 # Output is going to a temporary file
10  mv tmp$$ $1

(The Command Line)
11  $ numberit memo
    Processing file memo...

 12 $ cat memo
    1 abc
    2 def
    3 ghi
```

EXPLANATION

1. The contents of file memo are displayed.
2. If the user did not provide a command line argument when running this script, the number of arguments ($#) will be less than one and the error message appears.
3. The usage message is sent to stderr (>&2) if the number of arguments is less than 1.
4. The count variable is assigned the value 1.
5. The UNIX cat command displays the contents of the filename stored in $1, and the output is piped to the while loop. The read command is assigned the first line of the file the first time in the loop, the second line of the file the next time through the loop, and so forth. The read command returns a zero exit status if it is successful in reading input and one if it fails.
6. If the value of count is 1, the echo command is executed and its output is sent to /dev/tty, the screen.
7. The echo command prints the value of count, followed by the line in the file.
8. The count is incremented by one.
9. The output of this entire loop, each line of the file in $1, is redirected to the file tmp$$,

with the exception of the first line of the file, which is redirected to the terminal, /dev/tty.[8]

10. The tmp file is renamed to the filename assigned to $1.
11. The program is executed. The file to be processed is called memo.
12. The file memo is displayed after the script has finished, demonstrating that line numbers have been prepended to each line.

Example 8.85

```
(The File)
$ cat testing
apples
pears
peaches

(The Script)
    #!/bin/sh
    # This program demonstrates the scope of variables when
    # assigned within loops where the looping command uses
    # redirection. A subshell is started when the loop uses
    # redirection, making all variables created within the loop
    # local to the shell where the loop is being executed.
1   while read line
    do
2       echo $line    # This line will be redirected to outfile
3       name=JOE
4   done < testing > outfile  # Redirection of input and output
5   echo Hi there $name

(The Output)
5   Hi there
```

EXPLANATION

1. If the exit status of the read command is successful, the body of the while loop is entered. The read command is getting input from the file testing, named after the done on line 4. Each time through the loop, the read command reads another line from the file testing.
2. The value of line will be redirected to outfile in line 4.
3. The variable name is assigned JOE. Since redirection is utilized in this loop, the variable is local to the loop.
4. The done keyword consists of the redirection of input from the file testing, and the redirection of output to the file outfile. All output from this loop will go to outfile.
5. When out of the loop, name is undefined. It was local to the while loop and known only within the body of that loop. Since the variable name has no value, only the string Hi there is displayed.

Piping the Output of a Loop to a UNIX Command. Output can be either piped to another command(s) or redirected to a file.

Example 8.86

```
(The Script)
    #!/bin/sh
1   for i in 7 9 2 3 4  5
2   do
        echo  $i
3   done | sort –n
```

```
(The Output)
2
3
4
5
7
9
```

EXPLANATION

1. The for loop iterates through a list of unsorted numbers.
2. In the body of the loop, the numbers are printed. This output will be piped into the UNIX sort command, a numerical sort.
3. The pipe is created after the done keyword. The loop is run in a subshell.

Running Loops in the Background. Loops can be executed to run in the background. The program can continue without waiting for the loop to finish processing.

Example 8.87

```
(The Script)
    #!/bin/sh
1   for person in bob jim joe sam
    do
2       mail $person < memo
3   done &
```

EXPLANATION

1. The for loop shifts through each of the names in the wordlist: bob, jim, joe, and sam. Each of the names is assigned to the variable person, in turn.
2. In the body of the loop, each person is sent the contents of the memo file.
3. The ampersand at the end of the done keyword causes the loop to be executed in the background. The program will continue to run while the loop is executing.

The exec Command and Loops. The exec command can be used to open or close standard input or output without creating a subshell. Therefore, when starting a loop, any variables created within the body of the loop will remain when the loop completes. When using redirection in loops, any variables created within the loop are lost.

The exec command is often used to open files for reading and writing, either by name or by file descriptor number. Recall that file descriptors 0, 1, and 2 are reserved for standard input, output, and error. If a file is opened, it will receive the next available file descriptor. For example, if file descriptor 3 is the next free descriptor, the new file will be assigned file descriptor 3.

Example 8.88

```
(The File)
1   $ cat tmp
    apples
    pears
    bananas
    pleaches
    plums
```

```
(The Script)
$ cat speller
    #!/bin/sh
    # Scriptname: speller
    # Purpose: Check and fix spelling errors in a file
2   exec < tmp                   # Opens the tmp file
3   while read line              # Read from the tmp file
    do
4       echo $line
5       echo  –n  "Is this word correct? [Y/N] "
6       read answer < /dev/tty   # Read from the terminal
7       case  "$answer" in
8       [Yy]*)
9            continue;;
        *)
             echo  "What is the correct spelling? "
10           read word < /dev/tty
11           sed  "s/$line/$word/g" tmp > error
12           mv error tmp
13           echo $line has been changed to $word.
        esac
14  done
```

EXPLANATION

1. The contents of the tmp file are displayed.
2. The exec command changes standard input (file descriptor 0) so that instead of input coming from the keyboard, it is coming from the tmp file.
3. The while loop starts. The read command gets a line of input from the tmp file.
4. The value stored in the line variable is printed.
5. The user is asked if the word is correct.
6. The read gets the user's response from the terminal, /dev/tty. If the input is not redirected directly from the terminal, it will continue to be read from the file tmp, still opened for reading.
7. The case command evalutates the user's answer.
8. If the variable answer evaluates to a string starting with a Y or y, the continue statement on the next line will be executed.
9. The continue statement causes the program to go to the beginning of the while loop on line 3.
10. The user is again asked for input (the correct spelling of the word). The input is redirected from the terminal, /dev/tty.
11. The sed command will replace the value of line with the value of word wherever it occurs in the tmp file, and send the output to the error file.
12. The error file will be renamed tmp, thus overwriting the old contents of tmp with the contents of the error file.
13. This line is displayed to indicate that the change has been made.
14. The done keyword marks the end of the loop body.

IFS and Loops. The shell's internal field separator (IFS) evaluates to spaces, tabs, and the newline character. It is used as a word (token) separator for commands that parse lists of words, such as read, set, and for. It can be reset by the user if a different separator will be used in a list. Before changing its value, it is a good idea to save the original value of the IFS in another variable. Then it is easy to return to its default value, if needed.

Example 8.89

```
(The Script )
$ cat runit
    #/bin/sh
    # Script is called runit.
    # IFS is the internal field separator and defaults to
    # spaces, tabs, and newlines.
    # In this script it is changed to a colon.
1   names=Tom:Dick:Harry:John
2   OLDIFS="$IFS"  # Save the original value of IFS
3   IFS=":"
4   for persons in $names
    do
5       echo  Hi $persons
    done
6   IFS="$OLDIFS"            # Reset the IFS to old value
7   set Jill Jane Jolene     # Set positional parameters
8   for girl in $*
    do
9      echo Howdy $girl
    done

(The Output)
$ runit
5   Hi Tom
    Hi Dick
    Hi Harry
    Hi John
9   Howdy Jill
    Howdy Jane
    Howdy Jolene
```

EXPLANATION

1. The names variable is set to the string Tom:Dick:Harry:John. Each of the words is separated by a colon.
2. The value of IFS, whitespace, is assigned to another variable, OLDIFS. Since the value of the IFS is whitespace, it must be quoted to preserve it.
3. The IFS is assigned a colon. Now the colon is used to separate words.
4. After variable substitution, the for loop will iterate through each of the names, using the colon as the internal field separator between the words.
5. Each of the names in the wordlist are displayed.
6. The IFS is reassigned its original value stored in OLDIFS.
7. The positional parameters are set. $1 is assigned Jill, $2 is assigned Jane, and $3 is assigned Jolene.
8. $* evaluates to all the positional parameters, Jill, Jane, and Jolene. The for loop assigns each of the names to the girl variable, in turn, through each iteration of the loop.
9. Each of the names in the parameter list is displayed.

8.2.8 Functions

Functions were introduced to the Bourne shell in AT&T's UNIX System VR2. A function is a name for a command or group of commands. Functions are used to modularize your program and make it more efficient. You may even store functions in another file and load them into your script when you are ready to use them.

Here is a review of some of the important rules about using functions.

1. The Bourne shell determines whether you are using a built−in command, a function, or an executable program found out on the disk. It looks for built−in commands first, then functions, and last, executables.
2. A function must be defined before it is used.
3. The function runs in the current environment; it shares variables with the script that invoked it, and lets you pass arguments by assigning them as positional parameters. If you use the exit command in a function, you exit the entire script. If, however, either the input or output of the function is redirected or the function is enclosed within backquotes (command substitution), a subshell is created and the function and its variables and present working directory are known only within the subshell. When the function exits, any variables set there will be lost, and if you have changed directories, you will revert to the directory you were in before invoking the function. If you exit the function, you return to where the script left off when the function was invoked.
4. The return statement returns the exit status of the last command executed within the function or the value of the argument given, and cannot exceed a value of 255.
5. Functions exist only in the shell where they are defined; they cannot be exported to subshells. The dot command can be used to execute functions stored in files.
6. To list functions and definitions, use the set command.
7. Traps, like variables, are global within functions. They are shared by both the script and the functions invoked in the script. If a trap is defined in a function, it is also shared by the script. This could have unwanted side effects.
8. If functions are stored in another file, they can be loaded into the current script with the dot command.

FORMAT

```
function_name () { commands ; commands; }
```

Example 8.90

```
dir () { echo "Directories: " ; ls −l | nawk '/^d/ {print $NF}' ; }
```

EXPLANATION

The name of the function is dir. The empty parentheses are necessary syntax for naming the function but have no other purpose. The commands within the curly braces will be executed when dir is typed. The purpose of the function is to list only the subdirectories below the present working directory. The spaces surrounding the curly braces are required.

To Unset a Function. To remove a function from memory, the unset command is used.

FORMAT

```
unset function_name
```

Function Arguments and the Return Value. Since the function is executed within the current shell, the variables will be known to both the function and the shell. Any changes made to your environment in the function will also be made to the shell. Arguments can be passed to functions by using positional parameters. The positional parameters are private to the function; that is, arguments to the function will not affect any positional parameters used outside the function.

The return command can be used to exit the function and return control to the program at the place where the function was invoked. (Remember, if you use exit anywhere in your script, including within a function, the script terminates.) The return value of a function is really just the value of the exit status of the last command in the script, unless you give a specific argument to the return command. If a value is assigned to the return command, that value is stored in the ? variable and can hold an integer value between zero and 255. Because the return command is limited to returning only an integer between zero and 255, you can use command substitution to capture the output of a function. Place the entire function in backquotes and assign the output to a variable just as you would if getting the output of a UNIX command.

Example 8.91

```
(Using the return Command)
(The Script)
$ cat do_increment
    #!/bin/sh
    # Scriptname: do_increment
1    increment ()  {
2       sum='expr $1 + 1'
3       return $sum  # Return the value of sum to the script.
    }
4   echo  –n "The sum is "
5   increment 5    # Call function increment; pass 5 as a
                   # parameter. 5 becomes $1 for the increment
                   # function.
6   echo $?        # The return value is stored in $?
7   echo  $sum     # The variable "sum" is known to the function,
                   # and is also known to the main script.

(The Output)
      $ do_increment
4,6   The sum is 6
7     6
```

EXPLANATION

1. The function called increment is defined.
2. When the function is called, the value of the first argument, $1, will be incremented by one and the result assigned to sum.
3. The return built−in command, when given an argument, returns to the main script after the line where the function was invoked. It stores its argument in the ? variable.
4. The string is echoed to the screen.
5. The increment function is called with an argument of 5.
6. When the function returns, its exit status is stored in the ? variable. The exit status is the exit value of the last command executed in the function unless an explicit argument is used in the return statement. The argument for return must be an integer between 0 and 255.
7. Although the sum was defined in the function increment, it is global in scope, and therefore also known within the script that invoked the function. Its value is printed.

Example 8.92

```
(Using Command Substitution)
(The Script)
$ cat do_square
    #!/bin/sh
    # Scriptname: do_square
1   function square {
    sq='expr $1 \* $1'
    echo  "Number to be squared is $1."
```

```
2   echo  "The result is $sq "
    }
3   echo "Give me a number to square. "
    read number
4   value_returned='square $number' # Command substitution
5   echo   $value_returned

(The Output)
$ do_square
3   Give me a number to square.
    10
5   Number to be squared is 10. The result is 100
```

EXPLANATION

1. The function called square is defined. Its function, when called, is to multiply its argument, $1, by itself.
2. The result of squaring the number is printed.
3. The user is asked for input. This is the line where the program starts executing.
4. The function square is called with a number (input from the user) as its argument. Command substitution is performed because the function is enclosed in backquotes. The output of the function, both of its echo statements, is assigned to the variable value_returned.
5. The command substitution removes the newline between the strings Number to be squared is 10. and The result is 100.

8.2.9 Functions and the dot Command

Storing Functions. Functions are often defined in the .profile file, so that when you log in, they will be defined. Functions cannot be exported, but they can be stored in a file. Then when you need the function, the dot command is used with the name of the file to activate the definitions of the functions within it.

Example 8.93

```
1   $ cat myfunctions
2   go()  {
        cd $HOME/bin/prog
        PS1=''pwd' > '
         ls
    }
3   greetings() { echo "Hi $1! Welcome to my world." ; }

4   $ . myfunctions
5   $ greetings george
    Hi george! Welcome to my world.
```

EXPLANATION

1. The file myfunctions is displayed. It contains two function definitions.
2. The first function defined is called go. It sets the primary prompt to the present working directory.
3. The second function defined is called greetings. It will greet the name of the user passed in as an argument.
4. The dot command loads the contents of the file myfunctions into the shell's memory. Now both functions are defined for this shell.

5. The greetings function is invoked and executed.

Example 8.94

```
(The .dbfunctions file  shown below contains functions to be used by
the main program)
1   $ cat .dbfunctions
2   addon () {    # Function is named and defined in file .dbfunctions
3       while true
        do
            echo "Adding information "
            echo "Type the full name of employee "
            read name
            echo "Type address for employee "
            read address
            echo "Type start date for employee (4/10/88 ) :"
            read startdate
            echo $name:$address:$startdate
            echo –n "Is this correct? "
            read ans
            case "$ans"  in
            [Yy]*)
                      echo "Adding info..."
                      echo $name:$address:$startdate>>datafile
                 sort –u datafile –o datafile
                 echo –n "Do you want to go back to the main menu? "
                 read ans
                 if [ $ans = Y –o $ans = y ]
                 then
4                     return        # Return to calling program
                 else
5                     continue      # Go to the top of the loop
                 fi
                 ;;
            *)
                 echo "Do you want to try again? "
                 read answer
            case "$answer" in
            [Yy]*) continue;;
            *) exit;;
            esac
                 ;;
        esac
    done
6   }   # End of function definition
–––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––
(The Command Line)
7   $ more mainprog
    #!/bin/sh
    # Scriptname: mainprog
    # This is the main script that will call the function, addon

    datafile=$HOME/bourne/datafile
8   . .dbfunctions      # The dot command reads the dbfunctions file
                        # into memory
    if [ ! –f $datafile ]
    then
       echo "'basename $datafile' does not exist" 1>&2
       exit 1
    fi
9   echo "Select one: "
    cat <<EOF
        [1] Add info
```

```
        [2] Delete info
        [3] Exit
    EOF
    read choice
    case $choice in
10      1)  addon          # Calling the addon function
             ;;
        2)  delete         # Calling the delete function
             ;;

        3)  update
             ;;
        4)
            echo Bye
            exit 0
             ;;
        *)  echo Bad choice
            exit 2
             ;;
    esac
    echo Returned from function call
    echo The name is $name
    # Variable set in the function are known in this shell.
```

EXPLANATION

1. The .dbfunctions file is displayed.
2. The addon function is defined. Its function is to add new information to the file datafile.
3. A while loop is entered. It will loop forever unless a loop control statement such as break or continue is included in the body of the loop.
4. The return command sends control back to the calling program where the function was called.
5. Control is returned to the top of the while loop.
6. The closing curly brace ends the function definition.
7. This is the main script. The function addon will be used in this script.
8. The dot command loads the file .dbfunctions into the program's memory. Now the function addon is defined for this script and available for use. It is as though you had just defined the function right here in the script.
9. A menu is displayed with the here document. The user is asked to select a menu item.
10. The addon function is invoked.

8.2.10 Trapping Signals

While your program is running, if you press Control−C or Control−\, your program terminates as soon as the signal arrives. There are times when you would rather not have the program terminate immediately after the signal arrives. You could arrange to ignore the signal and keep running or perform some sort of cleanup operation before actually exiting the script. The trap command allows you to control the way a program behaves when it receives a signal.

A signal is defined as an asynchronous message that consists of a number that can be sent from one process to another, or by the operating system to a process if certain keys are pressed or if something exceptional happens.[9] The trap command tells the shell to terminate the command currently in execution upon the receipt of a signal. If the trap command is followed by commands within quotes, the command string will be executed upon receipt of a specified signal. The shell reads the command string twice, once when the trap is set, and again when the signal arrives. If the command string is surrounded by double quotes, all variable and command substitution will be performed when the trap is set the first time. If single quotes enclose the command string, variable and command substitution do not take place until the signal is detected and the trap is executed.

Use the command kill –l to get a list of all signals. Table 8.15 provides a list of signal numbers and their corresponding names.

FORMAT

```
trap 'command; command' signal-number
```

Example 8.95

```
trap 'rm tmp*; exit 1'  1 2 15
```

EXPLANATION

When any of the signals 1 (hangup), 2 (interrupt), or 15 (software termination) arrive, remove all the tmp files and exit.

If an interrupt signal comes in while the script is running, the trap command lets you handle the signal in several ways. You can let the signal behave normally (default), ignore the signal, or create a handler function to be called when the signal arrives.

Table 8.15. Signal Numbers and Signals

1) HUP12) SYS23) POLL2) INT13) PIPE24) XCPU3) QUIT14) ALRM25) XFSZ4) ILL15) TERM26) VTALRM5) TRAP16) URG27) PROF6) IOT17) STOP28) WINCH7) EMT18) TSTP29) LOST8) FPE19) CONT30) USR19) KILL20) CHLD31) USR210) BUS21) TTIN 11) SEGV22) TTOU

Resetting Signals. To reset a signal to its default behavior, the trap command is followed by the signal name or number.

Example 8.96

```
trap 2
```

EXPLANATION

Resets the default action for signal 2, SIGINT, which is used to kill a process, i.e., Control−C.

Example 8.97

```
trap 'trap 2' 2
```

EXPLANATION

Sets the default action for signal 2 (SIGINT) to execute the command string within quotes when the signal arrives. The user must press Control−C twice to terminate the program. The first trap catches the signal, the second trap resets the trap back to its default action, which is to kill the process.

Ignoring Signals. If the trap command is followed by a pair of empty quotes, the signals listed will be ignored by the process.

Example 8.98

```
trap " "  1  2
```

EXPLANATION

Signals 1 and 2 will be ignored by the shell.

Listing Traps. To list all traps and the commands assigned to them, type trap.

Example 8.99

```
(The Script)
$ cat trapping
    #/bin/sh
    # Scriptname: trapping
    # Script to illustrate the trap command and signals
1   trap 'echo "Control−C will not terminate $0."' 2
2   trap 'echo "Control−\ will not terminate $0."' 3

3   echo "Enter any string after the prompt."
    echo "When you are ready to exit, type \"stop\"."
4   while true
    do
       echo  −n "Go ahead...> "
       read reply
5      if [ "$reply" = stop ]
       then
6           break
       fi
7   done

(The Output)
$  trapping
Enter any string after the prompt.
When you are ready to exit, type "stop".
Go ahead...> this is it^C
Control−C will not terminate trapping.
Go ahead...> this is never it ^\
Control−\ will not terminate trapping.
Go ahead...> stop
$
```

EXPLANATION

1. The first trap catches the INT signal, Control−C. If ^C is pressed while the program is running, the command enclosed in quotes will be executed. Instead of aborting, the program will print Control−C will not terminate trapping, and continue to prompt the user for input.
2. The second trap command will be executed when the user presses Conrtrol−\, the QUIT signal. The string Control−\ will not terminate trapping will be displayed, and the program will continue to run. This signal, by default, kills the process and produces a core file.

3. The user is prompted for input.
4. The while loop is entered and a prompt, Go ahead…>, is displayed.
5. The user input is assigned to the reply variable and, if its value matches stop, the loop exits and the program terminates. This is the way we will get out of this program unless it is killed with the kill command.
6. The break command causes the body of the loop to be exited with control starting after line 7. In this case, the program is at its end.
7. This is the end of the while loop.

Traps in Functions. If you use a trap to handle a signal in a function, it will affect the entire script, once the function is called. The trap is global to the script. In the following example, the trap is set to ignore the interrupt key, ^C. This script had to be killed with the kill command to stop the looping. It demonstrates potential undesirable side effects when using traps in functions.

Example 8.100

```
(The Script)
   #!/bin/sh
1  trapper () {
          echo "In trapper"
2       trap 'echo "Caught in a trap!"' 2
        # Once set, this trap affects the entire script. Anytime
        # ^C is entered, the script will ignore it.
   }
3  while :
   do
      echo "In the main script"
4     trapper
5     echo "Still in main"
      sleep 5
  done
(The Output)
$ trapper
In the main script
In trapper
Still in main
^CCaught in a trap!
In the main script
In trapper
Still in main
^CCaught in a trap!
In the main script
```

EXPLANATION

1. The trapper function is defined. All variables and traps set in the function are global to the script.
2. The trap command will ignore signal 2, the interrupt key (^C). If ^C is pressed, the message Caught in a trap is printed, and the script continues forever.
3. The main script starts a forever loop.
4. The function trapper is called.
5. When the function returns, execution starts here.

Debugging. By using the –n option to the sh command, you can check the sytnax of your scripts without really executing any of the commands. If there is a syntax error in the script, the shell will report the error. If there are no errors, nothing is displayed.

The most commonly used method for debugging scripts is to use the set command with the –x option, or to use the –x option as an argument to the sh command, followed by the script name. See Table 8.16 for a list of debugging options. These options allow an execution trace of your script. Each command from your script is displayed after substitution has been performed, and then the command is executed. When a line from your script is displayed, it is preceded with a plus (+) sign.

With the verbose option turned on, or by invoking the Bourne shell with the –v option (sh –v scriptname), each line of the script will be displayed just as it was typed in the script, and then executed.

Table 8.16. Debugging Options

Command OptionWhat It Doessh –x scriptnameEcho optionDisplays each line of script after variable substitutions and before execution.sh –v scriptnameVerbose optionDisplays each line of script before execution, just as you typed it.sh –n scriptnameNoexec optionInterprets but does not execute commands.set –xTurns on echoTraces execution in a script.set +xTurns off echoTurns off tracing.

Example 8.101

```
(The Script)
$ cat todebug
    #!/bin/sh
1   # Scriptname: todebug
    name="Joe Blow"
    if  [ "$name" = "Joe Blow" ]
    then
       echo "Hi $name"
    fi

    num=1
    while [ $num –lt 5 ]
    do
         num='expr $num + 1'
    done
    echo The grand total is $num

(The Output)
2   $ sh –x todebug
    + name=Joe Blow
    + [ Joe Blow =  Joe Blow ]
    + echo Hi Joe Blow

    Hi Joe Blow
    num=1
    + [ 1 –lt 5 ]
    + expr 1 + 1
    num=2
    + [ 2 –lt 5 ]
    + expr 2 + 1
    num=3
    + [ 3 –lt 5 ]
    + expr 3 + 1
     num=4
    + [ 4 –lt 5 ]
    + expr 4 + 1
     num=5
    + [ 5 –lt 5 ]
    + echo The grand total is 5
```

```
The grand total is 5
```

EXPLANATION

1. The script is called todebug. You can watch the script run with the –x switch turned on. Each iteration of the loop is displayed and the values of variables are printed as they are set and when they change.
2. The sh command starts the Bourne shell with the –x option. Echoing is turned on. Each line of the script will be displayed to the screen prepended with a plus sign (+). Variable substitution is performed before the line is displayed. The result of the execution of the command appears after the line has been displayed.

8.2.11 Processing Command Line Options with getopts

If you are writing scripts that require a number of command line options, positional parameters are not always the most efficient. For example, the UNIX ls command takes a number of command line options and arguments. (An option requires a leading dash; an argument does not.) Options can be passed to the program in several ways: ls –laFi, ls –i –a –l –F, ls –ia –F, and so forth. If you have a script that requires arguments, positional parameters might be used to process the arguments individually, such as ls –l –i –F . Each dash option would be stored in $1, $2, and $3, respectively. But, what if the user listed all of the options as one dash option, as in ls –liF? Now the –liF would all be assigned to $1 in the script. The getopts function makes it possible to process command line options and arguments in the same way they are processed by the ls program.[10] The getopts function will allow the runit program to process its arguments using any variety of combinations.

Example 8.102

```
(The Command Line )
1   $ runit –x –n  200 filex

2   $ runit –xn200 filex

3   $ runit –xy

4   $ runit –yx –n 30

5   $ runit –n250 –xy filey

( any other combination of these arguments )
```

EXPLANATION

1. The program runit takes four arguments: x is an option, n is an option requiring a number argument after it, and filex is an argument that stands alone.
2. The program runit combines the options x and n and the number argument 200; filex is also an argument.
3. The program runit is invoked with the x and y options combined.
4. The program runit is invoked with the y and x options combined; the n option is passed separately, as is the number argument, 30.
5. The program runit is invoked with the n option combined with the number argument, the x and y options are combined, and the filey is separate.

Before getting into all the details of the runit program, we examine the line from the program where getopts is used to see how it processes the arguments.

Example 8.103

```
(A Line from the Script Called "runit")
while getopts :xyn: name
```

EXPLANATION

- x, y, and n are the options.
- Options typed at the command line begin with a dash.
- Any options that do not contain a dash tell getopts that the option list is at an end.
- Each time getopts is called, it places the next option it finds, without the dash, in the variable name. (You can use any variable name here.) If an illegal argument is given, name is assigned a question mark.
- OPTIND is a special variable that is initialized to one and is incremented each time getopts completes processing a command line argument to the number of the next argument getopts will process.
- The OPTARG variable contains the value of a legal argument.

getopts Scripts. The following examples illustrate how getopts processes arguments.

Example 8.104

```
(The Script)
$ cat opts1
   #!/bin/sh
   # Program opts1
   # Using getopts –– First try ––
1  while getopts xy options
   do
2     case $options in
3     x) echo "you entered –x as an option";;
      y) echo "you entered –y as an option";;
      esac
   done

(The Command Line)
4  $ opts1 –x
   you entered –x as an option
5  $ opts1 –xy
   you entered –x as an option
   you entered –y as an option
6  $ opts1 –y
   you entered –y as an option
7  $ opts1 –b
   opts1:   illegal option ––  b
8  $ opts1 b
```

EXPLANATION

1. The getopts command is used as a condition for the while command. The valid options for this program are listed after the getopts command; they are x and y. Each option is tested in the body of the loop, one after the other. Each option will be assigned to the variable options, without the leading dash. When there are no longer any arguments to process, getopts will exit with a nonzero status, causing the while loop to terminate.
2. The case command is used to test each of the possible options found in the options

variable, either x or y.
3. If x was an option, the string You entered x as an option is displayed.
4. At the command line, the opts1 script is given a x option, a legal option to be processed by getopts.
5. At the command line, the opts1 script is given a xy option; x and y are legal options to be processed by getopts.
6. At the command line, the opts1 script is given a y option, a legal option to be processed by getopts.
7. The opts1 script is given a b option, an illegal option. Getopts sends an error message to stderr.
8. An option without a dash prepended to it is not an option and causes getopts to stop processing arguments.

Example 8.105

```
(The Script)
$ cat opts2
   #!/bin/sh
   # Program opts2
   # Using getopts -- Second try --
1  while getopts xy options 2> /dev/null
   do
2     case $options in
      x) echo "you entered -x as an option";;
      y) echo "you entered -y as an option";;
3     \?) echo "Only -x and -y are valid options"  1>&2;;
      esac
   done

(The Command Line)
   $ opts2 -x
   you entered -x as an option

   $ opts2 -y
   you entered -y as an option

   $ opts2 xy

   $ opts2 -xy
   you entered -x as an option
   you entered -y as an option

4  $ opts2 -g
   Only -x and -y are valid options

5  $ opts2 -c
    Only -x and -y are valid options
```

EXPLANATION

1. If there is an error message from getopts, it is redirected to /dev/null.
2. If the option is a bad option, a question mark will be assigned to the options variable. The case command can be used to test for the question mark, allowing you to print your own error message to standard error.
3. If the options variable is assigned the question mark, the case statement is executed. The question mark is protected with the backslash so that the shell does not see it as a wildcard and try to perform filename substitution.

4. g is not a legal option. A question mark is assigned to the variable options, and the error message is displayed.
5. c is not a legal option. A question mark is assigned to the variable options, and the error message is displayed.

Example 8.106

```
(The Script)
$ cat opts3
   #!/bin/sh
   # Program opts3
   # Using getopts -- Third try --
1  while getopts dq: options
   do
       case $options in
2          d) echo "-d is a valid switch ";;
3          q) echo "The argument for -q is $OPTARG";;
           \?) echo "Usage:opts3 -dq filename ... " 1>&2;;
      esac
   done

(The Command Line)
4  $ opts3 -d
   -d is a valid switch

5  $ opts3 -q  foo
   The argument for -q is foo

6  $ opts3 -q
   Usage:opts3 -dq filename ...

7  $ opts3 -e
   Usage:opts3 -dq filename ...

8  $ opts3 e
```

EXPLANATION

1. The while command tests the exit status of getopts; if getopts can successfully process an argument, it returns zero exit status, and the body of the while loop is entered. The colon appended to the argument list means that the q option requires an argument. The argument will be stored in the special variable, OPTARG.
2. One of the legal options is d. If d is entered as an option, the d (without the dash) is stored in the options variable.
3. One of the legal options is q. The q option requires an argument. There must be a space between the q option and its argument. If q is entered as an option followed by an argument, the q, without the dash, is stored in the options variable and the argument is stored in the OPTARG variable. If an argument does not follow the q option, the question mark is stored in the variable options.
4. The d option is a legal option to opts3.
5. The q option with an argument is also a legal option to opts3.
6. The q option without an argument is an error.
7. The e option is invalid. A question mark is stored in the options variable if the option is illegal.
8. The option is prepended with neither a dash nor a plus sign. The getopts command will not process it as an option and returns a nonzero exit status. The while loop is terminated.

Example 8.107

```
$ cat opts4
   #!/bin/sh
   # Program opts4
   # Using getopts −− Fourth try −−
1  while getopts xyz: arguments 2>/dev/null
   do
      case $arguments  in
2     x) echo "you entered −x as an option.";;
      y) echo "you entered −y as an option.";;
3     z) echo "you entered −z as an option."
           echo "\$OPTARG is $OPTARG.";;
4     \?) echo "Usage opts4 [−xy] [−z  argument]"
           exit 1;;
      esac
   done
5  echo "The initial value of \$OPTIND is 1.
      The final value of \$OPTIND is $OPTIND.
      Since this reflects the number of the next command line
      argument,the number of arguments passed was
      'expr $OPTIND − 1'. "

(The Command Line)
$ opts4 −xyz foo
you entered −x as an option.
you entered −y as an option.
you entered −z as an option.
$OPTARG is foo.
The initial value of $OPTIND is 1.
The final value of $OPTIND is 3.
Since this reflects the number of the next command
line argument, the number of arguments passed was 2.
$ opts4 −x −y −z  boo
you entered −x as an option.
you entered −y as an option.
you entered −z as an option.
$OPTARG is boo.
The initial value of $OPTIND is 1.
The final value of $OPTIND is 5.
Since this reflects the number of the next command
line argument,the number of arguments passed was 4.
$ opts4 −d
Usage: opts4  [−xy] [−z argument]
```

EXPLANATION

1. The while command tests the exit status of getopts; if getopts can successfully process an argument, it returns zero exit status, and the body of the while loop is entered. The colon appended to the z option tells getopts that an argument must follow the –z option. If the option takes an argument, the argument is stored in the getopts built−in variable OPTARG.
2. If x is given as an option, it is stored in the variable arguments.
3. If z is given as an option with an argument, the argument is stored in the built−in variable OPTARG.
4. If an invalid option is entered, the question mark is stored in the variable arguments, and an error message is displayed.

5. The special getopts variable, OPTIND, holds the number of the next option to be processed. Its value is always one more than the actual number of command line arguments.

8.2.12 The eval Command and Parsing the Command Line

The eval command evaluates a command line, performs all shell substitutions, and then executes the command line. It is used when normal parsing of the command line is not enough.

Example 8.108

```
1   $ set a b c d
2   $ echo The last argument is \$$#
3   The last argument is $4

4   $ eval echo The last argument is \$$#
    The last argument is d

5   $ set -x
    $ eval echo The last argument is \$$#
    + eval echo the last argument is $4
    + echo the last argument is d
    The last argument is d
```

EXPLANATION

1. Four positional parameters are set.
2. The desired result is to print the value of the last positional parameter. The \$ will print a literal dollar sign. The $# evaluates to 4, the number of positional parameters. After the shell evaluates the $#, it does not parse the line again to get the value of $4.
3. $4 is printed instead of the last argument.
4. After the shell performs variable substitution, the eval command performs the variable substitution and then executes the echo command.
5. Turn on the echoing to watch the order of parsing.

Example 8.109

```
(From SVR4 Shutdown Program)
1  eval '/usr/bin/id | /usr/bin/sed 's/[^a-z0-9=].*//''
2  if [ "${uid:=0}" -ne 0 ]
   then
3      echo $0: Only root can run $0
       exit 2
   fi
```

EXPLANATION

1. This is a tricky one. The id program's output is sent to sed to extract the uid part of the string. The output for id is:

   ```
   uid=9496(ellie) gid=40 groups=40
   uid=0(root) gid=1(daemon) groups=1(daemon)
   ```

   The sed regular expression reads: Find any character that is not a letter, number, or an equal sign and remove that character and all characters following it. The result is to substitute everything from the first opening parenthesis to the end of the line with nothing. What is left is either uid=9496 or uid=0.

After eval evaluates the command line, it then executes the resulting command:

```
uid=9496
```

or

```
uid=0
```

For example, if the user's ID is root, the command executed would be uid=0. This creates a local variable in the shell called uid and assigns zero to it.

2. The value of the uid variable is tested for zero, using command modifiers.
3. If the uid is not zero, the echo command displays the script name ($0) and the message.

8.2.13 Shell Invocation Options

When the shell is started using the sh command, it can take options to modify its behavior. See Table 8.17.

Table 8.17. Shell Invocation Options

Option	Meaning
–i	Shell is in the interactive mode. QUIT and INTERRUPT are ignored.
–s	Commands are read from standard input and output is sent to standard error.
–c string	Commands are read from string.

8.2.14 The set Command and Options

The set command can be used to turn shell options on and off, as well as for handling command line arguments. To turn an option on, the dash (–) is prepended to the option; to turn an option off, the plus sign (+) is prepended to the option. See Table 8.18 for a list of set options.

Example 8.110

```
1   $ set −f

2   $ echo *
    *

3   $ echo ??
    ??

4   $ set +f
```

EXPLANATION

1. The f option is turned on, disabling filename expansion.
2. The asterisk is not expanded.
3. The question marks are not expanded.
4. The f is turned off; filename expansion is enabled.

Table 8.18. The set Command Options

Option Meaning–aMarks variables that have been modified or exported.–eExits the program if a command returns a nonzero status.–fDisables globbing (filename expansion).–hLocates and remembers function commands as functions when they are defined, not just when they are executed.–kAll keyword arguments are placed in the environment for a command, not just those that precede the command name.–nReads commands but does not execute them; used for debugging.–tExits after reading and executing one command.–uTreats unset variables as an error when performing substitution.–vPrints shell input lines as they are read; used for debugging.–xPrints commands and their arguments as they are being executed. Used for debugging.– –Does not change any of the flags.

8.2.15 Shell Built−In Commands

The shell has a number of commands that are built into its source code. Since the commands are built−in, the shell doesn't have to locate them on disk, making execution much faster. The built−in commands are listed in Table 8.19.

Table 8.19. Built−In Commands

CommandWhat It Does:Do−nothing command; returns exit status zero.. fileThe dot command reads and executes command from file.break [n]See looping.continue [n]See looping.cdChange directory.echo [args]Echo arguments.eval commandShell scans the command line twice before execution.exec commandRuns command in place of this shell.exit [n]Exit the shell with status n.export [var]Make var known to subshells.hashControls the internal hash table for quicker searches for commands.kill [–signal process]Sends the signal to the PID number or job number of the process. See /usr/include/sys/signal.h for a list of signals.getoptsUsed in shell scripts to parse command line and check for legal options.login [username]Sign onto the system.newgrp [arg]Logs a user into a new group by changing the real group and effective group ID.pwdPrint present working directory.read [var]Read line from standard input into variable var.readonly [var]Make variable var read−only. Cannot be reset.return [n]Return from a function where n is the exit value given to the return.setSee Table 8.18.shift [n]Shift positional parameters to the left n times.stop pidHalt execution of the process number PID.suspendStops execution of the current shell (but not if a login shell).timesPrint accumulated user and system times for processes run from this shell.trap [arg] [n]When shell receives signal n (0, 1, 2, or 15), execute arg.type [command]Prints the type of command; e.g., pwd has a built−in shell, in ksh, an alias for the command whence –v.umask [octal digits]User file creation mode mask for owner, group, and others.unset [name]Unset value of variable or function.wait [pid#n]Wait for background process with PID number n and report termination status.ulimit [options size]Set maximum limits on processes.umask [mask]Without argument, print out file creation mask for permissions.

BOURNE SHELL LAB EXERCISES

Lab 8: Getting Started

1: What process puts the login prompt on your screen?

2: What process assigns values to HOME, LOGNAME, and PATH?

3: How do you know what shell you are using?

4: Where is your login shell assigned? (What file?)

5: Explain the difference between the /etc/profile and .profile file. Which one is executed first?

6: Edit your .profile file as follows:

a. Welcome the user.
b. Add your home directory to the path if it is not there.
c. Set the erase function to the Backspace key using stty.
d. Type: profile

What is the function of the dot command?

Lab 9: Shell Metacharacters

1: Make a directory called wildcards. Cd to that directory and type at the prompt:

```
touch ab abc a1 a2 a3 all a12 ba ba.1 ba.2 filex filey AbC ABC
ABc2 abc
```

2: Write and test the command that will do the following:

a. List all files starting with a.
b. List all files ending in at least one digit.
c. List all files starting with an a or A.
d. List all files ending in a period, followed by a digit.
e. List all files containing just two of the letter a.
f. List three character files where all letters are uppercase.
g. List files ending in 10, 11, or 12.
h. List files ending in x or y.
i. List all files ending in a digit, an uppercase letter, or a lowercase letter.
j. List all files not starting with a b or B.
k. Remove two−character files starting with a or A.

Lab 10: Redirection

1: What are the names of the three file streams associated with your terminal?

2: What is a file descriptor?

3: What command would you use to do the following:

a. Redirect the output of the ls command to a file called lsfile?
b. Redirect and append the output of the date command to lsfile?
c. Redirect the output of the who command to lsfile? What happened?

4: Perform the following:

a. Type cp all by itself. What happens?
b. Save the error message from the above example to a file.
c. Use the find command to find all files, starting from the parent directory, of type directory. Save the standard output in a file called found and any errors in a file called found.errs.
d. Take the output of three commands and redirect the output to a file called gottem_all.
e. Use a pipe(s) with the ps and wc commands to find out how many processes you are currently running.

Lab 11: First Script

1: Write a script called greetme that will do the following:

a. Contain a comment section with your name, the name of this script, and the purpose of this script.
b. Greet the user.
c. Print the date and the time.
d. Print a calendar for this month.
e. Print the name of your machine.
f. Print the name and release of this operating system, (cat /etc/motd).
g. Print a list of all files in your parent directory.
h. Print all the processesroot is running.
i. Print the value of the TERM, PATH, and HOME variables.
j. Print your disk usage (du).
k. Use theid command to print your group ID.
l. Print Please couldn't you loan me $50.00?
m. Tell the user Good bye and the current hour (see man pages for the date command).

2: Make sure your script is executable.

```
chmod +x greetme
```

3: What was the first line of your script? Why do you need this line?

Lab 12: Command Line Arguments

1: Write a script called rename that will take two arguments: the first argument is the name of the original file and the second argument is the new name for the file.

If the user does not provide two arguments, a usage message will appear on the screen and the script will exit. Here is an example of how the script works:

```
$ rename
Usage: rename oldfilename newfilename
$

$ rename file1 file2
file1 has been renamed file2
Here is a listing of the directory:
a file2
b file.bak
```

2: The following find command (SunOS) will list all files in the root partition that are larger than 100K and that have been modified in the last week. (Check your man pages for the correct find syntax on your system.)

```
find / –xdev –mtime –7 –size +200 –print
```

Write a script called bigfiles that will take two arguments: One will be the mtime and one the size value. An appropriate error message will be sent to stderr if the user does not provide two arguments.

3: If you have time, write a script called vib that creates backup files for vi. The backup files will have the extension .bak appended to the original name.

Lab 13: Getting User Input

1: Write a script called nosy that will do the following:

a. Ask the user's full name—first, last, and middle name.
b. Greet the user by his or her first name.
c. Ask the user's year of birth and calculate his or her age (useexpr).
d. Ask the user's login name and print his or her user ID (from /etc/passwd).Tell the user his or her home directory.
e. Show the user the processes he or she is running.
f. Tell the user the day of the week, and the current time in nonmilitary time. The output should resemble

```
The day of the week is Tuesday and the current time is
04:07:38 PM.
```

2: Create a text file called datafile (unless this file has already been provided for you). Each entry consists of fields separated by colons. The fields are as follows:

a. First and last name
b. Phone number
c. Address
d. Birth date
e. Salary

3: Create a script called lookup that will do the following:

a. Contain a comment section with the script name, your name, the date, and the reason for writing this script. The reason for writing this script is to display the datafile in sorted order.
b. Sort the datafile by last names.
c. Show the user the contents of the datafile.
d. Tell the user the number of entries in the file.

4: Try the –x and –v options for debugging your script. How did you use these commands? How do they differ?

Lab 14: Conditional Statements

1: Write a script called checking that will do the following:

a. Take a command line argument: a user's login name.
b. Test to see if a command line argument was provided.
c. Check to see if the user is in the /etc/passwd file. If so, it will print

```
Found <user> in the /etc/passwd file.
```

Otherwise, it will print

```
No such user on our system.
```

2: In the lookup script, ask the user if he or she would like to add an entry to the datafile. If the answer is yes or y:

a. Prompt the user for a new name, phone, address, birth date, and salary. Each item will be stored in a separate variable. You will provide the colons between the fields and append the information to the datafile.
b. Sort the file by last names. Tell the user you added the entry, and show him or her the line preceded by the line number.

Lab 15: Conditionals and File Testing

1: Rewrite checking. After checking whether the named user is in the /etc/passwd file, the program will check to see if the user is logged on. If so, the program will print all the processes that are running; otherwise, it will tell the user

```
<user> is not logged on.
```

2: The lookup script depends on the datafile in order to run. In the lookup script, check to see if the datafile exists and if it is readable and writeable. Add a menu to the lookup script to resemble the following:

1. `Add entry.`
2. `Delete entry.`
3. `View entry.`
4. `Exit.`

a. You already have the Add entry part of the script written. The Add entry routine should now include code that will check to see if the name is already in the datafile and if it is, tell the user so. If the name is not there, add the new entry.
b. Now write the code for the Delete entry, View entry, and Exit functions.
c. The Delete part of the script should first check to see if the entry exists before trying to remove it. If it does not exist, notify the user; otherwise, remove the entry and tell the user you removed it. On exit, make sure that you use a digit to represent the appropriate exit status.

d. How do you check the exit status from the command line?

Lab 16: The Case Statement

1: The ps command is different on UCB and AT&T UNIX. On AT&T UNIX, the command to list all processes is

```
ps –ef
```

On UCB UNIX, the command is

```
ps –aux
```

Write a program called systype that will check for a number of different system types. The cases to test for will be

```
AIX

IRIX

HP–UX

SCO

OSF1

ULTRIX

SunOS (Solaris / SunOS)

OS
```

Solaris, HP–UX, SCO, and IRIX are AT&T−type systems. The rest are BSDish.

The version of UNIX you are using will be printed to stdout. The system name can be found with the uname –s command or from the /etc/motd file.

Lab 17: Loops

Select one of the following:

1: Write a program called mchecker to check for new mail and write a message to the screen if new mail has arrived.

a. The program will get the size of the mail spool file for the user. (The spool files are found in /usr/mail/$LOGNAME on AT&T systems and /usr/spool/mail/$USER on UCB systems. Use the find command if you cannot locate the file.) The script will execute in a continuous loop, once every 30 seconds. Each time the loop executes, it will compare the size of the mail spool file with its size from the previous loop. If the new size is greater than the old size, a message will be printed on your screen, saying Username, You have new mail.

The size of a file can be found by looking at the output fromls –l, wc –c or from the find command.

2: Write a program called dusage that will mail a list of users, one at a time, a listing of the number of blocks they are currently using. The list of users will be in a file called potential_hogs. One of the users listed in the potential_hogs file will be admin.

a. Use file testing to check that potential_hogs file exists and is readable.
b. A loop will be used to iterate through the list of users. Only those users who are using over 500 blocks will be sent mail. The user admin will be skipped over (i.e., he or she does not get a mail message). The mail message will be stored in a here document in your dusage script.
c. Keep a list of the names of each person who received mail. Do this by creating a log file. After everyone on the list has been sent mail, print the number of people who received mail and a list of their names.

Lab 18: Functions

1: Rewrite the systype program from Lab 9 as a function that returns the name of the system. Use this function to determine what options you will use with the ps command in the checking program.

2: The ps command to list all processes on AT&T UNIX is

```
ps –ef
```

3: On BSD UNIX, the command is

```
ps –aux
```

4: Write a function called cleanup that will remove all temporary files and exit the script. If the interrupt or hangup signal is sent while the program is running, the trap command will call the cleanup function.

5: Use a here document to add a new menu item to the lookup script to resemble the following:

1. `Add entry`
2. `Delete entry`
3. `Change entry`
4. `View entry`
5. `Exit`

Write a function to handle each of the items in the menu. After the user has selected a valid entry and the function has completed, ask if the user would like to see the menu again. If an invalid entry is entered, the program should print

```
Invalid entry, try again.
```

and the menu will be redisplayed.

6: Create a submenu under View entry in the lookup script. The user will be asked if he or she would like to view specific information for a selected individual:

a. `Phone`
b. `Address`
c. `Birthday`
d. `Salary`

7: Use the trap command in a script to perform a cleanup operation if the interrupt signal is sent while the program is running.

[1] If the .profile were executed directly as a script, a subshell would be started. Then the variables would be set in the subshell, but not in the login shell (parent shell).

[2] A variable set to some value or to null will be displayed by using the set command, whereas an unset variable will not.

[3] The Korn shell allows backquotes for command substitution for upward−compatibility, but provides an alternate method as well.

[4] Remember, without arguments, the set command displays all the variables that have been set for this shell, local and exported. With options, the set command turns on and off shell control options such as –x and –v.

[5] Unlike the C shell, the Bourne shell does not support an if statement without a then, even for a simple statement.

[6] If using NIS+, the command would read: If nismatch "$name" passwd.org_dir.

[7] If the continue command is given a number higher than the number of loops, the loop exits.

[8] $$ expands to the PID number of the current shell. By appending this number to the filename, the filename is made unique.

[9] Bolsky, Morris I., and Korn, David G., *The New KornShell Command and Programming Language* (Englewood Cliffs, NJ: Prentice Hall PTR, 1995), p. 327.

[10] See the UNIX manual pages (Section 3) for the C library function getopt.

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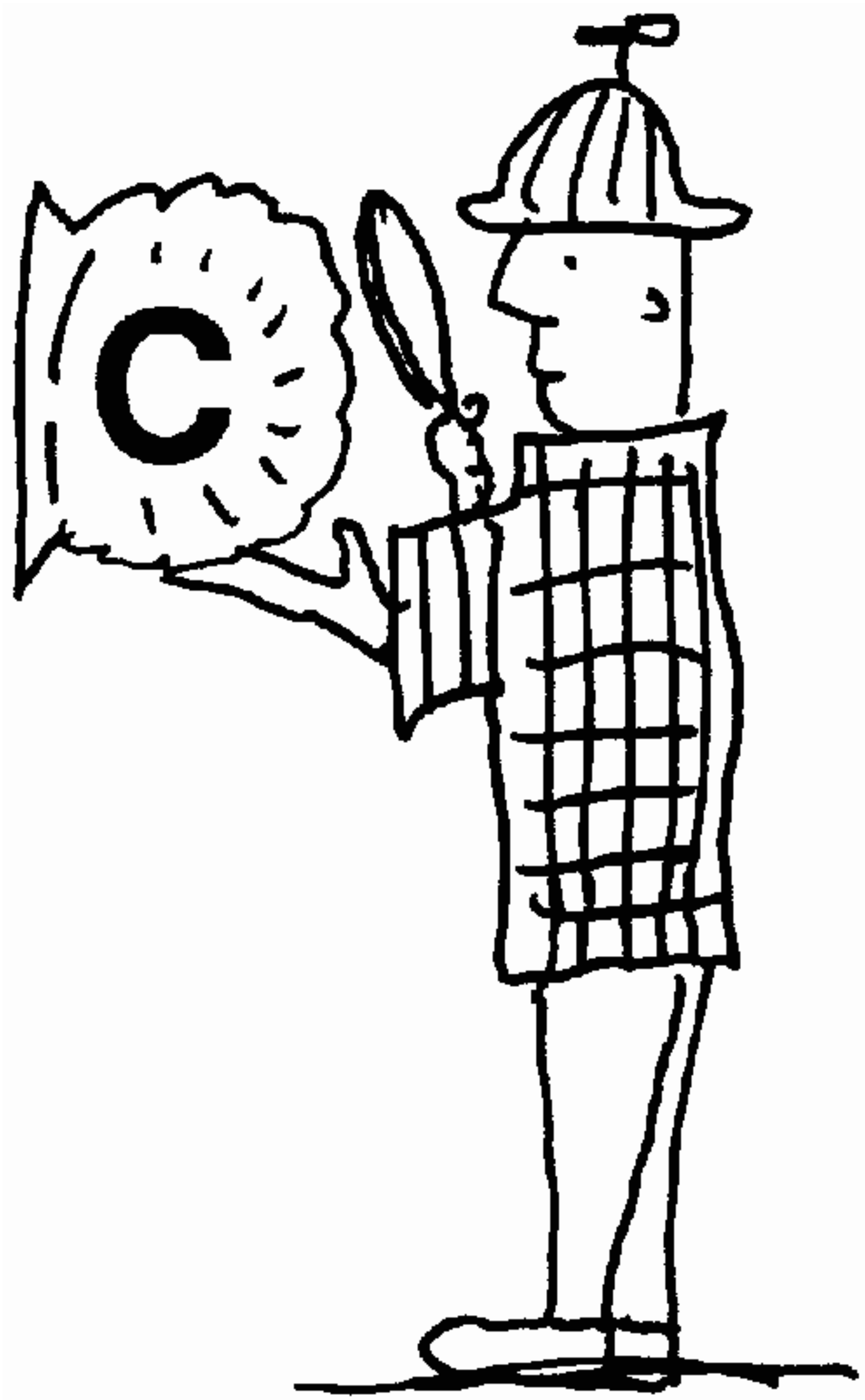
CONTENTS

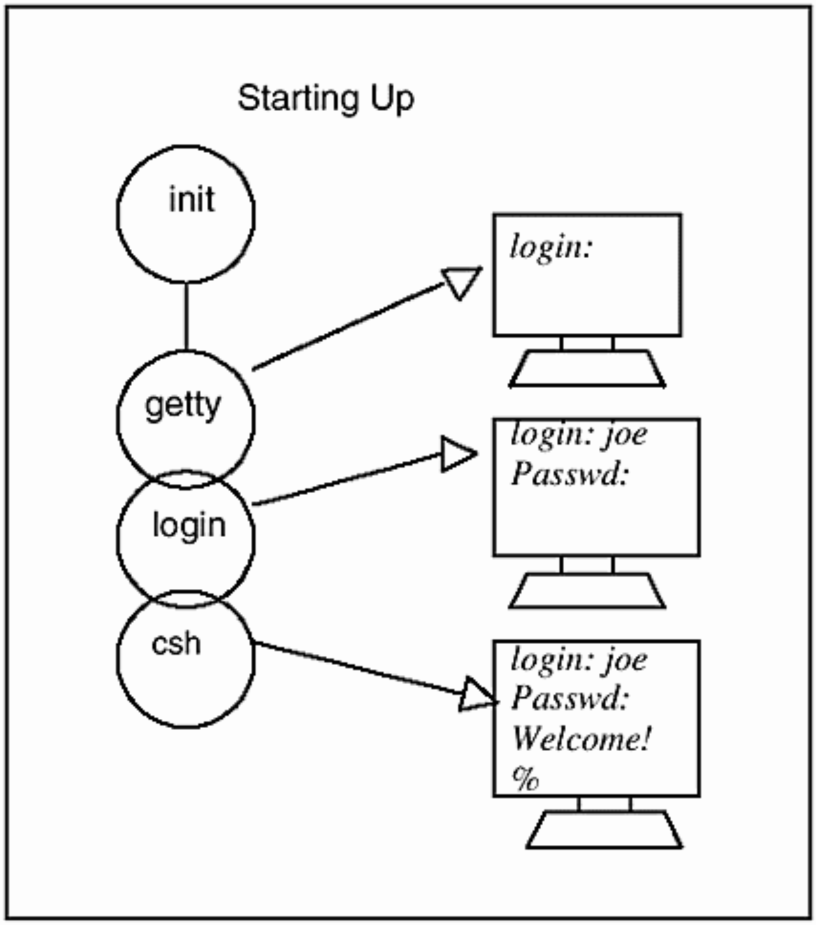
Chapter 9. The C Shell



9.1 The Interactive C Shell

Before the C shell displays a prompt, it is preceded by a number of processes. See Figure 9.1.

Figure 9.1. System startup and the C shell.



9.1.1 Startup

After the system boots, the first process to run is called init; it is assigned process identification number (PID) 1. It gets instructions from a file called inittab (System V) or spawns a getty process (BSD). These processes are responsible for opening up the terminal ports, for providing a place where input comes from (stdin), where standard output (stdout) and error (stderr) go, and for putting a login prompt on your screen. The /bin/login program is then executed. The login program prompts for a password, encrypts and verifies your password, sets up an initial working environment, and then initiates the shell, /bin/csh. The C shell looks in the user's home directory for a file called .cshrc, an initialization file allowing you to customize the C shell environment you will be working in. After executing commands in the .cshrc file, commands in the .login file are executed. The .cshrc file will be executed every time a new C shell is started. The .login file is executed only once when the user logs on, and also contains commands and variables to initialize the user's environment. After executing commands from those files, the percent sign prompt appears on your screen and the C shell awaits commands.

9.1.2 The Environment

Initialization Files. After the csh program starts, it is programmed to execute two files in the user's home directory: the .cshrc file and the .login file. These files allow users to initialize their own environments.

The .cshrc File. The .cshrc file contains C shell variable settings and is executed every time a csh subshell is started. Aliases and history are normally set here.

Example 9.1

```
(The .cshrc File)
1   if ( $?prompt ) then
2      set prompt = "\! stardust > "
3      set history = 32
4      set savehist = 5
5      set noclobber
6      set filec fignore = ( .o )
7      set cdpath = ( /home/jody/ellie/bin /usr/local/bin /usr/bin )
8      set ignoreeof
9      alias m more
       alias status 'date;du −s'
       alias cd 'cd \!*;set prompt = "\! <$cwd> "'
    endif
```

EXPLANATION

1. If the prompt has been set ($?prompt), the shell is running interactively; i.e., it is not running in a script.
2. The primary prompt is set to the number of the current history event, the name stardust, and a > character. This will change the % prompt, the default.
3. The history variable is set to 32. This controls the number of history events that will appear on the screen. The last 32 commands you entered will be displayed when you type history (see "Command Line History").
4. Normally, when you log out, the history list is cleared. The savehist variable allows you to save a specified number of commands from the end of the history list. In this example, the last 5 commands will be saved in a file in your home directory, the .history file, so that when you log in again, the shell can check to see if that file exists and put the history lines saved at the top of the new history list.
5. The noclobber variable is set to protect the user from inadvertently removing files when using redirection. For example, sort myfile > myfile will destroy myfile. With noclobber set, the message file exists will appear on the screen.
6. The filec variable is used for filename completion so that you only need to type the first number of significant characters in a filename, press the ESC key, and the shell will complete the rest of the filename. By pressing ^D (Control−D) when typing in the filename, the C shell will display a list of files that match that string. The fignore variable allows you to exclude files that you do not want affected by filename completion. In this case, all the .o filenames (object files) will not be affected by filec, even though filec is set (see "Filename Completion: The filec Variable" on page 355).
7. The cdpath variable is assigned a list of path elements. When changing directories, if you specify just the directory name, and that directory is not a subdirectory directly below the current working directory, the shell will search the cdpath directory entries to see if it can find the directory in any of those locations and then will change the directory.
8. The ignoreeof variable prevents you from logging out with ^D. UNIX utilities that accept input from the keyboard, such as the mail program, are terminated by pressing ^D. Often, on a slow system, the user will be tempted to press ^D more than once. The first time, the mail program would be terminated, the second time, the user is logged out. By setting ignoreeof, you are required to type logout to log out.
9. The aliases are set to give a shorthand notation for a single command or group of commands. Now when you type the alias, the command(s) assigned to it will be executed. The alias for the more command is m. Every time you type m, the more command is

executed. The status alias prints the date and a summary of the user's disk usage. The cd alias creates a new prompt every time the user changes directory. The new prompt will contain the number of the current history event (\!*) and the current working directory, $cwd surrounded by < >. (see "Aliases").

The .login File. The .login file is executed one time when you first log in. It normally contains environment variables and terminal settings. It is the file where window applications are usually started. Since environment variables are inherited by processes spawned from this shell and only need to be set once, and terminal settings do not have to be reset for every process, those settings belong in the login file.

Example 9.2

```
(The .login File)
1   stty -istrip
2   stty erase ^H
3   #
    # If possible start the windows system.
    # Give a user a chance to bail out
    #
4   if ( 'tty' == "/dev/console" ) then
5       if ( $TERM == "sun" || $TERM == "AT386" ) then
6              if ( ${?OPENWINHOME} == 0 ) then
7                   setenv OPENWINHOME /usr/openwin
8              endif
           echo ""
9          echo -n "Starting OpenWindows in 5 seconds\
               (type Control-C to interrupt)"
10         sleep 5
           echo ""
11         $OPENWINHOME/bin/openwin
12         clear
13         logout
       endif
    endif
```

EXPLANATION

1. The stty command sets options for the terminal. Input characters will not be stripped to seven bits if −istrip is an option.
2. The stty command sets the Backspace key (Control−H) to erase characters.
3. Any line beginning with a # is a comment. It is not an executable statement.
4. If the current terminal window (tty) is the console (/dev/console), the next line is executed; otherwise, program control goes to the last endif.
5. If the value of the TERM variable is equal to sun or AT386, then the next line is executed.
6. If the OPENWINHOME environment variable has not been set ($? is 0 if not set, and 1 if set), the next line is executed.
7. The OPENWINHOME environment variable is set to /usr/openwin.
8. This endif ends the if on line 5.
9. The line is displayed on the screen, letting the user know that OpenWindows is starting unless Control−C is typed within the next 5 seconds.
10. The program sleeps (stops execution) for 5 seconds.
11. The openwin program is started. A set of terminal windows (shell and command tool windows and a console window) will appear on the screen.
12. After closing windows, the screen will be cleared.
13. The user will be logged out.

The Search Path. The path variable is used by the shell to locate commands typed at the command line. The search is from left to right. The dot represents the current working directory. If the command is not found in any of the directories listed in the path, or in the present working directory, the shell sends the message Command not found to standard error. It is recommended that the path be set in the .login file.[1] The search path is set differently in the C shell than it is in the Bourne and Korn shells. Each of the elements is separated by whitespace.

```
set path = (/usr/bin /usr/ucb /bin /usr .)
echo $path
/usr/bin /usr/ucb /bin /usr .
```

The environment variable PATH will display as:

```
echo $PATH
/usr/bin:/usr/ucb:/bin:.
```

The C shell internally updates the environment variable for PATH to maintain compatibility with other programs (such as the Bourne or Korn shells) that may be started from this shell and will need to use the path variable.

The rehash Command. The shell builds an internal hash table consisting of the contents of the directories listed in the search path. (If the dot is in the search path, the files in the dot directory, the current working directory, are not put in the hash table.) For efficiency, the shell uses the hash table to find commands that are typed at the command line, rather than searching the path each time. If a new command is added to one of the directories already listed in the search path, the internal hash table must be recomputed. This is done by typing

```
% rehash
```

(The % is the C shell prompt.) The hash table is also automatically recomputed when you change your path at the prompt or start another shell.

The hashstat Command. The hashstat command displays performance statistics to show the effectiveness of its search for commands from the hash table. The statistics are in terms of "hits" and "misses." If the shell finds most of its commands you use at the end of your path, it has to work harder than if they were at the front of the path, resulting in a higher number of misses than hits. In such cases, you can put the most heavily hit directory toward the front of the path to improve performance.

```
% hashstat
2 hits, 13 misses, 13%
```

The source Command. The source command is a shell built−in command, that is, part of the shell's internal code. It is used to execute a command or set of commands from a file. Normally, when a command is executed, the shell forks a child process to execute the command, so that any changes made will not affect the original shell, called the parent shell. The source command causes the program to be executed in the current shell, so that any variables set within the file will become part of the environment of the current shell. The source command is normally used to reexecute the .cshrc or .login if either has been modified. For example, if the path is changed after logging in, type

```
% source .login or .cshrc
```

The Shell Prompts. The C shell has two prompts: the primary prompt, a percent sign (%), and the secondary prompt, a question mark (?). The primary prompt is the one displayed on the terminal after you have logged in; it waits for you to type commands. The primary prompt can be reset. If you are writing scripts at the prompt that require C shell programming constructs, for example, decision−making or looping, the secondary prompt will appear so that you can continue onto the next line. It will continue to appear after each newline, until the construct has been properly terminated. The secondary prompt cannot be reset.

The Primary Prompt. When running interactively, the prompt waits for you to type a command and press the Enter key. If you do not want to use the default prompt, reset it in the .cshrc file and it will be set for this and all other C subshells. If you only want it set for this login session, set it at the shell prompt.

Example 9.3

```
1   % set prompt = "$LOGNAME > "
2   ellie >
```

EXPLANATION

1. The primary prompt is assigned the user's login name, followed by a > symbol and a space.
2. The new prompt is displayed.

The Secondary Prompt. The secondary prompt appears when you are writing on−line scripts at the prompt. Whenever shell programming constructs are entered, followed by a newline, the secondary prompt appears and continues to appear until the construct is properly terminated. Writing scripts correctly at the prompt takes practice. Once the command is entered and you press Enter, you cannot back up, and the C shell history mechanism does not save commands typed at the secondary prompt.

Example 9.4

```
1   % foreach pal (joe tom ann)
2   ? mail $pal < memo
3   ? end
4   %
```

EXPLANATION

1. This is an example of on−line scripting. Because the C shell is expecting further input after the foreach loop is entered, the secondary prompt appears. The foreach loop processes each word in the parenthesized list.
2. The first time in the loop, joe is assigned to the variable pal. The user joe is sent the contents of memo in the mail. Then next time through the loop, tom is assigned to the variable pal, and so on.
3. The end statement marks the end of the loop. When all of the items in the parenthesized list have been processed, the loop ends and the primary prompt is displayed.
4. The primary prompt is displayed.

9.1.3 The Command Line

After logging in, the C shell displays its primary prompt, by default a percent sign. The shell is your command interpreter. When the shell is running interactively, it reads commands from the terminal and breaks the command line into words. A command line consists of one or more words (or tokens) separated by whitespace (blanks and/or tabs) and terminated with a newline, generated by pressing the Enter key. The first word is the command, and subsequent words are the command's options and/or arguments. The command may be a UNIX executable program such as ls or pwd, an alias, a built−in command such as cd or jobs, or a shell script. The command may contain special characters, called metacharacters, that the shell must interpret while parsing the command line. If the last character in the command line is a backslash, followed by a newline, the line can be continued to the next line.[2]

The Exit Status. After a command or program terminates, it returns an exit status to the parent process. The exit status is a number between 0 and 255. By convention, when a program exits, if the status returned is zero, the command was successful in its execution. When the exit status is nonzero, the command failed in some way. The C shell status variable is set to the value of the exit status of the last command that was executed. Success or failure of a program is determined by the programmer who wrote the program.

Example 9.5

```
1 % grep "ellie" /etc/passwd
    ellie:GgMyBsSJavd16s:9496:40:Ellie Quigley:/home/jody/ellie
2 % echo $status
    0
3 % grep "nicky" /etc/passwd
4   % echo $status
    1
5   % grep "scott" /etc/passsswd
    grep: /etc/passsswd: No such file or directory
6   % echo $status
    2
```

EXPLANATION

1. The grep program searches for the pattern ellie in the /etc/passwd file and is successful. The line from /etc/passwd is displayed.
2. The status variable is set to the exit value of the grep command; 0 indicates success.
3. The grep program cannot find user nicky in the /etc/passwd file.
4. The grep program cannot find the pattern, so it returns an exit status of 1.
5. The grep fails because the file /etc/passsswd cannot be opened.
6. Grep cannot find the file, so it returns an exit status of 2.

Command Grouping. A command line can consist of multiple commands. Each command is separated by a semicolon and the command line is terminated with a newline.

Example 9.6

```
% ls; pwd; cal 2001
```

EXPLANATION

The commands are executed from left to right until the newline is reached.

Commands may also be grouped so that all of the output is either piped to another command or redirected to a file. The shell executes commands in a subshell.

Example 9.7

```
1  % ( ls ; pwd; cal 2001 ) > outputfile
2  % pwd; ( cd / ; pwd ) ; pwd
   /home/jody/ellie
   /
   /home/jody/ellie
```

EXPLANATION

1. The output of each of the commands is sent to the file called outputfile. Without the parentheses, the output of the first two commands would go to the screen, and only the output of the cal command would be redirected to the output file.
2. The pwd command displays the present working directory. The parentheses cause the commands enclosed within them to be processed by a subshell. The cd command is built into the shell. While in the subshell, the directory is changed to root and the present working directory is displayed. When out of the subshell, the present working directory of the original shell is displayed.

Conditional Execution of Commands. With conditional execution, two command strings are separated by two special metacharacters, double ampersand and double vertical (&& and ||). The command on the right of either of these metacharacters will or will not be executed based on the exit condition of the command on the left.

Example 9.8

```
% grep '^tom:' /etc/passwd && mail tom < letter
```

EXPLANATION

If the first command is successful (has a zero exit status), the second command after the && is executed. If the grep command successfully finds tom in the passwd file, the command on the right will be executed: The mail program will send tom the contents of the letter file.

Example 9.9

```
% grep '^tom:' /etc/passwd || echo "tom is not a user here."
```

EXPLANATION

If the first command fails (has a nonzero exit status), the second command after the || is executed. If the grep command does not find tom in the passwd file, the command on the right will be executed: The echo program will print tom is not a user here. to the screen.

Commands in the Background. Normally, when you execute a command, it runs in the foreground, and the prompt does not reappear until the command has completed execution. It is not always convenient to wait for the command to complete. By placing an ampersand at the end of the command line, the shell will return the shell prompt immediately so that you do not have to wait for the last command to complete before starting another one. The command running in the background is called a background job and its output will be sent to the screen as it processes. It can be confusing if two commands are sending output to the screen concurrently. To avoid confusion, you can send the output of the job running in the background to a file or pipe it to another device such as a printer. It is often handy to start a new shell window in the background, so you will have access to both the window from which you started and the new shell window.

Example 9.10

```
1   % man xview | lp&
2   [1] 1557
3   %
```

EXPLANATION

1. The output from the man pages for the xview program is piped to the printer. The ampersand at the end of the command line puts the job in the background.
2. There are two numbers that appear on the screen: The number in square brackets indicates that this is the first job to be placed in the background, and the second number is the PID of this job.
3. The shell prompt appears immediately. While your program is running in the background, the shell is prompting you for another command in the foreground.

9.1.4 Command Line History

The history mechanism is built into the C shell. It keeps a numbered list of the commands (called history events) that you have typed at the command line. You can recall a command from the history list and reexecute it without retyping the command. The history substitution character, the exclamation point, is often called the bang character. The history built−in command displays the history list.

Example 9.11

```
(The Command Line)
% history
1 cd
2 ls
3 more /etc/fstab
4 /etc/mount
5 sort index
6 vi index
```

EXPLANATION

The history list displays the last commands that were typed at the command line. Each event in the list is preceded with a number.

Setting History. The C shell history variable is set to the number of events you want to save from the history list and display on the screen. Normally, this is set in the cshrc file, the user's initialization file.

Example 9.12

```
set history=50
```

EXPLANATION

The last 50 commands typed at the terminal are saved and may be displayed on the screen by typing the history command.

Saving History. To save history events across logins, set the savehist variable. This variable is normally set in the .cshrc file, the user's initialization file.

Example 9.13

```
set savehist=25
```

EXPLANATION

The last 25 commands from the history list are saved and will be at the top of the history list the next time you log in.

Displaying History. The history command displays the events in the history list. The history command also has options that control the number of events and the format of the events that will be displayed. The numbering of events does not necessarily start at one. If you have 100 commands on the history list, and you have set the history variable to 25, you will only see the last 25 commands saved.

Example 9.14

```
% history
1 ls
2 vi file1
3 df
4 ps –eaf
5 history
6 more /etc/passwd
7 cd
8 echo $USER
9 set
```

EXPLANATION

The history list is displayed. Each command is numbered.

Example 9.15

```
% history –h       # Print without line numbers
ls
vi file1
df
ps –eaf
history
more /etc/passwd
cd
echo $USER
set
history –n
```

EXPLANATION

The history list is displayed without line numbers.

Example 9.16

```
% history –r       # Print the history list in reverse
11 history –r
10 history –h
 9 set
 8 echo $USER
 7 cd
 6 more /etc/passwd
 5 history
 4 ps –eaf
 3 df
 2 vi file1
```

```
 1 ls
```

EXPLANATION

The history list is displayed in reverse order.

Example 9.17

```
% history 5        # Prints the last 5 events on the history list
7   echo $USER
8   cd
9   set
10  history –n
11  history 5
```

EXPLANATION

The last five commands on the history list are displayed.

Reexecuting Commands. To reexecute a command from the history list, the exclamation point (bang) is used. If you type two exclamation points (!!), the last command is reexecuted. If you type the exclamation point followed by a number, the number is associated with the command from the history list and the command is executed. If you type an exclamation point and a letter, the last command that started with that letter is executed. The caret (^) is also used as a shortcut method for editing the previous command.

Example 9.18

```
1   % date
    Mon Feb  8 12:27:35 PST 2001

2   % !!
    date
    Mon Feb  8 12:28:25 PST 2001

3   % !3
    date
    Mon Feb  8 12:29:26 PST 2001

4   % !d
    date
    Mon Feb  8 12:30:09 PST 2001

5   % dare
    dare: Command not found.

6   % ^r^t
    date
    Mon Feb  8 12:33:25 PST 2001
```

EXPLANATION

1. The UNIX date command is executed at the command line. The history list is updated. This is the last command on the list.
2. The !! (bang bang) gets the last command from the history list; the command is reexecuted.
3. The third command on the history list is reexecuted.

4. The last command on the history list that started with the letter d is reexecuted.
5. The command is mistyped.
6. The carets are used to substitute letters from the last command on the history list. The first occurrence of an r is replaced with a t.

Example 9.19

```
1   % cat  file1 file2 file3

       <Contents of files displayed here>

    % vi !:1
    vi file1

2   % cat file1 file2 file3

       <Contents of file, file2, and file3 are displayed here>

    % ls !:2
    ls file2
    file2

3   % cat file1 file2 file3
    % ls  !:3
    ls file3
    file3

4   % echo a b c
    a b c
    % echo !$
    echo c
    c

5   % echo a b c
    a b c
    % echo !^
    echo a
    a

6   % echo a b c
    a b c
    % echo !*
    echo a b c
    a b c

7   % !!:p
    echo a b c
```

EXPLANATION

1. The cat command displays the contents of file1 to the screen. The history list is updated. The command line is broken into words, starting with word number zero. If the word number is preceded by a colon, that word can be extracted from the history list. The !:1 notation means, get the first argument from the last command on the history list and replace it in the command string. The first argument from the last command is file1. (Word 0 is the command itself.)
2. The !:2 is replaced with the second argument of the last command, file2, and given as an argument to ls. file2 is printed. (file2 is the third word.)

3. ls !:3 reads, go to the last command on the history list and get the fourth word (words start at zero) and pass it to the ls command as an argument (file3 is the fourth word).
4. The bang (!) with the dollar sign ($) refers to the last argument of the last command on the history list. The last argument is c.
5. The caret (^) represents the first argument after the command. The bang (!) with the ^ refers to the first argument of the last command on the history list. The first argument of the last command is a.
6. The asterisk (*) represents all arguments after the command. The bang (!) with the * refers to all of the arguments of the last command on the history list.
7. The last command from the history list is printed but not executed. The history list is updated. You could now perform caret substitutions on that line.

9.1.5 Aliases

An alias is a C shell user−defined abbreviation for a command. Aliases are useful when a command has a number of options and arguments or the syntax is difficult to remember. Aliases set at the command line are not inherited by subshells. Aliases are normally set in the .cshrc file. Since the .cshrc is executed when a new shell is started, any aliases set there will get reset for the new shell. Aliases may also be passed into shell scripts, but will cause potential portability problems unless they are directly set within the script.

Listing Aliases. The alias built−in command lists all set aliases. The alias is printed first, followed by the real command or commands it represents.

Example 9.20

```
% alias
co      compress
cp      cp –i
ls1     enscript –B –r –Porange –f Courier8 !* &
mailq   /usr/lib/sendmail –bp
mroe    more
mv      mv –i
rn      /usr/spool/news/bin/rn3
uc      uncompress
uu      uudecode
vg      vgrind –t –s11 !:1 | lpr –t
weekly  (cd /home/jody/ellie/activity; ./weekly_report; echo Done)
```

EXPLANATION

The alias command lists the alias (nickname) for the command in the first column and the real command the alias represents in the second column.

Creating Aliases. The alias command is used to create an alias. The first argument is the name of the alias, the nickname for the command. The rest of the line consists of the command or commands that will be executed when the alias is executed. Multiple commands are separated by a semicolon, and commands containing spaces and metacharacters are surrounded by single quotes.

Example 9.21

```
1   % alias m more
2   % alias mroe more
3   % alias lF 'ls −alF'
4   % alias cd  'cd \!*; set prompt = "$cwd   >"'
    % cd ..
    /home/jody >  cd /         # New prompt displayed
```

```
/ >
```

EXPLANATION

1. The nickname for the more command is set to m.
2. The alias for the more command is set to mroe. This is handy if you can't spell.
3. The alias definition is enclosed in quotes because of the whitespace. The alias lF is a nickname for the command ls –alF.
4. When cd is executed, the alias for cd will cause cd to go to the directory named as an argument and will then reset the prompt to the current working directory followed by the string >. The !* is used by the alias in the same way it is used by the history mechanism. The backslash prevents the history mechanism from evaluating the !* first before the alias has a chance to use it. The \!* represents the arguments from the most recent command on the history list.

Deleting Aliases. The unalias command is used to delete an alias. To temporarily turn off an alias, the alias name is preceded by a backslash.

Example 9.22

```
1   % unalias mroe
2   % \cd ..
```

EXPLANATION

1. The unalias command deletes the alias mroe from the list of defined aliases.
2. The alias cd is temporarily turned off for this execution of the command only.

Alias Loop. An alias loop occurs when an alias definition references another alias that references back to the original alias.

Example 9.23

```
1   % alias m more
2   % alias mroe m
3   % alias m mroe         # Causes a loop
4   % m datafile
    Alias loop.
```

EXPLANATION

1. The alias is m. The alias definition is more. Every time m is used, the more command is executed.
2. The alias is mroe. The alias definition is m. If mroe is typed, the alias m is invoked and the more command is executed.
3. This is the culprit. If alias m is used, it invokes alias mroe, and alias mroe references back to m, causing an alias loop. Nothing bad happens. You just get an error message.
4. Alias m is used. It is circular. M calls mroe and mroe calls m, then m calls mroe, etc., etc. Rather than looping forever, the C shell catches the problem and displays an error message.

9.1.6 Job Control

Job control is a powerful feature of the C shell that allows you to run programs, called jobs, in the background or foreground. Normally, a command typed at the command line runs in the foreground, and will continue until it has finished. If you have windows, job control may not be necessary, since you can simply open another window to start a new task. On the other hand, with a single terminal, job control is a very useful feature. For a list of job commands, see Table 9.1.

Table 9.1. Job Control Commands

Command MeaningjobsLists all the jobs running.^Z (Control−Z)Stops (suspends) the job; the prompt appears on the screen.bgStarts running the stopped job in the background.fgBrings a background job to the foreground.killSends the kill signal to a specified job.

The Ampersand and Background Jobs. If you expect a command to take a long time to complete, you can append the command with an ampersand and the job will execute in the background. The C shell prompt returns immediately and now you can type another command. Now the two commands are running concurrently, one in the background and one in the foreground. They both send their standard output to the screen. If you place a job in the background, it is a good idea to redirect its output either to a file or pipe it to a device such as a printer.

Example 9.24

```
1   % find . −name core −exec rm {} \; &
2   [1]  543
3   %
```

EXPLANATION

1. The find command runs in the background. (Without the –print option, the find command does not send any output to the screen).[3]
2. The number in square brackets indicates this is the first job to be run in the background and the PID for this process is 543.
3. The prompt returns immediately. The shell waits for user input.

The Suspend Key Sequence and Background Jobs. To suspend a program, the suspend key sequence, ^Z, is issued. The job is now suspended (stopped), the shell prompt is displayed, and the program will not resume until the fg or bg commands are issued. (When using the vi editor, the ZZ command writes and saves a file. Do not confuse this with ^Z, which would suspend the vi session.) If you try to log out when a job is suspended, the message There are stopped jobs appears on the screen.

The jobs Command. The C shell built−in command, jobs, displays the programs that are currently active and either running or suspended in the background. Running means the job is executing in the background. When a job is stopped, it is suspended; it is not in execution. In both cases, the terminal is free to accept other commands.

Example 9.25

```
(The Command Line)
1   % jobs
2   [1] + Stopped vi filex
    [2] − Running sleep 25
```

```
3   % jobs −l
    [1] + 355  Stopped vi filex
    [2] − 356  Running sleep 25

4   [2] Done sleep 25
```

EXPLANATION

1. The jobs command lists the currently active jobs.
2. The notation [1] is the number of the first job; the plus sign indicates that the job is not the most recent job to be placed in the background; the dash indicates that this is the most recent job put in the background; Stopped means that this job was suspended with ^Z and is not currently active.
3. The –l option (long listing) displays the number of the job as well as the PID of the job. The notation [2] is the number of the second job, in this case, the last job placed in the background. The dash indicates that this is the most recent job. The sleep command is running in the background.
4. After sleep has been running for 25 seconds, the job will complete and a message saying that it has finished appears on the screen.

The Foreground and Background Commands. The fg command brings a background job into the foreground. The bg command starts a suspended job running in the background. A percent sign and the number of a job can be used as arguments to fg and bg if you want to select a particular job for job control.

Example 9.26

```
1   % jobs
2   [1] + Stopped vi filex
    [2] − Running cc prog.c −o prog
3   % fg %1
    vi filex
    (vi session starts)
4   % kill %2
    [2] Terminated cc prog.c −o prog
5   % sleep 15
    (Press ^z)
    Stopped
6   % bg
    [1] sleep 15 &
    [1] Done   sleep 15
```

EXPLANATION

1. The jobs command lists currently running processes, called jobs.
2. The first job stopped is the vi session, the second job is the cc command.
3. The job numbered [1] is brought to the foreground. The number is preceded with a percent sign.
4. The kill command is built−in. It sends the TERM (terminate) signal, by default, to a process. The argument is either the number or the PID of the process.
5. The sleep command is stopped by pressing ^Z. The sleep command is not using the CPU and is suspended in the background.
6. The bg command causes the last background job to start executing in the background. The sleep program will start the countdown in seconds before execution resumes.[4]

9.1.7 Metacharacters

Metacharacters are special characters that are used to represent something other than themselves. As a rule of thumb, characters that are neither letters nor numbers may be metacharacters. The shell has its own set of metacharacters, often called shell wildcards. Shell metacharacters can be used to group commands together, to abbreviate filenames and pathnames, to redirect and pipe input/output, to place commands in the background, and so forth. Table 9.2 presents a partial list of shell metacharacters.

Table 9.2. Shell Metacharacters

Metacharacter	**Purpose**	**Example**	**Meaning**
$	Variable substitution	set name=Tom echo $name Tom	Sets the variable name to Tom; displays the value stored there.
!	History substitution	!3	Reexecutes the third event from the history list.
*	Filename substitution	rm *	Removes all files.
?	Filename substitution	ls ??	Lists all two−character files.
[ ]	Filename substitution	cat f[123]	Displays contents of f1, f2, f3.
;	Command separator	ls;date;pwd	Each command is executed in turn.
&	Background processing	lp mbox&	Printing is done in the background. Prompt returns immediately.
>	Redirection of output	ls > file	Redirects standard output to file.
<	Redirection of input	ls < file	Redirects standard input from file.
>&	Redirection of output and error	ls >& file	Redirects both output and errors to file.
>!	If noclobber is set, override it	ls >! file	If file exists, truncate and overwrite it, even if noclobber is set.
>>!	If noclobber is set, override it	ls >>! file	If file does not exist, create it; even if noclobber is set.
( )	Groups commands to be executed in a subshell	(ls ; pwd) >tmp	Executes commands and sends output to tmp file.
{ }	Groups commands to be executed in this shell	{ cd /; echo $cwd }	Changes to root directory and displays current working directory.

Filename Substitution. When evaluating the command line, the shell uses metacharacters to abbreviate filenames or pathnames that match a certain set of characters. The filename substitution metacharacters listed in Table 9.3 are expanded into an alphabetically listed set of filenames. The process of expanding a metacharacter into filenames is also called globbing. Unlike the other shells, when the C shell cannot substitute a filename for the metacharacter it is supposed to represent, the shell reports No match.

Table 9.3. Shell Metacharacters and Filename Substitution

Metacharacter	**Meaning**
*	Matches zero or more characters.
?	Matches exactly one character.
[abc]	Matches one character in the set: a, b, or c.
[a–z]	Matches one character in the range a to z.
{a, ile,ax}	Matches for a character or set of characters.
~	Substitutes the user's home directory for tilde.
\	Escapes or disables the metacharacter.

9.1.8 Expanding the Metacharacters

The shell performs filename substitution by evaluating its metacharacters and replacing them with the appropriate letters or digits in a filename.

The Asterisk. The asterisk matches zero or more characters in a filename.

Example 9.27

```
1   % ls
    a.c b.c abc ab3 file1 file2 file3 file4 file5

2   % echo *
    a.c b.c abc ab3 file1 file2 file3 file4 file5

3   % ls  *.c
```

```
    a.c b.c

4   % rm  z*p
    No match.
```

EXPLANATION

1. All the files in the current directory are listed.
2. The echo program prints all its arguments to the screen. The asterisk (also called a splat) is a wildcard that means, match for zero or more of any characters found in a filename. All the files in the directory are matched and echoed to the screen.
3. Filenames ending in .c are listed.
4. Since none of the files in the directory start with z, the shell reports No match.

The Question Mark. The question mark matches exactly one character in a filename.

Example 9.28

```
1   % ls
    a.c b.c abc ab3 file1 file2 file3 file4 file5

2   % ls ???
    abc ab3

3   % echo How are you?
    No match.

4   % echo How are you\?
    How are you?
```

EXPLANATION

1. All the files in the current directory are listed.
2. The question mark matches for a single−character filename. Any filenames consisting of three characters are listed.
3. The shell looks for a filename spelled y−o−u followed by one character. There is not a file in the directory that matches these characters. The shell prints No match.
4. The backslash preceding the question mark is used to turn off the special meaning of the question mark. Now the shell treats the question mark as a literal character.

The Square Brackets. The square brackets match a filename for one character from a set or range of characters.

Example 9.29

```
1   % ls
    a.c b.c abc ab3 file1 file2 file3 file4 file5 file10
    file11  file12

2   % ls file[123]
    file1 file2 file3

3   % ls [A−Za−z][a−z][1−5]
    ab3

4   % ls file1[0−2]
    file10 file11 file12
```

EXPLANATION

1. All the files in the current directory are listed.
2. Filenames starting with file and follwed with a 1, 2, or 3 are matched and listed.
3. Filenames starting with a letter (either uppercase or lowercase) followed by a lowercase letter, and followed by a number between 1 and 5 are matched and listed.
4. Filenames starting with file1 and followed by a 0, 1, or 2 are listed.

The Curly Braces. The curly braces ({})match for a character or string of characters in a filename.

Example 9.30

```
1   % ls
    a.c b.c abc ab3 ab4 ab5 file1 file2 file3 file4 file5 foo
    faa fumble

2   % ls f{oo,aa,umble}
    foo faa fumble

3   % ls a{.c,c,b[3-5]}
    a.c ab3 ab4 ab5
```

EXPLANATION

1. All the files in the current directory are listed.
2. Files starting with f and followed by the strings oo, aa, or umble are listed. Spaces inside the curly braces will cause the error message Missing }.
3. Files starting with a followed by .c, c, or b3, b4, or b5 are listed. (The square brackets can be used inside the curly braces.)

Escaping Metacharacters. The backslash is used to escape the special meaning of a single character. The escaped character will represent itself.

Example 9.31

```
1   % gotta light?
    No match.
2   % gotta light\?
    gotta: Command not found.
```

EXPLANATION

1. This is a little UNIX joke. The question mark is a file substitution metacharacter and evaluates to a single character. The shell looks for a file in the present working directory that contains the characters l−i−g−h−t, followed by a single character. If the shell cannot find the file, it reports No match. This shows you something about the order in which the shell parses the command line. The metacharacters are evaluated before the shell tries to locate the gotta command.
2. The backslash protects the metacharacter from interpretation, often called escaping the metacharacter. Now the shell does not complain about a No match, but searches the path for the gotta command, which is not found.

Tilde Expansion. The tilde character by itself expands to the full pathname of the user's home directory. When the tilde is prepended to a username, it expands to the full pathname of that user's home directory.

When prepended to a path, it expands to the home directory and the rest of the pathname.

Example 9.32

```
1   % echo ~
    /home/jody/ellie

2   % cd ~/desktop/perlstuff
    % pwd
    /home/jody/ellie/desktop/perlstuff

3   % cd ~joe
    % pwd
    /home/bambi/joe
```

EXPLANATION

1. The tilde expands to the user's home directory.
2. The tilde followed by a pathname expands to the user's home directory, followed by /desktop/perlstuff.
3. The tilde followed by a username expands to the home directory of the user. In this example, the directory is changed to that user's home directory.

Filename Completion: The filec Variable. When running interactively, the C shell provides a shortcut method for typing a filename or username. The built−in filec variable, when set, is used for what is called filename completion. If you type the first few significant characters of a file in the current working directory and press the ESC key, the shell fills in the rest of the filename, provided that there are not a number of other files beginning with the same characters. If you type Control−D after the partial spelling of the file, the shell will print out a list of files that match those characters. The terminal beeps if there are multiple matches. If the list begins with a tilde, the shell attempts to expand that list to a username.

Example 9.33

```
1   % set filec
2   % ls
    rum rumple rumplestilsken run2
3   % ls ru[ESC][5]     # terminal beeps
4   % ls rum^D
    rum rumple rumplestilsken
5   % ls rump[ESC]
    rumple
6   % echo ~ell[ESC]
    /home/jody/ellie
```

EXPLANATION

1. The special C shell variable filec is set. Filename completion can be used.
2. The files in the present working directory are listed.
3. Filename completion is attempted. The letters r and u are not unique; that is, the shell does not know which one to pick, so it causes the terminal to beep.
4. After the letters r−u−m are typed, ^D is pressed. A list of all filenames beginning with rum are displayed.
5. The first filename starting with rump is completed and displayed.
6. If a tilde precedes a partially spelled username, the shell will attempt to complete the

spelling of the user's name and display the user's home directory.

Turning Off Metacharacters with noglob. If the noglob variable is set, filename substitution is turned off, meaning that all metacharacters represent themselves; they are not used as wildcards. This can be useful when searching for patterns in programs like grep, sed, or awk, which may contain metacharacters that the shell may try to expand.

Example 9.34

```
1   % set noglob
2   % echo * ?? [] ~
    * ?? [] ~
```

EXPLANATION

1. The variable noglob is set. It turns off the special meaning of the wildcards.
2. The metacharacters are displayed as themselves without any interpretation.

9.1.9 Redirection and Pipes

Normally, standard output (stdout) from a command goes to the screen, standard input (stdin) comes from the keyboard, and error messages (stderr) go to the screen. The shell allows you to use the special redirection metacharacters to redirect the input/output to or from a file. The redirection operators (<, >, >>, >&) are followed by a filename. This file is opened by the shell before the command on the left−hand side is executed.

Pipes, represented by a vertical bar (|) symbol, allow the output of one command to be sent to the input of another command. The command on the left−hand side of the pipe is called the writer because it writes to the pipe. The command on the right−hand side of the pipe is the reader because it reads from the pipe. See Table 9.4 for a list of redirection and pipe metacharacters.

Table 9.4. Redirection Metacharacters

Metacharacter Meaningcommand < fileRedirects input from file to command.command > fileRedirects output from command to file.command >& fileRedirects output and errors to file.command >> fileRedirects output of command and appends it to file.command >>& fileRedirects and appends output and errors of command to file.command << WORDRedirects input from first WORD to terminating WORD to command.<input>User input goes here. It will be treated as a doubly quoted string of text.WORDWORD marks the termination of input to command.command | commandPipes output of first command to input of second command.command |& commandPipes output and errors of first command to input of second command.command >! fileIf the noclobber variable is set, override its effects for this command and either open or overwrite file.command >>! fileOverride noclobber variable; if file does not exist, it is created and output from command is appended to it.command >>&! fileOverride noclobber variable; if file does not exist, it is created and both output and errors are appended to it.

Redirecting Input. Instead of the input coming from the terminal keyboard, it can be redirected from a file. The shell will open the file on the right−hand side of the < symbol and the program on the left will read from the file. If the file does not exist, the error No such file or directory will be reported by the C shell.

FORMAT

```
command < file
```

Example 9.35

```
mail bob < memo
```

EXPLANATION

The file memo is opened by the shell, and the input is redirected to the mail program. Simply, the user bob is sent a file called memo by the mail program.

The here document. The here document is another way to redirect input to a command. It is used in shell scripts for creating menus and processing input from other programs. Normally, programs that accept input from the keyboard are terminated with Control−D (^d). The here document provides an alternate way of sending input to a program and terminating the input without typing ^D. The << symbol is followed by a user−defined word, often called a terminator. Input will be directed to the command on the left−hand side of the << symbol until the user−defined terminator is reached. The final terminator is on a line by itself, and cannot be surrounded by any spaces. Variable and command substitution are performed within the here document. (Normally, here documents are used in shell scripts to create menus and provide input to commands such as mail, bc, ex, ftp, etc.)

FORMAT

```
command << MARK
       ... input ...
MARK
```

Example 9.36

```
(Without the here document)
(The Command Line)
1   % cat
2   Hello There.
    How are you?
    I'm tired of this.
3   ^D

(The Output)
4   Hello There.
    How are you?
    I'm tired of this.
```

EXPLANATION

1. The cat program, without arguments, waits for keyboard input.
2. The user types input at the keyboard.
3. The user types ^D to terminate input to the cat program.
4. The cat program sends its output to the screen.

Example 9.37

```
(With the here document)
(The Command Line)
1   % cat << DONE
2   Hello There.
    How are you?
    I'm tired of this.
3   DONE

(The Output)
4   Hello There.
    How are you?
    I'm tired of this.
```

EXPLANATION

1. The cat program will receive input from the first DONE to the terminating DONE. The words are user−defined terminators.
2. These lines are input. When the word DONE is reached, no more input is accepted.
3. The final terminator marks the end of input. There cannot be any spaces on either side of this word.
4. The text between the first word DONE and the final word DONE is the output of the cat command (from "here" to "here") and is sent to the screen. The final DONE must be against the left margin with no space or other text to the right of it.

Example 9.38

```
(The Command Line)
1   % set name = steve
2   % mail $name << EOF
3   Hello there, $name
4   The hour is now 'date +%H'
5   EOF
```

EXPLANATION

1. The shell variable name is assigned the username steve. (Normally, this example would be included in a shell script.)
2. The variable name is expanded within the here document.
3. The mail program will receive input until the terminator EOF is reached.
4. Command substitution is performed within the here document; that is, the command within the backquotes is executed and the output of the command is replaced within the string.
5. The terminator EOF is reached, and input to the mail program is stopped.

Redirecting Output. By default, the standard output of a command or commands normally goes to the terminal screen. To redirect standard output from the screen to a file, the > symbol is used. The command is on the left−hand side of the > symbol, and a filename is on the right−hand side. The shell will open the file on the right−hand side of the > symbol. If the file does not exist, the shell will create it; if it does exist, the shell will open the file and truncate it. Often files are inadvertently removed when using redirection. (A special C shell variable, called noclobber, can be set to prevent redirection from clobbering an existing file. See Table 9.5.)

FORMAT

```
command > file
```

Example 9.39

```
cat file1 file2 > file3
```

EXPLANATION

The contents of file1 and file2 are concatenated and the output is sent to file3. Remember that the shell opens file3 before it attempts to execute the cat command. If file3 already exists and contains data, the data will be lost. If file3 does not exist, it will be created.

Appending Output to an Existing File. To append output to an existing file, the >> symbol is used. If the file on the right−hand side of the >> symbol does not exist, it is created; if it does exist, the file is opened and output is appended to the end of the file.

FORMAT

```
command >> file
```

Example 9.40

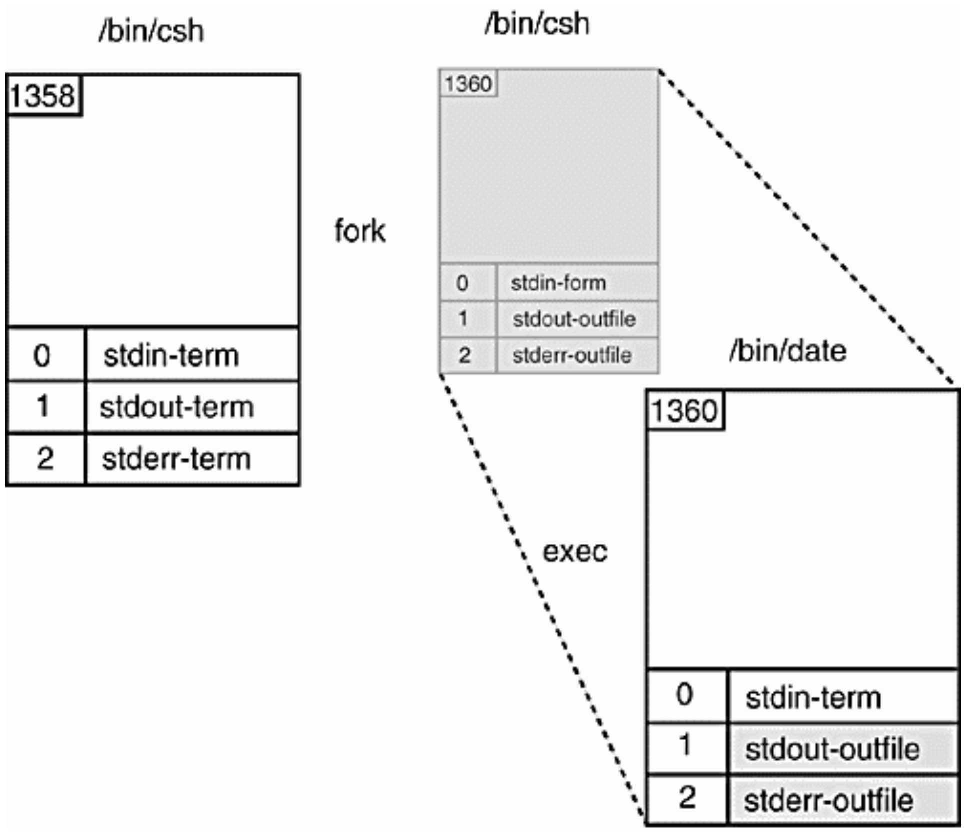
```
date >> outfile
```

EXPLANATION

The standard output of the date command is redirected and appended to outfile.

Redirecting Output and Error. The >& symbol is used to redirect both standard output and standard error to a file. Normally, a command is either successful and sends its output to stdout, or fails and sends its error messages to stderr. Some recursive programs, such as find and du, send both standard output and errors to the screen as they move through the directory tree. By using the >& symbol, both standard output and standard error can be saved in a file and examined. The C shell does not provide a symbol for redirection of only standard error, but it is possible to get just the standard error by executing the command in a subshell. See Figure 9.2.

Figure 9.2. Redirecting stdout and stderr. See Example 9.41.



Example 9.41

```
1   % date
    Tue Aug 3 10:31:56  PDT  2001
2   % date >& outfile
3   % cat outfile
    Tue Aug 3 10:31:56  PDT  2001
```

EXPLANATION

1. The output of the date command is sent to standard output, the screen.
2. The output and errors are sent to outfile.
3. Since there were no errors, the standard output is sent to outfile and the contents of the file are displayed.

Example 9.42

```
1   % cp file1 file2
2   % cp file1
     Usage: cp [−ip] f1 f2; or: cp [−ipr] f1 ... fn d2

3   % cp file1 >& errorfile
4   % cat errorfile
     Usage: cp [−ip] f1 f2; or: cp [−ipr] f1 ... fn d2
```

EXPLANATION

1. To copy a file, the cp command requires both a source file and a destination file. The cp command makes a copy of file1 and puts the copy in file2. Since the cp command is given the correct syntax, nothing is displayed to the screen. The copy was successful.
2. This time the destination file is missing and the cp command fails, sending an error to stderr, the terminal.
3. The >& symbol is used to send both stdout and stderr to errorfile. Since the only output from the command is the error message, that is what is saved in errorfile.
4. The contents of errorfile are displayed, showing that it contains the error message produced by the cp command.

Separating Output and Errors. Standard output and standard error can be separated by enclosing the command in parentheses. When a command is enclosed in parentheses, the C shell starts up a subshell, handles redirection from within the subshell, and then executes the command. By using the technique shown in Example 9.43, the standard output can be separated from the errors.

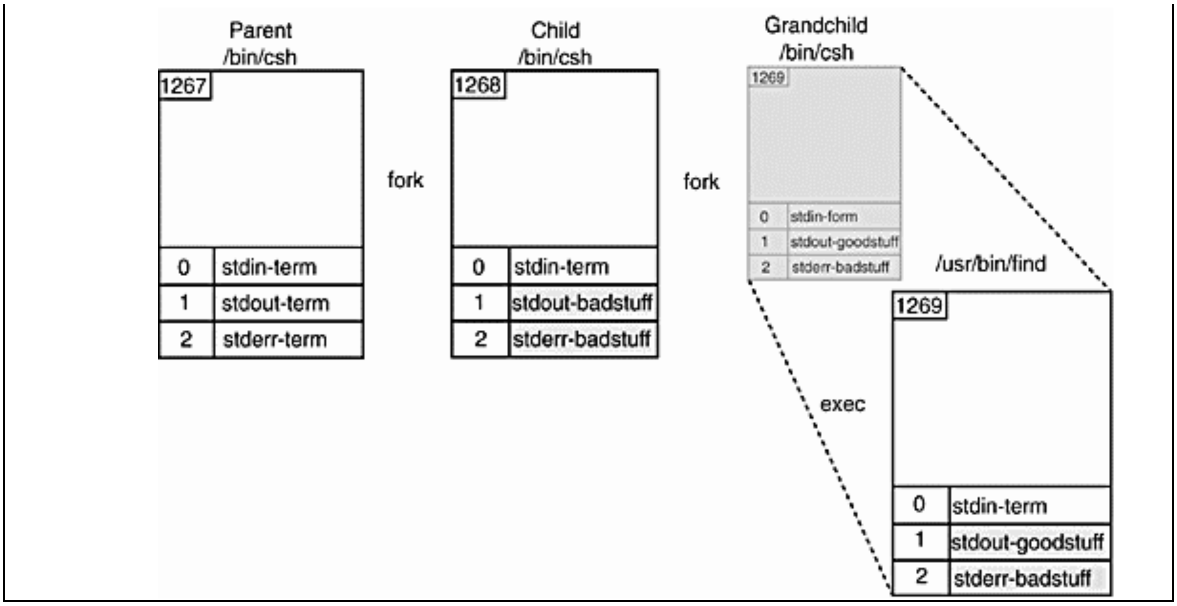
Example 9.43

```
(The Command Line)
1   % find . −name ' * .c' −print >& outputfile
2   % (find . −name '*.c' −print > goodstuff) >& badstuff
```

EXPLANATION

1. The find command will start at the current directory, searching for all files ending in .c, and will print the output to outputfile. If an error occurs, that will also go into outputfile.
2. The find command is enclosed within parentheses. The shell will create a subshell to handle the command. Before creating the subshell, the words outside the parentheses will be processed; that is, the badstuff file will be opened for both standard output and error. When the subshell is started, it inherits the standard input, output, and errors from its parent. The subshell then has standard input coming from the keyboard, and both standard output and standard error going to the badstuff file. Now the subshell will handle the > operator. The stdout will be assigned the file goodstuff. The output is going to goodstuff, and the errors are going to badstuff. See Figure 9.3.

Figure 9.3. Separating stdout and stderr.



The noclobber Variable. The special C shell built−in variable noclobber, when set, protects you from clobbering files with redirection. See Table 9.5.

Table 9.5. The noclobber Variable

noclobber Is Not SetFile ExistsFile Does Not Existcommand > filefile is overwritten.file is created.command >> filefile is appended to.file is created. noclobber Is Setcommand > fileError message.file is created.command >> filefile is appended to.Error message. Overwriting noclobbercommand >! fileIf the noclobber variable is set, override its effects for this command and either open or truncate file, redirecting output of command to file.command >>! fileOverride noclobber variable; if file does not exist, it is created and output from command is appended to it. (See Example 9.44.)

Example 9.44

```
1   % cat filex
    abc
    123

2   % date > filex
3   % cat filex
    Wed Aug 5 11:51:04  PDT 2001

4   % set noclobber
5   % date > filex
    filex: File exists.

6   % ls >! filex   # Override noclobber for this command only
    % cat filex
    abc
    ab1
    dir
    filex
    plan.c
7   % ls > filex
    filex:  File exists.

8   % unset noclobber     # Turn off noclobber permanently
```

EXPLANATION

1. The contents of filex are displayed on the screen.
2. The output of the date command is redirected to filex. The file is truncated and its original contents overwritten.
3. The contents of filex are displayed.
4. The noclobber variable is set.
5. Since filex already exists and noclobber is set, the shell reports that the file exists and will not allow it to be overwritten.
6. The output of ls is redirected to filex because the >! operator overrides the effects of noclobber.
7. The effects of the >! symbol were temporary. It does not turn off noclobber. It simply overrides noclobber for the command where it is implemented.
8. The noclobber variable is unset.

9.1.10 Variables

C shell variables hold only strings or a set of strings. Some variables are built into the shell and can be set by turning them on or off, such as the noclobber or filec variable. Others are assigned a string value, such as the path variable. You can create your own variables and assign them to strings or the output of commands. Variable names are case−sensitive and may contain up to 20 characters consisting of numbers, letters, and the underscore.

There are two types of variables: local and environment. The scope of a variable is its visibility. A local variable is visible to the shell where it is defined. The scope of environment variables is often called global. Their scope is for this shell and all processes spawned (started) from this shell.

The dollar sign ($) is a special metacharacter that, when preceding a variable name, tells the shell to extract the value of that variable. The echo command, when given the variable as an argument, will display the value of the variable after the shell has processed the command line and performed variable substitution.

The special notation $?, when prepended to the variable name, lets you know whether the variable has been set. If a one is returned, it means true, the variable has been set. If a zero is returned, it means false, the variable has not been set.

Example 9.45

```
1   % set filec
2   % set history = 50
3   % set name = George
4   % set machine = 'uname −n'
5   % echo  $?machine
    1
6   % echo  $?blah
    0
```

EXPLANATION

1. Sets the built−in variable filec for filename completion.
2. Sets the built−in variable history to 50 to control the number of events displayed.
3. Sets the user−defined variable name to George.

4. Sets the user−defined variable machine to the output of the UNIX command. The command is in backquotes, telling the shell to perform command substitution.
5. The $? is prepended to the variable name to test whether or not the variable has been set. Since the test yields a one (true), the variable has been set.
6. The $? yields zero (false). The variable has not been set.

Curly Braces. Curly braces insulate a variable from any characters that may follow it.

Example 9.46

```
1   % set var = net
    % echo $var
    net

2   % echo $varwork
    varwork: Undefined variable.

3   % echo ${var}work
    network
```

EXPLANATION

1. The curly braces surrounding the variable name insulate the variable from characters that follow it.
2. A variable called varwork has not been defined. The shell prints an error message.
3. The curly braces shield the variable from characters appended to it. $var is expanded and the string work is appended.

Local Variables. Local variables are known only in the shell where they were created. If a local variable is set in the .cshrc file, the variable will be reset every time a new C shell is started. By convention, local variables are named with lowercase letters.

Setting Local Variables. If the string being assigned contains more than one word, it must be quoted; otherwise, only the first word will be assigned to the variable. It does not matter if there are spaces around the equal sign, but if there is a space on one side of the equal sign, there must be one on the other side.

Example 9.47

```
1   % set round = world
2   % set name = "Santa Claus"

3   % echo $round
    world

4   % echo $name
    Santa Claus

5   % csh              # Start a subshell
6   % echo $name
    name: Undefined variable.
```

EXPLANATION

1. The local variable round is assigned the value world.

2. The local variable name is assigned the value Santa Claus. The double quotes keep the shell from evaluating the whitespace between Santa and Claus.
3. The dollar sign prepended to the variable allows the shell to perform variable substitution, that is, to extract the value stored in the variable.
4. Variable substitution is performed.
5. A new C shell (called a subshell) process is started.
6. In the subshell, the variable name has not been defined. It was defined in the parent shell as a local variable.

The set Command. The set command prints all local variables set for this shell.

Example 9.48

```
(The Command Line)
% set
argv       ()
cwd        /home/jody/ellie
fignore    .o
filec
history    500
home       /home/jody/ellie
hostname   jody
ignoreeof
noclobber
notify
path       (/home/jody/ellie /bin /usr/local /usr/usr/bin/usr/etc .)
prompt     jody%
shell      /bin/csh
status     0
term       sun−cmd
user       ellie
```

EXPLANATION

All of the local variables set for this shell are printed. Most of these variables are set in the cshrc file. The argv, cwd, shell, term, user, and status variables are preset, built−in variables.

Built−In Local Variables. The shell has a number of predefined variables with their own definitions. Some of the variables are either on or off. For example, if you set noclobber, the variable is on and effective, and when you unset noclobber, it is turned off. Some variables require a definition when set. Built−in variables are usually set in the .cshrc file if they are to be effective for different C shells. Some of the built−in variables already discussed include noclobber, cdpath, history, filec, and noglob. For a complete list, see Table 9.16.

Environment Variables. Environment variables are often called global variables. They are defined in the shell where they were created and inherited by all shells spawned from that shell. Although environment variables are inherited by subshells, those defined in subshells are not passed back to parent shells. Inheritance is from parent to child, not the other way around (like real life). By convention, environment variables are named with capital letters.

Example 9.49

```
(The Command Line)
1   % setenv TERM wyse
2   % setenv PERSON "Joe Jr."
3   % echo $TERM
    wyse
4   % echo $PERSON
```

```
    Joe Jr.
5   % echo $$        # $$ evaluates to the PID of the current shell
    206
6   % csh            # Start a subshell
7   % echo $$
    211
8   % echo $PERSON
    Joe Jr.
9   % setenv PERSON "Nelly Nerd"
10  % echo $PERSON
    % Nelly Nerd
11  % exit              # Exit the subshell
12  % echo $$
    206
13  % echo $PERSON      # Back in parent shell
    Joe Jr.
```

EXPLANATION

1. The shell environment variable TERM is set to a wyse terminal.
2. The user−defined variable PERSON is set to Joe Jr. The quotes are used to protect the space.
3. The dollar sign ($) prepended to the variable name allows the shell to evaluate the contents of the variable, called variable substitution.
4. The value of the environment variable PERSON is printed.
5. The $$ variable contains the PID of the current shell. The PID is 206.
6. The csh command starts a new C shell, called a subshell.
7. The PID of the current shell is printed. Since this is a new C shell, it has a different PID number. The PID is 211.
8. The environment variable PERSON was inherited by the new shell.
9. The PERSON variable is reset to Nelly Nerd. This variable will be inherited by any shells spawned from this shell.
10. The new value of the PERSON variable is printed.
11. This C shell is exited.
12. The original C shell is running; to attest to that, the PID 206 is printed. It is the same as it was before the subshell was started.
13. The PERSON variable contains its original value.

Printing Environment Variables. The printenv (UCB) and env (SVR4) commands print all the environment variables set for this shell and its subshells. The setenv command prints variables and their values on both the UCB and SVR4 versions of the C shell.

Example 9.50

```
% env
FONTPATH=/usr/local/OW3/lib/fonts
HELPPATH=/usr/local/OW3/lib/locale:/usr/local/OW3/lib/help
HOME=/home/jody/ellie
LD_LIBRARY_PATH=/usr/local/OW3/lib
LOGNAME=ellie
MANPATH=/ur/local/man:/usr/local/man:/usr/local/doctools/man:/usr/man
NOSUNVIEW=0
OPENWINHOME=/usr/local/OW3
PATH=/bin:/usr/local:/usr:/usr/bin:/usr/etc:/home/5bin:/usr/
   doctools:/usr:.
PWD=/home/jody/ellie
SHELL=/bin/csh
```

```
TERM=sun-cmd
USER=ellie
WINDOW_PARENT=/dev/win0
WINDOW_TTYPARMS=
WMGR_ENV_PLACEHOLDER=/dev/win3
```

EXPLANATION

The environment variables are set for this session and all processes that are started from this shell. Many applications require the setting of environment variables. For example, the man command has a MANPATH variable set to the location that man pages can be found, and the openwin program has an environment variable set to the place where its fonts are stored. When any of these programs are executed, the information in these variables is passed to them.

Arrays. In the C shell, an array is simply a list of words, separated by spaces or tabs, and enclosed in parentheses. The elements of the array are numbered by subscripts starting at one. If there is not an array element for a subscript, the message Subscript out of range is displayed. Command substitution will also create an array. If the $# notation precedes an array name, the number of elements in the array is displayed.

Example 9.51

```
1   % set fruit = ( apples pears peaches plums )
2   % echo $fruit
    apples pears peaches plums

3   % echo $fruit[1]       # Subscripts start at 1
    apples

4   % echo $fruit[2-4]     # Prints the 2nd, 3rd, and 4th elements
    pears peaches plums

5   $ echo $fruit[6]
    Subscript out of range.

6   % echo $fruit[*]       # Prints all elements of the array
    apples pears peaches plums
7   % echo $#fruit         # Prints the number of elements
    4

8   % echo $fruit[$#fruit]     # Prints the last element
    plums

9   % set fruit[2] = bananas    # Reassigns the second element
    % echo $fruit
    apples bananas peaches plums

10  % set path = ( ~ /usr/bin /usr /usr/local/bin . )
    % echo $path
    /home/jody/ellie /usr/bin /usr /usr/local/bin .

11  % echo $path[1]
    /home/jody/ellie
```

EXPLANATION

1. The wordlist is enclosed within parentheses. Each word is separated by whitespace. The array is called fruit.
2. The words in the fruit array are printed.
3. The first element of the fruit array is printed. The subscripts start at one.
4. The second, third, and fourth elements of the wordlist are printed. The dash allows you to specify a range.
5. The array does not have six elements. The subscript is out of range.
6. All elements of the fruit array are printed.
7. The $# preceding the array is used to obtain the number of elements in the array. There are four elements in the fruit array.
8. Since the subscript $#fruit evaluates to the total number of elements in the array, if that value is used as an index value of the array, i.e., [$#fruit], the last element of the fruit array is printed.
9. The second element of the array is assigned a new value. The array is printed with its replaced value, bananas.
10. The path variable is a special C shell array of directories used to search for commands. By creating an array, the individual elements of the path can be accessed or changed.
11. The first element of path is printed.

The shift Command and Arrays. If the built−in shift command takes an array name as its argument, it shifts off (to the left) the first element of the array. The length of the array is decreased by one. (Without an argument, the shift command shifts off the first element of the built−in argv array. See "Command Line Arguments")

Example 9.52

```
1   % set names = ( Mark Tom Liz Dan Jody )

2   % echo $names
    Mark Tom Liz Dan Jody

3   % echo $names[1]
    Mark

4   % shift  names

5   % echo $names
    Tom Liz Dan Jody

6   % echo $names[1]
    Tom

7   % set days = ( Monday Tuesday )

8   % shift days

9   % echo $days
    Tuesday

10  % shift days

11  % echo $days

12  % shift days
    shift: no more words.
```

EXPLANATION

1. The array is called names. It is assigned the list of words in parentheses. Each word is separated by whitespace.
2. The array is printed.
3. The first element of the array is printed.
4. The array is shifted to the left by one element. The word Mark is shifted off.
5. The array was decreased by one element after the shift.
6. The first element of the array, after the shift, is Tom.
7. An array called days is created. It has two elements, Monday and Tuesday.
8. The array days is shifted one to the left.
9. The array is printed. Tuesday is the only element left.
10. The array days is shifted again. The array is empty.
11. The days array is empty.
12. This time, attempting to shift causes the shell to send an error message indicating that it cannot shift elements from an empty array.

Creating an Array from a String. You may want to create a wordlist out of a quoted string. This is accomplished by placing the string variable within a set of parentheses.

Example 9.53

```
1   % set name = "Thomas Ben Savage"
    % echo $name[1]
    Thomas Ben Savage

2   % echo $name[2]
    Subscript out of range.

3   % set name = ( $name )

4   % echo $name[1] $name[2] $name[3]
    Thomas Ben Savage
```

EXPLANATION

1. The variable name is assigned the string Thomas Ben Savage.
2. When treated as an array, there is only one element, the entire string.
3. The variable is enclosed in parentheses, creating an array of words, called name.
4. The three elements of the new array are displayed.

9.1.11 Special Variables

Built into the C shell are several variables consisting of one character. The $ preceding the character allows variable interpretation. See Table 9.6.

Table 9.6. Variables and Their Meanings

Variable Example Meaning$?varecho $?nameReturns 1 if variable has been set, 0 if not.$#varecho $#fruitPrints the number of elements in an array.$$echo $$Prints the PID of the current shell.$<set name = $<Accepts a line of input from user up to newline.

Example 9.54

```
1   % set num
    % echo $?num
    1
2   % echo $path
    /home/jody/ellie   /usr/bin/   usr/local/bin
    % echo $#path
    3

3   % echo $$
    245

    % csh              # Start a subshell
    % echo $$
    248

4   % set name = $<
    Christy Campbell
    % echo $name
    Christy Campbell
```

EXPLANATION

1. The variable num is set to null. The $? preceding the variable evaluates to one if the variable has been set (either to null or some value), and to zero if the variable has not been set.
2. The path variable is printed. It is an array of three elements. The $# preceding the variable extracts and prints the number of elements in the array.
3. The $$ is the PID of the current process, in this case, the C shell.
4. The $< variable accepts a line of input from the user up to, but not including, the newline, and stores the line in the name variable. The value of the name variable is displayed.

Pathname Variable Modifiers. If a pathname is assigned to a variable, it is possible to manipulate the pathname variable by appending special C shell extensions to it. The pathname is divided into four parts: head, tail, root, and extension. See Table 9.7 for examples of pathname modifiers and what they do.

Table 9.7. Pathname Modifiers `set pn = /home/ellie/prog/check.c`

Modifier Meaning Example Result:rrootecho $pn:r/home/ellie/prog/check:hheadecho $pn:h/home/ellie/prog:ttailecho $pn:tcheck.c:eextensionecho $pn:ec:gglobalecho $p:gt(See Example 9.55)

Example 9.55

```
1   % set pathvar = /home/danny/program.c

2   % echo $pathvar:r
    /home/danny/program

3   % echo $pathvar:h
    /home/danny

4   % echo $pathvar:t
    program.c

5   % echo $pathvar:e
```

```
    c

6   % set pathvar = ( /home/* )
    echo $pathvar
    /home/jody /home/local /home/lost+found /home/perl /home/tmp

7   % echo $pathvar:gt
    jody  local  lost+found  perl tmp
```

EXPLANATION

1. The variable pathvar is set to /home/danny/program.c.
2. When :r is appended to the variable, the extension is removed when displayed.
3. When :h is appended to the variable, the head of the path is displayed; that is, the last element of the path is removed.
4. When :t is appended to the variable, the tail end of the path (the last element) is displayed.
5. When :e is appended to the variable, the extension is displayed.
6. The variable is set to /home/*. The asterisk expands to all the pathnames in the current directory starting in /home/.
7. When :gt is appended to the variable, the tail end of each (global) of the path elements is displayed.

9.1.12 Command Substitution

A string or variable can be assigned the output of a UNIX command by placing the command in backquotes. This is called command substitution. (On the keyboard, the backquote is normally below the tilde character.) If the output of a command is assigned to a variable, it is stored as a wordlist (see "Arrays" on page 370), not a string, so that each of the words in the list can be accessed separately. To access a word from the list, a subscript is appended to the variable name. Subscripts start at one.

Example 9.56

```
1   % echo The name of my machine is 'uname −n'.
    The name of my machine is stardust.

2   % echo The present working directory is 'pwd'.
    The present working directory is /home/stardust/john.

3   % set d = 'date'
    % echo $d
    Sat Jun 20 14:24:21 PDT 2001

4   % echo $d[2] $d[6]
    Jun 2001

5   % set d = "'date'"
    % echo $d[1]
    Sat Jun 20 14:24:21 PDT 2001
```

EXPLANATION

1. The UNIX command uname –n is enclosed in backquotes. When the shell encounters the backquotes, it will execute the enclosed command, uname –n, and substitute the output of the command, stardust, into the string. When the echo command prints its arguments to standard output, the name of the machine will be one of its arguments.

2. The UNIX command pwd is executed by the shell and the output is substituted in place within the string.
3. The local variable d is assigned the output of the date command. The output is stored as a list of words (an array).
4. Elements 2 and 6 of the d array are printed. The subscripts start at one.
5. Since the output is enclosed in double quotes, it is a single string rather than a wordlist.

Wordlists and Command Substitution. When a command is enclosed in backquotes and assigned to a variable, the resulting value is an array (wordlist). Each element of the array can be accessed by appending a subscript to the array name. The subscripts start at one. If a subscript that is greater than the number of words in the array is used, the C shell prints Subscript out of range. If the output of a command consists of more than one line, the newlines are stripped from each line and replaced with a single space.

Example 9.57

```
1   % set d = 'date'
    % echo $d
    Fri Aug 29 14:04:49 PDT 2001


3   % echo $d[1–3]
    Fri Aug 29

4   % echo $d[6]
    2001

4   % echo $d[7]
    Subscript out of range.

5   % echo The calendar for the month of November is 'cal 11 2001'"
    The calendar for month of November is November 2001 S M Tu W
    Th F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
    22 23 24 25 26 27 28 29 30
```

EXPLANATION

1. The variable d is assigned the output of the UNIX date command. The output is stored as an array. The value of the variable is displayed.
2. The first three elements of the array are displayed.
3. The sixth element of the array is displayed.
4. There are not seven elements in the array. The shell reports that the subscript is out of range.
5. The output spans more than one line. Each newline is replaced with a space. This may not be the output you expected.

Example 9.58

```
1   % set machine = 'rusers | awk '/tom/{print $1}''

2   % echo $machine
    dumbo bambi dolphin

3   % echo $#machine
    3

4   % echo $machine[$#machine]
    dolphin
```

```
5   % echo $machine
    dumbo bambi dolphin

6   % shift $machine
    % echo $machine
    bambi dolphin


7   % echo $machine[1]
    bambi

8   % echo $#machine
    2
```

EXPLANATION

1. The output of the rusers command is piped to awk. If the regular expression tom is found, awk prints the first field. The first field, in this case, is the name of the machine(s) where ser tom is logged on.
2. User tom is logged on three machines. The names of the machines are displayed.
3. The number of elements in the array is accessed by preceding the array name with $#. There are three elements in the array.
4. The last element of the array is displayed. The number of elements in the array ($#machine) is used as a subscript.
5. The array is displayed.
6. The shift command shifts the array to the left. The first element of the array is dropped and the subscripts are renumbered, starting at one.
7. The first element of the array after the shift is displayed.
8. After the shift, the length of the array has decreased by one.

9.1.13 Quoting

The C shell has a whole set of metacharacters that have some special meaning. In fact, almost any character on your keyboard that is not a letter or a number has some special meaning for the shell. Here is a partial list:

```
* ? [  ] $ ~ ! ^ & {  } (  ) > < | ; : %
```

The backslash and quotes are used to escape the interpretation of metacharacters by the shell. Whereas the backslash is used to escape a single character, the quotes can be used to protect a string of characters. There are some general rules for using quotes:

1. Quotes are paired and must be matched on a line. The backslash character can be used to escape a newline so that a quote can be matched on the next line.
2. Single quotes will protect double quotes, and double quotes will protect single quotes.
3. Single quotes protect all metacharacters from interpretation, with the exception of the history character (!).
4. Double quotes protect all metacharacters from interpretation, with the exception of the history character (!), the variable substitution character ($), and the backquotes (used for command substitution).

The Backslash. The backslash is used to escape the interpretation of a single character and, in the C shell, is the only character that can be used to escape the history character, the exclamation point (also called the bang). Often the backslash is used to escape the newline character. Backslash interpretation does not take place within quotes.

Example 9.59

```
1   % echo Who are you?
    echo: No match.

2   % echo Who are you\?
    Who are you?

3   % echo This is a very,very long line and this is where I\
    break the line.
    This is a very, very long line and this is where I
       I break the line.

4   % echo "\\abc"
    \\abc
    % echo '\\abc'
    \\abc
    % echo \\abc
    \abc
```

EXPLANATION

1. The question mark is used for filename expansion. It matches for a single character. The shell is looking for a file in the current directory that is spelled y−o−u, followed by a single character. Since there is not a file by that name in the directory, the shell complains that it could not find a match with No match.
2. The shell will not try to interpret the question mark, since it is escaped with the backslash.
3. The string is continued to the next line by escaping the newline with a backslash.
4. If the backslash is enclosed in either single or double quotes, it is printed. When not enclosed in quotes, the backslash escapes itself.

Single Quotes. Single quotes must be matched on the same line and will escape all metacharacters with the exception of the history (bang) character (!). The history character is not protected because the C shell evaluates history before it does quotes, but not before backslashes.

Example 9.60

```
1   % echo 'I need $5.00'
    I need $5.00

2   % echo 'I need $500.00 now\!\!'
    I need $500.00 now!!

3   % echo 'This is going to be a long line so
    Unmatched '.

4   % echo 'This is going to be a long line so \
    I used the backslash to suppress the newline'
    This is going to be a long line so
    I used the backslash to suppress the newline
```

EXPLANATION

1. The string is enclosed in single quotes. All characters, except the history (bang) character (!), are protected from shell interpretation.
2. The !! must be protected from shell interpretation by using the backslash character.
3. The quotes must be matched on the same line, or the shell reports Unmatched.
4. If the line is to be continued, the backslash character is used to escape the newline character. The quote is matched at the end of the next line. Even though the shell ignored the newline, the echo command did not.

Double Quotes. Double quotes must be matched, will allow variable and command substitution, and hide everything else except the history (bang) character (!). The backslash will not escape the dollar sign when enclosed in double quotes.

Example 9.61

```
1   % set name = Bob
    % echo "Hi $name"
    Hi Bob

2   % echo "I don't have time."
    I don't have time.

3   % echo "WOW!"       # Watch the history metacharacter!
    ": Event not found.

4   % echo "Whoopie\!"
    Whoopie!

5   % echo "I need \$5.00"
    I need \.00
```

EXPLANATION

1. The local variable name is assigned the value Bob. The double quotes allow the dollar sign to be used for variable substitution.
2. The single quote is protected within double quotes.
3. Double or single quotes will not protect the exclamation point from shell interpretation. The built−in history command is looking for the last command that began with a double quote and that event was not found.
4. The backslash is used to protect the exclamation point.
5. The backslash does not escape the dollar sign when used within double quotes.

The Quoting Game. As long as the quoting rules are adhered to, double quotes and single quotes can be used in a variety of combinations in a single command.

Example 9.62

```
1   % set name = Tom

2   % echo "I can't give $name" ' $5.00\!'
    I can't give Tom $5.00!

3   % echo She cried, \"Oh help me\!' "', $name.
    She cried, "Oh help me!", Tom.
```

EXPLANATION

1. The local variable name is assigned Tom.
2. The single quote in the word can't is protected when enclosed within double quotes. The shell would try to perform variable substitution if the dollar sign in $5.00 were within double quotes. Therefore, the string $5.00 is enclosed in single quotes so that the dollar sign will be a literal. The exclamation point is protected with a backslash since neither double nor single quotes can protect it from shell interpretation.
3. The first conversational quotes are protected by the backslash. The exclamation point is also protected with a backslash. The last conversational quotes are enclosed in a set of single quotes. Single quotes will protect double quotes.

Steps to Successful Quoting. In a more complex command, it is often difficult to match quotes properly unless you follow the steps listed here. (See Appendix C.)

1. Know the UNIX command and its syntax. Before variable substitution, hard code the values into the command line to see if you get the expected results.

   ```
   % nawk −F: '/^Zippy Pinhead/{print "Phone is " $2}' datafile 408−123−4563
   ```
2. If the UNIX command worked correctly, then plug in the variables. At this point, do not remove or change any quotes. Simply put the variables in place of the words they represent. In this example, replace Zippy Pinhead with $name.

   ```
   % set name = "Zippy Pinhead"
   % nawk −F: '/^$name/{print "Phone is " $2}' datafile
   ```
3. Play the quoting game as follows: Starting at the left−hand side with the first single quote, insert a matching single quote just before the dollar sign in $name. Now you have a set of matched quotes.

   ```
   nawk −F: '/^'$name/{print "Phone is " $2}' datafile
   ```

   Now, right after the last letter, e in $name, place another single quote. (Believe me, this works.) This quote matches the quote after the closing curly brace.

   ```
   % nawk −F: '/^'$name'/{print "Phone is  " $2}' datafile
   ```

   Count the number of single quotes, starting at the left−hand side. You have four, a nice even number. Everything within each set of single quotes is ignored by the shell. The quotes are matched as follows:

   ```
   % nawk -F: '$1 ~ /'$name'/{print $2}' filename
   ```
4. Last step: Double quote the variables. Surround each variable very snugly within a set of double quotes. The double quotes protect the whitespace in the expanded variable; for example, the space in Zippy Pinhead is protected.

   ```
   % nawk -F: '$1 ~ /'"$name"'/{print $2}' filename
   ```

Quoting Variables. The :x and :q modifiers are used when it is necessary to quote variables.

Quoting with the :q Modifier. The :q modifier is used to replace double quotes.

Example 9.63

```
1   % set name = "Daniel Savage"
2   % grep $name:q database
        same as
3   % grep "$name" database

4   % set food = "apple pie"

5   % set dessert = ( $food    "ice cream")

6   % echo $#dessert
    3
7   % echo $dessert[1]
    apple

8   % echo $dessert[2]
    pie

9   % echo $dessert[3]
    ice cream

10  % set dessert = ($food:q "ice cream")

11  % echo $#dessert
    2
12  % echo $dessert[1]
    apple pie
13  % echo $dessert[2]
    ice cream
```

EXPLANATION

1. The variable is assigned the string Daniel Savage.
2. When :q is appended to the variable, the variable is quoted. This is the same as enclosing the variable in double quotes.
3. The double quotes surrounding the variable $name allow variable substitution to take place, but protect any whitespace characters. Without the double quotes, the grep program will search for Daniel in a file called Savage and a file called database.
4. The variable food is assigned the string apple pie.
5. The variable dessert is assigned an array (wordlist) consisting of apple pie and ice cream.
6. The number of elements in the dessert array is three. When the food variable was expanded, the quotes were removed. There are three elements, apple, pie, and ice cream.
7. The first element of the array is printed. The variable expands to separated words if not quoted.
8. The second element of the array is printed.
9. Since "ice cream" is quoted, it is treated as one word.
10. The dessert array is assigned apple pie and ice cream. The :q can be used to quote the variable in the same way double quotes quote the variable; i.e., $food:q is the same as "$food".
11. The array consists of two strings, apple pie and ice cream.
12. The first element of the array, apple pie, is printed.
13. The second element of the array, ice cream, is printed.

Quoting with the :x Modifier. If you are creating an array and any of the words in the list contain metacharacters, :x prevents the shell from interpreting the metacharacters when performing variable substitution

Example 9.64

```
1   % set  things = "*.c  a??  file[1-5]"
    % echo $#things
    1

2   % set newthings = ( $things )
    set: No match.

3   % set newthings = ( $things:x )
4   % echo $#newthings
    3

5   % echo "$newthings[1] $newthings[2] $newthings[3] "
    *.c  a??   file[1-5]

6   %  grep $newthings[2]:q filex
    The question marks in a?? would be used for filename expansion
    it is not quoted
```

EXPLANATION

1. The variable things is assigned a string. Each string contains a wildcard. The number of elements in the variable is one, one string.
2. When attempting to create an array out of the string things, the C shell tries to expand the wildcard characters to perform filename substitution within things and produces a No match.
3. The :x extension prevents the shell from expanding the wildcards in the things variable.
4. The array newthings consists of three elements.
5. To print the elements of the array, they must be quoted or, again, the shell will try to expand the wildcards.
6. The :q quotes the variable just as though the variable were surrounded by double quotes. The grep program will print any lines containing the pattern a?? in file filex.

9.2 Programming with the C Shell

9.2.1 Steps in Creating a Shell Script

A shell script is normally written in an editor and consists of commands interspersed with comments. Comments are preceded by a pound sign and consist of text used to document what is going on.

The First Line. At the top left corner, the line preceded by #! (often called shbang) indicates the program that will be executing the lines in the script. This line is commonly

```
#!/bin/csh
```

The #!, also called a magic number, is used by the kernel to identify the program that should be interpreting the lines in the script. When a program is loaded into memory, the kernel will examine the first line. If the first line is binary data, the program will be executed as a compiled program; if the first line contains the #!, the kernel will look at the path following the #! and start that program as the interpreter. If the path is /bin/csh, the C shell will interpret the lines in the program. This line must be the top line of your script or the line will be treated as a comment line.

When the script starts, the .cshrc file is read first and executed, so that anything set within that file will become part of your script. You can prevent the .cshrc from being read into your script by using the –f (fast) option to the C shell program. This option is written as

```
#!/bin/csh −f
```

Comments. Comments are lines preceded by a pound sign (#). They are used to document your script. It is sometimes difficult to understand what the script is supposed to do if it is not commented. Although comments are important, they are often too sparse or not even used at all. Try to get used to commenting what you are doing not only for someone else, but also for yourself. Two days from now you may not remember exactly what you were trying to do.

Making the Script Executable. When you create a file, it is not given execute permission. You need this permission to run your script. Use the chmod command to turn on execute permission.

Example 9.65

```
1   % chmod +x myscript
2   % ls −lF  myscript
    −rwxr−−xr−−x    1  ellie  0 Jul  13:00 myscript*
```

EXPLANATION

1. The chmod command is used to turn on execute permission for the user, the group, and others.
2. The output of the ls command indicates that all users have execute permission on the myscript file. The asterisk at the end of the filename (resulting from the −F option) also indicates that this is an executable program.

An Example Scripting Session. In the following example, the user will create the script in the editor. After saving the file, the execute permissions are turned on with the chmod command, and the script is executed. If there are errors in the program, the C shell will respond immediately.

Example 9.66

```
(The Script − info)
    #!/bin/csh −f
    # This script is called info
1   echo Hello ${LOGNAME}!
2   echo The hour is 'date +%H'
3   echo "This machine is 'uname −n'"
4   echo The calendar for this month is
5   cal
6   echo The processes you are running are:
7   ps −ef | grep  "^ *$LOGNAME"
8   echo "Thanks for coming. See you soon\!\!"

    (The Command Line)
    % chmod +x info
    % info
1   Hello ellie!
2   The hour is 09
3   This machine is jody
4   The calendar for this month is
5       July 2001
    S    M   Tu   W   Th   F   S
```

```
                        1   2   3
    4    5    6   7    8   9  10
   11   12   13  14   15  16  17
   18   19   20  21   22  23  24
   25   26   27  28   29  30  31
7   The processes you are running are:
    < output of ps prints here >
8   Thanks for coming. See you soon!!
```

EXPLANATION

1. The user is greeted. The variable LOGNAME holds the user's name. On BSD systems, USER is used. The curly braces shield the variable from the exclamation point. The exclamation point does not need to be escaped because it will not be interpreted as a history character unless there is a character appended to it.

2. The date command is enclosed in backquotes. The shell will perform command substitution and the date's output, the current hour, will be substituted into the echo string.

3. The uname –n command displays the machine name.

4. The cal command is not enclosed in backquotes because when the shell performs command substitution, the newlines are all stripped from the output. This produces a strange−looking calendar. By putting the cal command on a line by itself, the formatting is preserved.

5. The calendar for this month is printed.

6,7. The user's processes are printed. Use ps –aux for BSD.

8. The string is printed. Note that the two exclamation points are prepended with backslashes. This is necessary to prevent history substitution.

9.2.2 Reading User Input

The $< Variable. To make a script interactive, a special C shell variable is used to read standard input into a variable. The $< symbol reads a line from standard input up to but not including the newline, and assigns the line to a variable[6].

Example 9.67

```
(The Script − greeting)
   #/bin/csh  −f
   # The greeting script
1  echo −n  "What is your name? "
2  set name = $<
3  echo Greetings to you, $name.

(The Command Line)
   % chmod +x greeting
   % greeting
1  What is your name?  Dan Savage
3  Greetings to you, Dan Savage.
```

EXPLANATION

1. The string is echoed to the screen. The –n option causes the echo command to suppress the newline at the end of the string. On some versions of echo, use a \c at the end of the string to suppress the newline; e.g., echo hello\c.
2. Whatever is typed at the terminal, up to a newline is stored as a string in the name variable.
3. The string is printed after variable substitution is performed.

Creating a Wordlist from the Input String. Since the input from the $< variable is stored as a string, you may want to break the string into a wordlist.

Example 9.68

```
1   % echo What is your full name\?

2   % set name = $<
    Lola Justin Lue

3   % echo Hi $name[1]
    Hi Lola Justin Lue

4   % echo $name[2]
    Subscript out of range.

5   % set name = ( $name )

6   % echo Hi $name[1]
    Hi Lola

7   % echo $name[2] $name[3]
    Justin Lue
```

EXPLANATION

1. The user is asked for input.
2. The special variable $< accepts input from the user in a string format.
3. Since the value Lola Justin Lue is stored as a single string, the subscript [1] displays the whole string. Subscripts start at one.
4. The string consists of one word. There are not two words, so by using a subscript of [2], the shell complains that the Subscript is out of range.
5. To create a wordlist, the string is enclosed in parentheses. An array is created. The string is broken up into a list of words and assigned to the variable name.
6. The first element of the array is printed.
7. The second and third elements of the array are printed.

9.2.3 Arithmetic

There is not really a need to do math problems in a shell script, but sometimes arithmetic is necessary, e.g., to increment or decrement a loop counter. The C shell supports integer arithmetic only. The @ symbol is used to assign the results of calculations to numeric variables.

Arithmetic Operators. The following operators in Table 9.8 are used to perform integer arithmetic operations. They are the same operators as found in the C programming language. See Table 9.13 for operator precedence. Also borrowed from the C language are shortcut assignment operators, shown in Table 9.9.

Table 9.8. Operators

Function	Operator
Addition	+
Subtraction	−
Division	/
Multiplication	*
Modulus	%
Left shift	<<
Right shift	>>

Table 9.9. Shortcut Operations

Operator	Example	Equivalent to
+=	@ num += 2	@ num = $num + 2
−=	@ num −= 4	@ num = $num − 4
*=	@ num *= 3	@ num = $num * 3
/=	@ num /= 2	@ num = $num / 2
++	@ num++	@ num = $num + 1
− −	@ num−−	@ num = $num − 1

Example 9.69

```
1   % @ sum = 4 + 6
    echo $sum
    10

2   % @ sum++
    echo $sum
    11

3   % @ sum += 3
    echo $sum
    14

4   % @ sum−−
    echo $sum
    13

5   % @ n = 3+4
    @: Badly formed number
```

EXPLANATION

1. The variable sum is assigned the result of adding 4 and 6. (The space after the @ is required.)
2. The variable sum is incremented by 1.
3. The variable sum is incremented by 3.
4. The variable sum is decremented by 1.
5. Spaces are required after the @ symbol and surrounding the operator.

Floating Point Arithmetic. Since floating point arithmetic is not supported by this shell, if you should need more complex mathematical operations, you can use UNIX utilities.

The bc and nawk utilities are useful if you need to perform complex calculations.

Example 9.70

```
(The Command Line)
1   set n='echo "scale=3; 13 / 2" | bc'
    echo $n
    6.500

2   set product='nawk −v x=2.45 −v y=3.124 'BEGIN{\
```

```
printf "%.2f\n", x * y }''

% echo $product
7.65
```

EXPLANATION

1. The output of the echo command is piped to the bc program. The scale is set to 3; that is, the number of significant digits to the right of the decimal point that will be printed. The calculation is to divide 13 by 2. The entire pipeline is enclosed in backquotes. Command substitution will be performed and the output assigned to the variable n.
2. The nawk program gets its values from the argument list passed in at the command line. Each argument passed to nawk is preceded by the –v switch; for example, –v x=2.45 and –v y=3.124. After the numbers are multiplied, the printf function formats and prints the result with a precision of 2 places to the right of the decimal point. The output is assigned to the variable product.

9.2.4 Debugging Scripts

C shell scripts often fail because of some simple syntax error or logic error. Options to the csh command are provided to help you debug your programs. See Table 9.10.

Table 9.10. Echo (–x) and Verbose (–v)

As options to cshcsh –x scriptnameDisplay each line of script after variable substitution and before execution.csh –v scriptnameDisplay each line of script before execution, just as you typed it.csh –n scriptnameInterpret but do not execute commands. As arguments to the set commandset echoDisplay each line of script after variable substitution and before execution.set verboseDisplay each line of script before execution, just as you typed it. As the first line in a script#!/bin/csh –xvTurns on both echo and verbose. These options can be invoked separately or combined with other csh invocation arguments.

Example 9.71

```
(The −v and −x Options)
1   % cat practice
    #!/bin/csh
    echo Hello $LOGNAME
    echo The date is 'date'
    echo Your home shell is $SHELL
    echo Good−bye $LOGNAME

2   % csh −v practice
    echo Hello $LOGNAME
    Hello ellie
    echo The date is 'date'
    The date is Sun May 23 12:24:07 PDT  2001
    echo Your login shell is $SHELL
    Your login shell is /bin/csh
    echo Good−bye $LOGNAME
    Good−bye ellie

3   % csh −x practice
    echo Hello ellie
    Hello ellie
    echo The date is 'date'
```

```
    date
    The date is Sun May 23 12:24:15 PDT  2001
    echo Your login shell is /bin/csh
    Your login shell is /bin/csh
    echo Good−bye ellie
    Good−bye ellie
```

EXPLANATION

1. The contents of the C shell script are displayed. Variable and command substitution lines are included so that you can see how echo and verbose differ.
2. The –v option to the csh command causes the verbose feature to be enabled. Each line of the script is displayed as it was typed in the script, and then the line is executed.
3. The –x option to the csh command enables echoing. Each line of the script is displayed after variable and command substitution are performed, and then the line is executed. Since this feature allows you to examine what is being replaced as a result of command and variable substitution, it is used more often than the verbose option.

Example 9.72

```
(Echo and Verbose)
1   % cat practice
    #!/bin/csh
    echo Hello $LOGNAME
    echo The date is 'date'
    set echo
    echo Your home shell is $SHELL
    unset echo
    echo Good−bye $LOGNAME

    % chmod +x practice

2   % practice
    Hello ellie
    The date is Sun May 26 12:25:16 PDT  2001
−−> echo Your login shell is /bin/csh
−−> Your login shell is /bin/csh
−−> unset echo
    Good−bye ellie
```

EXPLANATION

1. The echo option is set and unset within the script. This enables you to debug certain sections of your script where you have run into a bottleneck, rather than echoing each line of the entire script.
2. The – –> marks where the echoing was turned on. Each line is printed after variable and command substitution and then executed.

Example 9.73

```
1   % cat practice
    #!/bin/csh
    echo Hello $LOGNAME
    echo The date is 'date'
    set verbose
    echo Your home shell is $SHELL
    unset verbose
    echo Good−bye $LOGNAME
```

```
2   % practice
    Hello ellie
    The date is Sun May 23 12:30:09 PDT  2001
--> echo Your login shell is $SHELL
--> Your login shell is /bin/csh
--> unset verbose
    Good-bye ellie
```

EXPLANATION

1. The verbose option is set and unset within the script.
2. The – –> marks where verbose was turned on. The lines are printed just as they were typed in the script and then executed.

9.2.5 Command Line Arguments

Shell scripts can take command line arguments. Arguments are used to modify the behavior of the program in some way. The C shell assigns command line arguments to positional parameters and enforces no specific limit on the number of arguments that can be assigned (the Bourne shell sets a limit of nine positional parameters). Positional parameters are number variables. The scriptname is assigned to $0, and any words following the scriptname are assigned to $1, $2, $3 … ${10}, ${11}, and so on. $1 is the first command line argument. In addition to using positional parameters, the C shell provides the argv built−in array.

Positional Parameters and argv. If using the argv array notation, a valid subscript must be provided to correspond to the argument being passed in from the command line or the error message Subscript out of range is sent by the C shell. The argv array does not include the scriptname. The first argument is $argv[1], and the number of arguments is represented by $#argv. (There is no other way to represent the number of arguments.) See Table 9.11 for a list of command line arguments.

Table 9.11. Command Line Arguments

Argument Meaning$0The name of the script.$1, $2, … ${10}…The first and second positional parameters are referenced by the number preceded by a dollar sign. The curly braces shield the number 10 so that it does not print the first positional parameter followed by a zero.$*All the positional parameters.$argv[0]Not valid; nothing is printed. C shell array subscripts start at 1.$argv[1] $argv[2]…The first argument, second argument, etc.$argv[*]All arguments.$argvAll arguments.$#argvThe number of arguments.$argv[$#argv]The last argument.

Example 9.74

```
(The Script)
#!/bin/csh –f
# The greetings script
# This script greets a user whose name is typed in at the
# command line.

1   echo $0 to you $1 $2 $3
2   echo Welcome to this day 'date | awk '{print $1, $2, $3}''
3   echo Hope you have a nice day, $argv[1]\!
4   echo Good–bye $argv[1] $argv[2] $argv[3]

(The Command Line)
    % chmod +x greetings
```

```
    % greetings Guy Quigley
1   greetings to you Guy Quigley
2   Welcome to this day Fri Aug 28
3   Hope you have a nice day, Guy!
4   Subscript out of range
```

EXPLANATION

1. The name of the script and the first three positional parameters are to be displayed. Since there are only two positional parameters coming in from the command line, Guy and Quigley, $1 becomes Guy, $2 becomes Quigley, and $3 is not defined.
2. The awk command is quoted with single quotes so that the shell does not confuse awk's field numbers $1, $2, and $3 with positional parameters. (Do not confuse awk's field designators $1, $2, and $3 with the shell's positional parameters.)
3. The argv array is assigned values coming in from the command line. Guy is assigned to argv[1] and its value is displayed. You can use the argv array to represent the command line arguments within your script, or you can use positional parameters. The difference is that positional parameters do not produce an error if you reference one that has no value, whereas an unassigned argv value causes the script to exit with the Subscript out of range error message.
4. The shell prints the error Subscript out of range because there is no value for argv[3].

9.2.6 Flow Control and Conditional Constructs

When making decisions, the if, if/else, if/else if, and switch commands are used. These commands control the flow of the program by allowing decision−making based on whether an expression is true or false.

Testing Expressions. An expression consists of a set of operands separated by operators. Operators and precedence are listed in Tables 9.12 and 9.13. To test an expression, the expression is surrounded by parentheses. The C shell evaluates the expression, resulting in either a zero or nonzero numeric value. If the result is nonzero, the expression is true; if the result is zero, the expression is false.

Table 9.12. Comparison and Logical Operators

Operator	**Meaning**	**Example**
==	Is equal to	$x == $y
!=	Is not equal to	$x != $y
>	Is greater than	$x > $y
>=	Is greater than or equal to	$x >= $y
<	Is less than	$x < $y
<=	Is less than or equal to	$x <= $y
=~	String matches	$ans =~ [Yy]*
!~	String does not match	$ans !~ [Yy]*
!	Logical not	! $x
||	Logical or	$x || $y
&&	Logical and	$x && $y

When evaluating an expression with the logical and (&&), the shell evaluates from left to right. If the first expression (before the &&) is false, the shell assigns false as the result of the entire expression, never checking the remaining expressions. If the first expression is false, the whole expression is false when using the logical and (&&) operator. Both expressions surrounding a logical && operator must be true for the entire expression to evaluate to true.

When evaluating an expression with the logical or (||), if the first expression to the left of the || is true, the shell assigns true to the entire expression and never checks further. In a logical || expression, only one of the expressions must be true.

The logical not is a unary operator; that is, it evaluates one expression. If the expression to the right of the not operator is true, the expression becomes false. If it is false, the expression becomes true.

Precedence and Associativity. Like C, the C shell uses precedence and associativity rules when testing expressions. If you have an expression with a mix of different operators, such as the following:

```
@  x = 5 + 3 * 2
echo $x
11
```

the shell reads the operators in a certain order. Precedence refers to the order of importance of the operator. Associativity refers to whether the shell reads the expression from left to right or right to left when the precedence is equal.[7] Other than in arithmetic expressions (which you will not readily need in shell scripts anyway), the order of associativity is from left to right if the precedence is equal. You can change the order by using parentheses. (See Table 9.13.)

```
@ x = ( 5 + 3 ) * 2
echo $x
16
```

Expressions can be numeric, relational, or logical. Numeric expressions use the following arithmetic operators:

```
+ – * /  ++ -- %
```

Relational expressions use the operators that yield either a true (nonzero) or false (zero) result:

```
>  <   >=   <=   ==   !=
```

Logical expressions use these operators:

```
!   &&  ||
```

Table 9.13. Operator Precedence

Precedence Operator Meaning High( )Change precedence; group ~Complement !Logical not, negation * / %Multiply, divide, modulo + −Add, subtract << >>Bitwise left and right shift > >= < <=Relational operators: greater than, less than == !=Equality: equal to, not equal to =~ !~Pattern matching: matches, does not match &Bitwise and ^Bitwise exclusive or |Bitwise inclusive or &&Logical andLow||Logical or

The if Statement. The simplest form of conditional is the if statement. After the if is tested, and if the expression evaluates to true, the commands after the then keyword are executed until the endif is reached. The endif keyword terminates the block. The if statement may be nested as long as every single if statement is terminated with a matching endif. The endif goes with the nearest enclosing if.

FORMAT

```
if ( expression ) then
   command
   command
endif
```

Example 9.75

```
(In the Script: Checking for Arguments)
1   if ( $#argv != 1 ) then
2       echo "$0 requires an argument"
3       exit 1
4   endif
```

EXPLANATION

1. This line reads: If the number of arguments ($#argv) passed in from the command line is not equal to one, then…
2. If the first line is true, this line and line 3 are executed.
3. The program exits with a value of one, meaning it failed.
4. Every if block is closed with an endif statement.

Testing and Unset or Null Variables. The $? special variable is used to test if a variable has been set. It will return true if the variable is set to null.

Example 9.76

```
(From .cshrc File)
if ( $?prompt ) then
   set history = 32
endif
```

EXPLANATION

The .cshrc file is executed every time you start a new csh program. $? is used to check to see if a variable has been set. In this example, the shell checks to see if the prompt has been set. If the prompt is set, you are running an interactive shell, not a script. The prompt is only set for interactive use. Since the history mechanism is only useful when running interactively, the shell will not set history if you are running a script.

Example 9.77

```
(The Script)
    echo −n "What is your name? "
1   set name = $<
2   if ( "$name" != "" ) then
       grep "$name" datafile
    endif
```

EXPLANATION

1. The user is asked for input. If the user just presses Enter, the variable name is set, but it is set to null.
2. The variable is double quoted so that if the user enters more than one word in name, the expression will still be evaluated. If the quotes were removed and the user entered first and last name, the shell would exit the script with the error message if: Expression syntax. The empty double quotes represent a null string.

The if/else Statements. The if/else construct is a two−way branching control structure. If the expression after the if command is true, the block following it is executed; otherwise, the block after the else is executed. The endif matches the innermost if statement and terminates the statement.

FORMAT

```
if ( expression ) then
    command
else
    command
endif
```

Example 9.78

```
1   if ( $answer =~ [Yy]* ) then
2      mail bob < message
3   else
4      mail john < datafile
5   endif
```

EXPLANATION

1. This line reads: If the value of $answer matches a Y or a y, followed by zero or more characters, then go to line 2; otherwise, go to line 3. (The * is a shell metacharacter.)
2. The user bob is mailed the contents of the file message.
3. The commands under the else are executed if line 1 is not true.
4. The user john is mailed the contents of the file datafile.
5. The endif block ends the if block.

Debugging Expressions. The –x option (called echoing) to the C shell allows you to trace what is going on in your script as it executes. If you are unsure what is going on, this is a good way to debug your script.

Example 9.79

```
(The Script: Using Logical Expressions and Checking Values)
    #!/bin/csh -f
    # Scriptname: logical
    set x = 1
    set y = 2
    set z = 3
1   if ( ( "$x" && "$y" ) ||  ! "$z" ) then
      # Note: grouping and parentheses
2     echo TRUE
   else
      echo FALSE
   endif

(The Output)
3   % csh -x logical
    set x = 1
    set y = 2
    set z = 3
    if  ( ( 1 &&  2 )  ||  !  3 )  then
    echo TRUE
    TRUE
    else
    %
```

EXPLANATION

1. The logical expression is being evaluated. The first expression is enclosed in parentheses (not necessary since && is of higher precedence than ||). The parentheses do not require spaces when nested, but the negation operator (!) must have a space after it.
2. If the expression evaluates true, this line is executed.
3. The csh program is executed with the –x switch. This turns on echoing. Every line in your script is echoed back to you after variable substitution has been performed.

The if Statement and a Single Command. If an expression is followed by a single command, the then and endif keywords are not necessary.

FORMAT

```
if ( expression ) single command
```

Example 9.80

```
if ($#argv == 0) exit 1
```

EXPLANATION

The expression is tested. If the number of command line arguments, $#argv, is equal to zero, the program is exited with a status of one.

The if/else if Statements. The if/else if construct offers a multiway decision−making mechanism. A number of expressions can be tested, and when one of the expressions evaluated is true, the block of statements that follow is executed. If none of the expressions are true, the else block is executed.

FORMAT

```
if ( expression ) then
    command
    command
else if ( expression ) then
    command
    command
else
    command
endif
```

Example 9.81

```
(The Script: grade)
    #!/bin/csh −f
    # This script is called grade
    echo −n "What was your grade? "
    set grade = $<
1   if ( $grade >= 90 && $grade <= 100 ) then
       echo "You got an A\!"
2   else if ( $grade > 79 ) then
       echo "You got a B"
3   else if ( $grade > 69 ) then
       echo "You're average"
```

```
    else
4      echo "Better study"
5   endif
```

EXPLANATION

1. If grade is greater than or equal to 90 and grade is less than or equal to 100, then You got an A! is printed. Both expressions surrounding the && must be true or program control will go to the else if on line 2.
2. If line 1 is false, test the expression (line 2), and if it is true, You got a B is printed.
3. If line 1 and 2 are both false, try this one. If this expression is true, then echo You're average is printed.
4. If all of the above expressions test false, the statements in the else block are executed.
5. The endif ends the entire if construct.

Exit Status and the Status Variable. Every UNIX command returns an exit status. If the command was successful, it returns an exit status of zero. If the command failed, it returns a nonzero exit status. You can test to see whether the command succeeded or failed by looking at the value of the C shell status variable. The status variable contains the exit status of the last command executed.

Example 9.82

```
1   % grep ellie /etc/passwd
    ellie:pHAZk66gA:9496:41:Ellie:/home/jody/ellie:/bin/csh
2   % echo $status
    0                  # Zero shows that grep was a success
3   % grep joe /etc/passwd
4   % echo $status
    1                  # Nonzero shows that grep failed
```

EXPLANATION

1. The grep program found ellie in the /etc/passwd file.
2. The grep program, if it finds the pattern ellie, returns a zero status when it exits.
3. The grep program did not find joe in the /etc/passwd file.
4. The grep program returns a nonzero status if the pattern is not found.

Exiting from a Shell Script. In your shell script, the exit command will take you back to the shell prompt. The exit command takes an integer value to indicate the type of exit. A nonzero argument indicates failure; zero indicates success. The number must be between 0 and 255.

Example 9.83

```
(The checkon Shell Script)
   #!/bin/csh -f
1  if ( $#argv != 1 ) then
2        echo "$0 requires an argument"
3        exit 2
4  endif


(At the command line)
5  % checkon
   checkon requires an argument
6  % echo $status
   2
```

EXPLANATION

1. If the number of arguments passed in from the command line ($#argv) is not equal to one, then go to line 2.
2. The echo prints the scriptname ($0) and the string requires an argument.
3. The program exits back to the prompt with a value of 2. This value will be stored in the status variable of the parent shell.
4. The end of the conditional if.
5. At the command line, the program checkon is executed without an argument.
6. The program exits with a value of 2, which is stored in the status variable.

Using the Status Variable in a Script. The status variable can be used in a script to test the status of a command. The status variable is assigned the value of the last command that was executed.

Example 9.84

```
(The Script)
    #!/bin/csh −f


1   ypmatch  $1  passwd >& /dev/null
2   if ( $status == 0 ) then
3        echo Found $1 in the NIS database
    endif
```

EXPLANATION

1. The ypmatch program checks the NIS database to see if the name of the user, passed in as the first argument, is in the database.
2. If the status returned from the last command is zero, the then block is executed.
3. This line is executed if the if test expression evaluated to be true.

Evaluating Commands within Conditionals. The C shell evaluates expressions in conditionals. To evaluate commands in conditionals, curly braces must enclose the command. If the command is successful, that is, returns an exit status of zero, the curly braces tell the shell to evaluate the expression as true (1).[8] If the command fails, the exit status is nonzero, and the expression is evaluated as false (0).

It is important, when using a command in a conditional, to know the exit status of that command. For example, the grep program returns an exit status of zero when it finds the pattern it is searching for, one when it cannot find the pattern, and two when it cannot find the file. When awk or sed are searching for patterns, those programs return zero whether or not they are successful in the pattern search. The criterion for success with awk and sed is based on whether or not the syntax is right; that is, if you typed the command correctly, the exit status of awk and sed is zero.

If the exclamation mark is placed before the expression, it nots the entire expression so that if true, it is now false, and vice versa. Make sure a space follows the exclamation mark, or the C shell will invoke the history mechanism.

FORMAT

```
if  { ( command ) }  then
    command
    command
endif
```

Example 9.85

```
    #!/bin/csh −f
1   if  { ( who | grep $1 >& /dev/null ) } then
2      echo $1 is logged on and running:
3      ps −ef | grep "^ *$1"       # ps −aux for BSD
4   endif
```

EXPLANATION

1. The who command is piped to the grep command. All of the output is sent to /dev/null, the UNIX "bit bucket." The output of the who command is sent to grep; grep searches for the name of the user stored in the $1 variable (first command line argument). If grep is successful and finds the user, an exit status of zero is returned. The shell will then invert the exit status of the grep command to yield one, or true. If the shell evaluates the expression to be true, it executes the commands between the then and endif.
2. If the C shell evaluates the expression in line 1 to be true, lines 2 and 3 are executed.
3. All the processes running and owned by $1 are displayed.
4. The endif ends the if statements.

FORMAT

```
if ! { (command) } then
```

Example 9.86

```
1   if  !  { ( ypmatch $user passwd >& /dev/null ) } then
2      echo $user is not a user here.
       exit 1
3   endif
```

EXPLANATION

1. The ypmatch command is used to search the NIS passwd file, if you are using a network. If the command succeeds in finding the user ($user) in the passwd file, the expression evaluates to be true. The exclamation point (!) preceding the expression nots or complements the expression; that is, makes it false if it is true, and vice versa.
2. If the expression is not true, the user is not found and this line is executed.
3. The endif ends this if block.

The goto. A goto allows you to jump to some label in the program and start execution at that point. Although gotos are frowned upon by many programmers, they are sometimes useful for breaking out of nested loops.

Example 9.87

```
(The Script)
    #!/bin/csh −f
1   startover:
2   echo "What was your grade? "
    set grade = $<
3   if ( "$grade" < 0 || "$grade" > 100 ) then
4      echo "Illegal grade"
5      goto startover
    endif
    if ( $grade >= 89 ) then
       echo "A for the genius\!"
    else if ( $grade >= 79 ) then
       .. < Program continues >
```

EXPLANATION

1. The label is a user−defined word with a colon appended. The label is called startover. During execution of the program, the label is ignored by the shell, unless the shell is explicitly directed to go to the label.
2. The user is asked for input.
3. If the expression is true, (the user entered a grade less than 0 or greater than 100), the string Illegal grade is printed, and the goto starts execution at the named label, startover. The program continues to execute from that point.
4. The if expression tested false, so this line is printed.
5. The goto sends control to line 1 and execution starts after the label, startover.

File Testing. The C shell has a built−in set of options for testing attributes of files, such as, Is it a directory, a plain file (not a directory), or a readable file, and so forth. For other types of file tests, the UNIX test command is used. The built−in options for file inquiry are listed in Table 9.14.

Table 9.14. File Testing

Test Flag (What It Tests) True If–rCurrent user can read the file.–wCurrent user can write to the file.–xCurrent user can execute the file.–eFile exists.–oCurrent user owns the file.–zFile is zero length.–dFile is a directory.–fFile is a plain file.

Example 9.88

```
    #!/bin/csh −f
1   if ( −e file ) then
       echo file exists
    endif

2   if ( −d file ) then
        echo file is a directory
    endif

3   if ( ! −z file ) then
        echo file is not of zero length
    endif
4   if ( −r file && −w file ) then
        echo file is readable and writeable
    endif
```

EXPLANATION

1. The statement reads, if the file exists, then …
2. The statement reads, if the file is a directory, then …
3. The statement reads, if the file is not of zero length, then …
4. The statement reads, if the file is readable and writeable, then … . The file testing flags cannot be stacked, as in –rwx file. A single option precedes the filename (e.g., –r file && –w file && –x file).

The test Command and File Testing. The UNIX test command includes options that were built−in to the C shell, as well as a number of options that were not. See Table 9.15 for a list of test options. You may need these additional options when testing less common attributes of files such as block and special character files, or setuid files. The test command evaluates an expression and returns an exit status of either zero for success or one for failure. When using the test command in an if conditional statement, curly braces must surround the command so that the shell can evaluate the exit status properly.[9]

To use the test command in a conditional statement, use curly braces as you would for any other command for the C shell to evaluate the exit status properly.

Table 9.15. File Testing with the test Command

Option Meaning—Tests True If–bFile is a block special file.–cFile is a character special file.–dFile exists and is a directory file.–fFile exists and is a plain file.–gFile has the set−group−ID bit set.–kFile has the sticky bit set.–pFile is a named pipe.–rCurrent user can read the file.–sFile exists and is not empty.–t nn is file descriptor for terminal.–uFile has the set−user−ID bit set.–wCurrent user can write to the file.–xCurrent user can execute the file.

Example 9.89

```
1   if { test  –b file } echo file is a block device file

2   if { test –u file }  echo file has the set–user–id bit set
```

EXPLANATION

1. The statement reads, if the file is a block special file (found in /dev), then …
2. The statement reads, if the file is a setuid program (set user ID), then …

Nesting Conditionals. Conditional statements can be nested. Every if must have a corresponding endif (else if does not have an endif). It is a good idea to indent nested statements and line up the ifs and endifs so that you can read and test the program more effectively.

Example 9.90

```
(The Script)
    #!/bin/csh -f
    # Scriptname: filecheck

    # Usage: filecheck filename

    set file=$1
1   if ( ! -e $file ) then
        echo "$file does not exist"
        exit 1
    endif
2   if ( -d $file ) then
        echo "$file is a directory"
3   else if (-f $file) then
4       if ( -r $file && -x $file ) then      # Nested if construct
            echo "You have read and execute permission on $file"
5       endif
    else
        print "$file is neither a plain file nor a directory."
6   endif

(The Command Line)
$ filecheck testing
You have read and execute permission of file testing.
```

EXPLANATION

1. If file (after variable substitution) is a file that does not exist (note the not operator, !), the commands under the then keyword are executed. An exit value of one means that the program failed.
2. If the file is a directory, print testing is a directory.
3. If the file is not a directory, else if the file is a plain file, then … the next statement is executed, another if.
4. This if is nested in the previous if. If file is readable, writeable, and executable, then … . This if has its own endif and is lined up to indicate where it belongs.
5. The endif terminates the innermost if construct.
6. The endif terminates the outermost if construct.

The switch Command. The switch command is an alternative to using the if–then–else if construct. Sometimes the switch command makes a program clearer to read when handling multiple options. The value in the switch expression is matched against the expressions, called labels, following the case keyword. The case labels will accept constant expressions and wildcards. The label is terminated with a colon. The default label is optional, but its action is taken if none of the other cases match the switch expression. The breaksw is used to transfer execution to the endsw. If a breaksw is omitted and a label is matched, any statements below the matched label are executed until either a breaksw or endsw is reached.

FORMAT

```
switch (variable)
case constant:
    commands
    breaksw
case constant:
    commands
    breaksw
endsw
```

Example 9.91

```
(The Script - colors)
    #!/bin/csh -f
    # This script is called colors
1   echo -n "Which color do you like? "
2   set color = $<
3   switch ("$color")
4   case bl*:
       echo I feel $color
       echo The sky is $color
5      breaksw
6   case red:          # Is is red or is it yellow?
7   case yellow:
8      echo The sun is sometimes $color.
9      breaksw
10  default:
11     echo $color not one of the categories.
12     breaksw
13  endsw

(The Command Line)
% colors

(The Output)
1   Which color do you like? red
8   The sun is sometimes red.
1   Which color do you like? Doesn't matter
11  Doesn't matter is not one of the categories.
```

EXPLANATION

1. The user is asked for input.
2. The input is assigned to the color variable.
3. The switch statement evaluates the variable. The variable is enclosed in double quotes in case the user entered more than one word. The switch statement evaluates a single word or string of words if the string of words is held together with double quotes.
4. The case label is bl*, meaning that the switch expression will be matched against any set of characters starting with b, followed by an l. If the user entered blue, black, blah, blast, etc., the commands under this case label would be executed.
5. The breaksw transfers program control to the endsw statement.
6. If the switch statement matches this label, red, the program starts executing statements until the breaksw on line 9 is reached. Line 8 will be executed. The sun is sometimes red is displayed.
7. If line 4 is not matched, cases red and yellow are tested.
8. If either label, red or yellow, is matched, this line is executed.
9. The breaksw transfers program control to the endsw statement.
10. The default label is reached if none of the case labels matches the switch expression. This is like the if/else if/else construct.
11. This line is printed if the user enters something not matched in any of the above cases.
12. This breaksw is optional since the switch will end here. It is recommended to leave the breaksw here so that if more cases are added later, it will not be overlooked.
13. The endsw terminates the switch statement.

Nesting Switches. Switches can be nested; i.e., a switch statement and its cases can be contained within another switch statement as one of its cases. There must be an endsw to terminate each switch statement. A default case is not required.

Example 9.92

```
(The Script: systype)
    #!/bin/csh −f
    # This script is called systype
    # Program to determine the type of system you are on.
    echo "Your system type is: "
1   set release = ('uname −r')
2   switch ('uname −s')
3   case SunOS:
4      switch ("$release")
5      case 4.*:
              echo "SunOS $release"
              breaksw
6      case [56].*:
              echo "Solaris $release"
              breaksw
7      endsw
       breaksw
    case HP*:
       echo HP−UX
       breaksw
    case Linux:
       echo Linux
       breaksw
8   endsw

(The Command Line)
% systype
Your system type:
SunOS 4.1.2
```

EXPLANATION

1. The variable release is assigned the output of uname −r, the release number for the version of the operating system.
2. The switch command evaluates the output of uname −s, the name of the operating system.
3. If the system type is SunOS, the case command on line 3 is executed.
4. The value of the variable release is evaluated in each of the cases for a match.
5. The case for all release versions 4 are tested.
6. The case for all release versions 5 and 6 are tested.
7. The inner switch statement is terminated.
8. The outer switch statement is terminated.

9.2.7 Loops

Looping constructs allow you to execute the same statements a number of times. The C shell supports two types of loops: the foreach loop and the while loop. The foreach loop is used when you need to execute commands on a list of items, one item at a time, such as a list of files or a list of usernames. The while loop is used when you want to keep executing a command until a certain condition is met.

The foreach Loop. The foreach command is followed by a variable and a wordlist enclosed in parentheses. The first time the loop is entered, the first word in the list is assigned to the variable. The list is shifted to the left by one and the body of the loop is entered. Each command in the loop body is executed until the end statement is reached. Control returns to the top of the loop. The next word on the list is assigned to the variable, the commands after the foreach line are executed, the end is reached, control returns to the top of the foreach loop, the next word in the wordlist is processed, and so on. When the wordlist is empty, the loop ends.

FORMAT

```
foreach variable (wordlist)
       commands
end
```

Example 9.93

```
1   foreach person (bob sam sue fred)
2      mail $person < letter
3   end
```

EXPLANATION

1. The foreach command is followed by a variable, person, and a wordlist enclosed in parentheses. The variable person will be assigned the value bob the first time the foreach loop is entered. Once bob has been assigned to person, bob is shifted off (to the left) and sam is at the beginning of the list. When the end statement is reached, control starts at the top of the loop, and sam is assigned to the variable person. This procedure continues until fred is shifted off, at which time the list is empty and the loop is over.
2. The user bob will be mailed the contents of the file letter the first time through the loop.
3. When the end statement is reached, loop control is returned to the foreach, and the next element in the list is assigned to the variable person.

Example 9.94

```
(The Command Line)
% cat maillist
tom
dick
harry
dan

(The Script − mailtomaillist)
    #!/bin/csh −f
    # This script is called mailtomaillist
1   foreach person ('cat maillist')
2      mail $person <<EOF
       Hi $person,
       How are you?  I've missed you. Come on over
       to my place.
       Your pal,
              $LOGNAME@'uname −n'
    EOF
3   end
```

EXPLANATION

1. Command substitution is performed within the parentheses. The contents of the file maillist become the wordlist. Each name in the wordlist (tom, dick, harry, dan) is

assigned, in turn, to the variable person. After the looping statements are executed and the end is reached, control returns to the foreach, a name is shifted off from the list, and assigned to the variable person. The next name in the list replaces the one that was just shifted off. The list therefore decreases in size by one. This process continues until all the names have been shifted off and the list is empty.
2. The here document is used. Input is sent to the mail program from the first EOF to the terminating EOF. (It is important that the last EOF is against the left−hand margin and has no surrounding whitespace.) Each person in the list will be sent the mail message.
3. The end statement for the foreach loop marks the end of the block of lines that is executed within this loop. Control returns to the top of the loop.

Example 9.95

```
1   foreach file (*.c)
2      cc $file −o $file:r
    end
```

EXPLANATION

1. The wordlist for the foreach command is a list of files in the current directory ending in .c (i.e., all the C source files).
2. Each file in the list will be compiled. If, for example, the first file to be processed is program.c, the shell will expand the cc command line to

   ```
   cc program.c −o program
   ```
3. The :r causes the .c extension to be removed.

Example 9.96

```
(The Command Line)
1   % runit f1 f2 f3 dir2 dir3

(The Script)
    #!/bin/csh −f
    # This script is called runit.
    # It loops through a list of files passed as
    # arguments.

2   foreach arg  ($*)


3      if ( −e $arg ) then
      ...          Program code continues here
       else
       ...         Program code continues here
       endif
4   end
5   echo "Program continues here"
```

EXPLANATION

1. The scriptname is runit; the command line arguments are f1, f2, f3, dir2, and dir3.
2. The $* variable evaluates to a list of all the arguments (positional parameters) passed in at the command line. The foreach command processes, in turn, each of the words in the wordlist, f1, f2, f3, dir2, and dir3. Each time through the loop, the first word in the list is assigned to the variable arg. After a word is assigned, it is shifted off (to the left) and the

next word is assigned to arg, until the list is empty.

3. The commands in this block are executed for each item in the list until the end statement is reached.
4. The end statement terminates the loop after the wordlist is empty.
5. After the loop ends, the program continues to run.

The while Loop. The while loop evaluates an expression, and as long as the expression is true (nonzero), the commands below the while command will be executed until the end statement is reached. Control will then return to the while expression, the expression will be evaluated, and if still true, the commands will be executed again, and so on. When the while expression is false, the loop ends and control starts after the end statement.

Example 9.97

```
(The Script)
    #!/bin/csh -f
1   set num = 0
2   while ($num < 10)
3      echo $num
4      @ num++        # See arithmetic.
5   end
6   echo "Program continues here"
```

EXPLANATION

1. The variable num is set to an initial value of zero.
2. The while loop is entered and the expression is tested. If the value of num is less than 10, the expression is true, and lines 3 and 4 are executed.
3. The value of num is displayed each time through the loop.
4. The value of the variable num is incremented. If this statement were omitted, the loop would continue forever.
5. The end statement terminates the block of executable statements. When this line is reached, control is returned to the top of the while loop and the expression is evaluated again. This continues until the while expression is false (i.e., when $num is 10).
6. Program execution continues here after the loop terminates.

Example 9.98

```
(The Script)
    #!/bin/csh -f
1   echo -n  "Who wrote \"War and Peace\"?"
2   set answer = $<
3   while ("$answer" != "Tolstoy")
       echo "Wrong, try again\!"
4      set answer = $<
5   end
6   echo Yeah!
```

EXPLANATION

1. The user is asked for input.
2. The variable answer is assigned whatever the user inputs.
3. The while command evaluates the expression. If the value of $answer is not equal to the string Tolstoy exactly, the message Wrong, try again! is printed and the program waits for

user input.
4. The variable answer is assigned the new input. This line is important. If the value of the variable answer never changes, the loop expression will never become false, thus causing the loop to spin infinitely.
5. The end statement terminates the block of code inside the while loop.
6. If the user enters Tolstoy, the loop expression tests false, and control goes to this line. Yeah! is printed.

The repeat Command. The repeat command takes two arguments, a number and a command. The command is executed that number of times.

Example 9.99

```
% repeat 3 echo hello
hello
hello
hello
```

EXPLANATION

The echo command is executed three times.

9.2.8 Looping Commands

The shift Command. The shift command, without an array name as its argument, shifts the argv array by one word from the left, thereby decreasing the size of the argv array by one. Once shifted off, the array element is lost.

Example 9.100

```
(The Script)
    #!/bin/csh -f
    # Script is called loop.args
1   while ($#argv)
2      echo $argv
3      shift
4   end

(The Command Line)
5   % loop.args a b c d e
    a b c d e
    b c d e
    c d e
    d e
    e
```

EXPLANATION

1. $#argv evaluates to the number of command line arguments. If there are five command line arguments, a, b, c, d, and e, the value of $#argv is 5 the first time in the loop. The expression is tested and yields 5, true.
2. The command line arguments are printed.
3. The argv array is shifted one to the left. There are only four arguments left, starting with b.

4. The end of the loop is reached, and control goes back to the top of the loop. The expression is reevaluated. This time, $#argv is 4. The arguments are printed, and the array is shifted again. This goes on until all of the arguments are shifted off. At that time, when the expression is evaluated, it will be 0, which is false, and the loop exits.
5. The arguments a, b, c, d, and e are passed to the script via the argv array.

The break Command. The break command is used to break out of a loop so that control starts after the end statement. It breaks out of the innermost loop. Execution continues after the end statement of the loop.

Example 9.101

```
    #!/bin/csh -f
    # This script is called baseball
1   echo -n "What baseball hero died in August 1995? "
2   set answer = $<
3   while ("$answer" !~ [Mm]*)
4           echo "Wrong\! Try again."
            set answer = $<
5           if ( "$answer" =~  [Mm]* ) break
6   end
7   echo "You are a scholar."
```

EXPLANATION

1. The user is asked for input.
2. The input from the user is assigned to the variable answer (answer: Mickey Mantle).
3. The while expression reads: While the value of answer does not begin with a big M or little m, followed by zero or more of any character, enter the loop.
4. The user gets to try again. The variable is reset.
5. If the variable answer matches M or m, break out of the loop. Go to the end statement and start executing statements at line 7.
6. The end statement terminates this block of statements after the loop.
7. After the loop exits, control starts here and this line is executed.

Example 9.102

```
    #!/bin/csh −f
    # This script is called database
1   while (1)
       echo "Select a menu item"
2      cat << EOF
       1) Append
       2) Delete
       3) Update
       4) Exit
    EOF
3      set choice = $<
4      switch ($choice)
       case 1:
              echo "Appending"
5             break           # Break out of loop; not a breaksw
       case 2:
              echo "Deleting"
              break
       case 3:
              echo "Updating"
              break
```

```
        case 4:
                exit 0
        default:
6               echo "Invalid choice. Try again.
       endsw
7   end
8   echo "Program continues here"
```

EXPLANATION

1. This is called an infinite loop. The expression always evaluates to one, which is true.
2. This is a here document. A menu is printed to the screen.
3. The user selects a menu item.
4. The switch command evaluates the variable.
5. If the user selects a valid choice, between 1 and 4, the command after the appropriate matching case label is executed. The break statement causes the program to break out of the loop and start execution on line 8. Don't confuse this with the breaksw statement, which merely exits the switch at endsw.
6. If the default case is matched, that is, none of the cases are matched, program control goes to the end of the loop and then starts again at the top of the while. Since the expression after the while always evaluates true, the body of the loop is entered and the menu is displayed again.
7. End of the while loop statements.
8. After the loop is exited, this line is executed.

Nested Loops and the repeat Command. Rather than a goto, the repeat command can be used to break out of nested loops. The repeat command will not do this with the continue command.

Example 9.103

```
(Simple Script)
   #!/bin/csh -f
1  while (1)
      echo "Hello, in 1st loop"
2     while (1)
            echo "In 2nd loop"
            while (1)
               echo "In 3rd loop"
               repeat 3 break
            end
      end
   end
5  echo "Out of all loops"
```

```
(The Output)
Hello, in 1st loop
In 2nd loop
In 3rd loop
Out of all loops
```

EXPLANATION

1. Start the first while loop.
2. Enter the second nested while loop.

3. Enter the third nested while loop.
4. The repeat command will cause break to be executed three times; it will break first out of this innermost loop, then the second loop, and last, the first loop. Control continues at line 5.
5. Program control starts here after loop terminates.

The continue Command. The continue statement starts execution at the top of the innermost loop.

Example 9.104

```
1   set done = 0
2   while ( ! $done )
        echo "Are you finished yet?"
        set answer = $<
3       if ("$answer" =~ [Nn]*) continue
4       set done = 1
5   end
```

EXPLANATION

1. The variable done is assigned zero.
2. The expression is tested. It reads: while (! 0). Not 0 is evaluated as true (logical not).
3. If the user entered No, no, or nope (anything starting with N or n), the expression is true and the continue statement returns control to the top of the loop where the expression is reevaluated.
4. If answer does not start with N or n, the variable done is reset to one. When the end of the loop is reached, control starts at the top of the loop and the expression is tested. It reads: while (! 1). Not 1 is false. The loop exits.
5. This marks the end of the while loop.

Example 9.105

```
(The Script)
    #!/bin/csh -f
1   if ( ! -e memo ) then
        echo  "memo file non existent"
        exit 1
    endif
2   foreach person (anish bob don karl jaye)
3       if ("$person" =~ [Kk]arl) continue
4       mail -s "Party time"  $person < memo
    end
```

EXPLANATION

1. A file check is done. If the file memo does not exist, the user is sent an error message and the program exits with a status of 1.
2. The loop will assign each person in the list to the variable person, in turn, and then shift off the name in the list to process the next one.
3. If the person's name is Karl or karl, the continue statement starts execution at the top of the foreach loop (Karl is not sent the memo because his name was shifted off after being assigned to person). The next name in the list is assigned to person.
4. Everyone on the mailing list is sent the memo, except karl.

9.2.9 Interrupt Handling

If a script is interrupted with the Interrupt key, it terminates and control is returned to the C shell, that is, you get your prompt back. The onintr command is used to process interrupts within a script. It allows you to ignore the interrupt (^C) or transfer control to another part of the program before exiting. Normally, the interrupt command is used with a label to "clean up" before exiting. The onintr command without arguments restores the default action.

Example 9.106

```
(The Script)
1   onintr  finish
2      < Script continues here >
3   finish:
4   onintr –        # Disable further interrupts
5   echo Cleaning temp files
6   rm $$tmp* ; exit 1
```

EXPLANATION

1. The onintr command is followed by a label name. The label finish is a user−defined label; control will be transferred to the finish label if an interrupt occurs. Usually this line is at the beginning of the script. It is not in effect until it is executed in the script.
2. The rest of the script lines are executed unless ^C (Interrupt key) is pressed while the program is in execution, at which time, control is transferred to the label.
3. This is the label; when the interrupt comes in, the program will continue to run, executing the statements below the label.
4. To shield this part of the script from interrupts, the onintr – is used. If Control−C is entered now, it will be ignored.
5. This line is echoed to the screen.
6. All tmp files are removed. The tmp files are prefixed with the shell's PID ($$) number and suffixed with any number of characters. The program exits with a status of 1.

9.2.10 setuid Scripts

Whoever runs a setuid program temporarily (as long as he or she is running the setuid program) becomes the owner of that program and has the same permissions as the owner. The passwd program is a good example of a setuid program. When you change your password, you temporarily become root, but only during the execution of the passwd program. That is why you are able to change your password in the /etc/passwd (or /etc/shadow) file, which normally is off−limits to regular users.

Shell programs can be written as setuid programs. You might want to do this if you have a script that is accessing a file containing information that should not be accessible to regular users, such as salary or personal information. If the script is a setuid script, the person running the script can have access to the data, but it is still restricted from others. A setuid program requires the following steps:

1. In the script, the first line is

   ```
       #!/bin/csh –feb

   The –feb options:
       –f   fast start up; don't execute .cshrc
       –e  abort immediately if interrupted
       –b  this is a setuid script
   ```

2. Next, change the permissions on the script so that it can run as a setuid program:

```
% chmod 4755 script_name
            or
% chmod +srx script_name
% ls –l
–rwsr–xr–x   2 ellie         512 Oct 10 17:18 script_name
```

9.2.11 Storing Scripts

After creating successful scripts, it is customary to collect them in a common script directory and change your path so that the scripts can be executed from any location.

Example 9.107

```
1   % mkdir ~/bin
2   % mv myscript ~/bin
3   % vi .login

    In .login reset the path to add ~/bin.
4      set path = ( /usr/ucb /usr /usr/etc ~/bin . )
5   (At command line)
    % source .login
```

EXPLANATION

1. Make a directory under your home directory called bin, or any other name you choose.
2. Move any error−free scripts into the bin directory. Putting buggy scripts here will just cause problems.
3. Go into your .login file and reset the path.
4. The new path contains the directory ~/bin, which is where the shell will look for executable programs. Since it is near the end of the path, a system program that may have the same name as one of your scripts will be executed first.
5. By sourcing the .login, the path changes are affected; it is not necessary to log out and back in again.

9.2.12 Built−In Commands

Rather than residing on disk like UNIX commands, built−in commands are part of the C shell's internal code and are executed from within the shell. If a built−in command occurs as any component of a pipeline except the last, it is executed in a subshell. See Table 9.16 for a list of built−in commands.

Table 9.16. Built−In Commands and Their Meanings

Built−In Command Meaning:Interpret null command, but perform no action.aliasA nickname for a command.bg [%job]Run the current or specified jobs in the background.breakBreak out of the innermost foreach or while loop.breakswBreak from a switch, resuming after the endsw.case label:A label in a switch statement.cd [dir] chdir [dir]Change the shell's working directory to dir. If no argument is given, change to the home directory of the user.continueContinue execution of the nearest enclosing while or foreach.default:Label the default case in a switch statement. The default should come after all case labels.dirs [–l]Print the directory stack, most recent to the left; the first directory shown is the current directory. With the –l argument, produce an unabbreviated printout; use of the ~ notation is suppressed.echo [–n] listWrite the words in list to the shell's standard output, separated by space characters. The output is terminated with a newline unless the –n option is used.eval commandRun command as standard input to the shell and execute the resulting commands. This is usually used to execute commands generated as the result of command or variable substitution, since parsing occurs before these substitutions (e.g., eval 'tset −s options').exec commandExecute command in place of the current shell, which terminates.exit [(expr)]Exit the shell, either with the value of the status variable or with the value specified by expr.fg [% job]Bring the current or specified job into the foreground.foreach var (wordlist)See "The foreach Loop" on page 412.glob wordlistPerform filename expansion on wordlist. Like echo, but no escapes (\) are recognized. Words are delimited by null characters in the output.goto labelSee "The goto" on page 405.hashstatPrint a statistics line indicating how effective the internal hash table has been at locating commands (and avoiding execs). An exec is attempted for each component of the path where the hash function indicates a possible hit, and in each component that does not begin with a backslash.history [–hr] [n]Display the history list; if n is given, display only the n most recent events.–rReverse the order of the printout to be most recent first rather than oldest first.–hDisplay the history list without leading numbers. This is used to produce files suitable for sourcing using the –h option to source.if (expr)See "Flow Control and Conditional Constructs".else if (expr2) thenSee "Flow Control and Conditional Constructs".jobs [–l]List the active jobs under job control.–lList IDs in addition to the normal information.kill [–sig] [pid] [%job] … kill –lSend the TERM (terminate) signal, by default or by the signal specified, to the specified ID, the job indicated, or the current job. Signals are given either by number or name. There is no default. Typing kill does not send a signal to the current job. If the signal being sent is TERM (terminate) or HUP (hangup), then the job or process is sent a CONT (continue) signal as well.–lList the signal names that can be sent.limit [–h] [resource max–use]]Limit the consumption by the current process or any process it spawns, each not to exceed max–use on the specified resource. If max–use is omitted, print the current limit; if resource is omitted, display all limits.–hUse hard limits instead of the current limits. Hard limits impose a ceiling on the values of the current limits. Only the superuser may raise the hard limits. Resource is one of: cputime, maximum CPU seconds per process; filesize, largest single file allowed; datasize, maximum data size (including stack) for the process; stacksize, maximum stack size for the process; coredump, maximum size of a core dump; and descriptors, maximum value for a file descriptor.login [username|–p]Terminate a login shell and invoke login(1). The .logout file is not processed. If username is omitted, login prompts for the name of a user.–pPreserve the current environment (variables).logoutTerminate a login shell.nice [+n|–n] command]Increment the process priority value for the shell or command by n. The higher the priority value, the lower the priority of a process and the slower it runs. If command is omitted, nice increments the value for the current shell. If no increment is specified, nice sets the nice value to 4. The range of nice values is from –20 through 19. Values of n outside this range set the value to the lower or higher boundary, respectively.+nIncrement the process priority value by n.–nDecrement by n. This argument can be used only by the superuser.nohup [command]Run command with HUPs (hangups) ignored. With no arguments, ignore HUPs throughout the remainder of a script.notify [%job]Notify the user asynchronously when the status of the current or of a specified job changes.onintr [– | label]Control the action of the shell on interrupts. With no arguments, onintr restores the default action of the shell on interrupts. (The shell terminates shell scripts and returns to the terminal command input level.) With the minus sign argument, the shell ignores all interrupts. With a label argument, the shell executes a goto label when an interrupt is received or a child process terminates because it was interrupted.popd [+n]Pop the directory stack and cd to the new top directory. The elements of the directory stack are numbered from zero, starting at the top.+nDiscard the nth entry in the stack.pushd [+n | dir]Push a directory onto the directory stack. With no arguments, exchange the top two elements.+nRotate the nth entry to the top of the stack and cd to it.dirPush the current working directory onto the stack and change to dir.rehashRecompute the internal hash table of the contents of directories listed in the path variable to account for new commands added.repeat count commandRepeat command count times.set [var [= value]]See "Variables".setenv [VAR [word]]See "Variables". The most commonly used environment variables, USER, TERM, and PATH, are automatically imported to and exported from the csh variables, user, term, and path; there is no need to use setenv for these. In addition, the shell sets the PWD environment variable from the csh variable cwd whenever the latter changes.shift [variable]The components of argv, or variable, if supplied, are shifted to the left, discarding the first component. It is an error for variable not to be set, or to have a null value.source [–h] nameRead commands from name. Source commands may be nested, but if they are nested too deeply, the shell may run out of file descriptors. An error in a sourced file at any level terminates all nested source commands. Used commonly to reexecute the .login or .cshrc files to ensure variable settings are handled within the current shell, i.e., shell does not create a child shell (fork). Place commands from the filename on the history list without executing them.–hstop [%job] …Stop the current or specified background job.suspendStop the shell in its tracks, much as if it had been sent a stop signal with ^Z. This is most often used to stop shells started by su.switch (string)See "The switch Command" on page 409.time [command]With no argument, print a summary of time used by this C shell and its children. With an optional command, execute command and print a summary of the time it uses.umask [value]Display the file creation mask. With value, set the file creation mask. Value, given in octal, is xored with the permissions of 666 for files and 777 for directories to arrive at the permissions for new files. Permissions cannot be added via umask.unalias patternDiscard aliases that match (filename substitution) pattern. All aliases are removed by unalias.*unhashDisable the internal hash table.unlimit [–h] [resource]Remove a limitation on resource. If no resource is specified, all resource limitations are removed. See the description of the limit command for the list of resource names.–hRemove corresponding hard limits. Only the superuser may do this.unset patternRemove variables whose names match (filename substitution) pattern. All variables are removed by 'unset *'; this has noticeably distasteful side effects.unsetenv variableRemove variable from the environment. Pattern matching, as with unset, is not performed.waitWait for background jobs to finish (or for an interrupt) before prompting.while (expr)See "The while Loop" on page 415.%[job] [&]Bring the current or indicated job to the foreground. With the ampersand, continue running job in the background.@ [var =expr] @ [var[n] =expr]With no arguments, display the values for all shell variables. With arguments, the variable var, or the nth word in the value of var, is set to the value that expr evaluates to.

C SHELL LAB EXERCISES

Lab 19: Getting Started

1: What does the init process do?

2: What is the function of the login process?

3: How do you know what shell you are using?

4: How can you change your login shell?

5: Explain the difference between the .cshrc and .login files. Which one is executed first?

6: Edit your .cshrc file as follows:

a. Create three of your own aliases.
b. Reset your prompt.

Set the following variables and put a comment after each variable explaining what it does:

```
noclobber    # Protects clobbering files from redirection overwriting
history
ignoreeof
savehist
```

```
filec
```

7: Type the following:

```
source .cshrc
```

What does the source command do?

8: Edit your .login file as follows:

a. Welcome the user.
b. Add your home directory to the path if it is not there.
c. Source the login file.

9: Type history. What is the output?

a. How do you reexecute the last command?
b. Now type: echo a b c

Use the history command to reexecute the echo command with only its last argument, c.

Lab 20: Shell Metacharacters

1: Type at the prompt:

```
touch ab abc a1 a2 a3 all a12 ba ba.1 ba.2 filex filey AbC ABC
ABc2 abc
```

2: Write and test the command that will do the following:

a. List all files starting with a.
b. List all files ending in at least one digit.
c. List all files starting with an a or A.
d. List all files ending in a period, followed by a digit.
e. List all files containing just two of the letter a.
f. List three character files where all letters are uppercase.
g. List files ending in 11 or 12.
h. List files ending in x or y.
i. List all files ending in a digit, an uppercase letter, or a lowercase letter.
j. List all files containing a b.
k. Remove two character files starting with a.

Lab 21: Redirection

1: What are the names of the three file streams associated with your terminal?

2: What is a file descriptor?

3: What command would you use to do the following:

a. Redirect the output of the ls command to a file called lsfile?
b. Redirect and append the output of the date command to lsfile?
c. Redirect the output of the who command to lsfile? What happened?

4: What happens when you type cp all by itself?

a. How do you save the error message from the above example to a file?

5: Use the find command to find all files, starting from the parent directory, and of type directory. Save the standard output in a file called found and any errors in a file called found.errs.

6: What is noclobber? How do you override it?

7: Take the output of three commands and redirect the output to a file called gotemail.

8: Use a pipe(s) with the ps and wc commands to find out how many processes you are currently running.

Lab 22: First Script

1: Write a script called greetme that will do the following:

a. Greet the user.
b. Print the date and time.
c. Print a calendar for this month.
d. Print the name of your machine.
e. Print a list of all files in your parent directory.
f. Print all the processes you are running.
g. Print the value of the TERM, PATH, and HOME variables.
h. Print Please couldn't you loan me $50.00?
i. Tell the user Good bye and the current hour. (See man pages for the date command.)

2: Make sure your script is executable.

```
chmod +x greetme
```

3: What was the first line of your script?

Lab 23: Getting User Input

1: Write a script called nosy that will do the following:

a. Ask the user's full name—first, last, and middle name.
b. Greet the user by his or her first name.

c. Ask the user's year of birth and calculate the user's age.
d. Ask the user's login name and print user's ID (from /etc/passwd).
e. Tell the user his or her home directory.
f. Show the user the processes he or she is running.
g. Tell the user the day of the week, and the current time in nonmilitary time.

The output should resemble the following:

The day of the week is Tuesday and the current time is 04:07:38 PM.

2: Create a text file called datafile (unless this file has already been provided for you.)

Each entry consists of fields separated by colons. The fields are:

a. First and last name
b. Phone number
c. Address
d. Birth date
e. Salary

3: Create a script called lookup that will do the following:

a. Contain a comment section with the scriptname, your name, the date, and the reason for writing this script. The reason for writing this script is to display the datafile in sorted order.
b. Sort the datafile by last names.
c. Show the user the contents of the datafile.
d. Tell the user the number of entries in the file.

4: Try the echo and verbose commands for debugging your script. How did you use these commands?

Lab 24: Command Line Arguments

1: Write a script called rename that will do the following:

a. Take two filenames as command line arguments, the first file is the old file and the second file is the new one.
b. Rename the old filename with the new filename.
c. List the files in the directory to show the change.

2: Write a script called checking that will do the following:

a. Take a command line argument, a user's login name.
b. Test to see if a command line argument was provided.
c. Check to see if the user is in the /etc/passwd file. If so, print the following:

Found <user> in the /etc/passwd file.

Otherwise, print the following:

No such user on our system.

Lab 25: Conditionals and File Testing

1: In the lookup script, ask the user if he or she would like to add an entry to the datafile. If yes or y:

a. Prompt the user for a new name, phone, address, birth date, and salary. Each item will be stored in a separate variable. You will provide the colons between the fields and append the information to the datafile.
b. Sort the file by last names. Tell the user you added the entry, and show the line preceded by the line number.

2: Rewrite checking.

a. After checking whether the named user is in the /etc/passwd file, the program will check to see if he or she is logged on. If so, the program will print all the processes that are running; otherwise it will tell the user the following:

<user> is not logged on."

3: The lookup script depends on the datafile in order to run. In the lookup script, check to see if the datafile exists and if it is readable and writeable.

4: Add a menu to the lookup script to resemble the following:

1. Add entry
2. Delete entry
3. View entry
4. Exit

5: You already have the Add entry part of the script written. The Add entry routine should now include code that will check to see if the name is already in the datafile and if it is, tell the user so. If the name is not there, add the new entry.

6: Now write the code for the Delete entry, View entry, and Exit functions.

7: The Delete part of the script should first check to see if the entry exists before trying to remove it. If the entry does not exist, notify the user; otherwise, remove the entry and tell the user you removed it. On exit, make sure that you use a digit to represent the appropriate exit status.

8: How do you check the exit status from the command line?

Lab 26: The switch Statement

1: Rewrite the following script using a switch statement.

```
#!/bin/csh –f
# Grades program
echo –n "What was your grade on the test? "
set score = $<
if ( $grade >= 90 && $grade <= 100 ) then
    echo You got an A\!
else if ( $grade >= 80 && $grade < 89 ) then
    echo You got a B.
else if ( $grade >= 79 && $grade < 79 ) then
    echo "You're average."
else if ( $grade >= 69 && $grade < 69 ) then
    echo Better study harder
else
    echo Better luck next time.
endif
```

2: Rewrite the lookup script using switch statements for each of the menu items.

Lab 27: Loops

1: Write a program called picnic that will mail a list of users, one at a time, an invitation to a picnic. The list of users will be in a file called friends. One of the users listed in the friends file will be Popeye.

a. The invitation will be in another file, called invite.
b. Use file testing to check that both files exist and are readable.
c. A loop will be used to iterate through the list of users. When Popeye is reached, he will be skipped over (i.e., he does not get an invitation), and the next user on the list sent an invitation, and so forth.
d. Keep a list with the names of each person who received an invitation. Do this by building an array. After everyone on the list has been sent mail, print the number of people who received mail and a list of their names.

Bonus: If you have time, you may want to customize yourinvite file so that each user receives a letter containing his or her name. For example, the message might start:

Dear John,

I hope you can make it to our picnic….

To do this your invite file may be written:

Dear XXX,

I hope you can make it to our picnic….

With sed or awk, you could then substitute XXX with the user name. (It might be tricky putting the capital letter in the user name, since user names are always lowercase.)

2: Add a new menu item to the lookup script to resemble the following:

1. Add entry
2. Delete entry
3. Change entry
4. View entry
5. Exit

After the user has selected a valid entry, when the function has completed, ask the user if he or she would like to see the menu again. If an invalid entry is entered, the program should print the following:

Invalid entry, try again.

The menu will be redisplayed.

3: Create a submenu under View entry in the lookup script. The user will be asked if he would like to view specific information for a selected individual:

a. Phone
b. Address
c. Birth date
d. Salary

4: Add the onintr command to your script using a label. When the program starts execution at the label, any temporary files will be removed, the user will be told Good–bye, and the program will exit.

[1] Do not confuse the search path variable with the cdpath variable set in the cshrc file.

[2] The length of the command line can be 256 characters or more; it can be even higher on different versions of UNIX.

[3] The find syntax requires a semicolon at the end of an exec statmemt. The semicolon is preceded by a backslash to prevent the shell from interpreting it.

[4] Programs such as grep, sed, and awk have a set of metacharacters, called regular expression metacharac−ters, for pattern matching. These should not be confused with shell metacharacters.

[5] [ESC] stands for Escape key.

[6] Another way to read one line of input is `setvariable = 'head −1`'.

[7] Associativity in arithmetic expressions is right to left in cases of equal precedence.

[8] The command's exit status is inverted by the shell so that the expression yields a true or false result.

[9] A common error is to name your script test. If your search path contains the UNIX test command first, itwill execute it. The test command either displays an error or nothing at all if

the syntax is correct.

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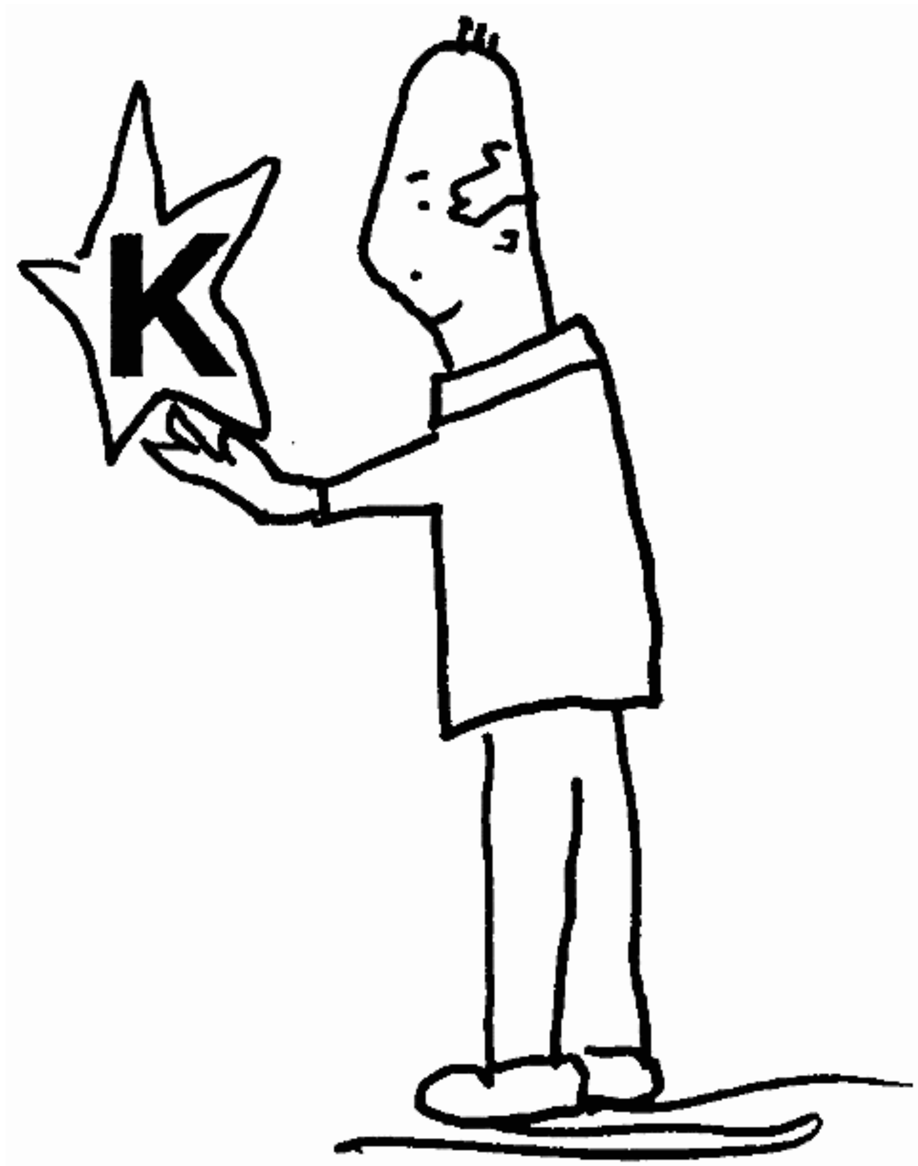
CONTENTS

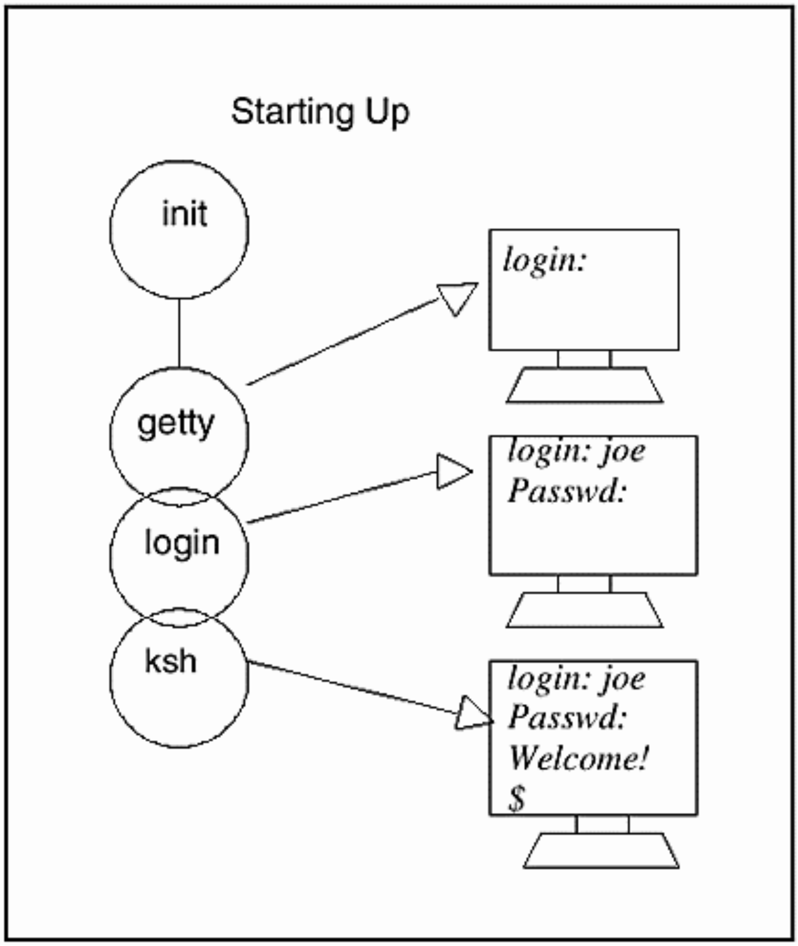
Chapter 10. The Korn Shell



10.1 Interactive Korn Shell

Before the Korn shell displays a prompt, it is preceded by a number of processes. See Figure 10.1.

Figure 10.1. System startup and the Korn shell.



10.1.1 Startup

The first process to run is called init, PID 1. It gets instructions from a file called inittab (System V) or spawns a getty (BSD) process. These processes open up the terminal ports, provide a place where input comes from, stdin, and the place where standard output (stdout) and standard error (stderr) go, and put a login prompt on your screen. The /bin/login program is then executed. The login program prompts you for a password, encrypts and verifies the password, sets up an initial environment, and starts up the login shell, /bin/ksh, the last entry in the passwd file. The ksh program looks for the system file, /etc/profile, and executes its commands. It then looks in the user's home directory for an initialization file called .profile, and an environment file, conventionally called .kshrc. After executing commands from those files, the dollar sign prompt appears on your screen and the Korn shell awaits commands.

10.1.2 The Environment

The Initialization Files. After executing the commands in /etc/profile, the initialization files in the user's home directory are executed. The .profile is executed, followed by the ENV file, commonly called the .kshrc file.

The /etc/profile File. The /etc/profile is a systemwide readable file set up by the system administrator to perform tasks when the user logs on and the Korn shell starts up. It is available to all Bourne and Korn shell users on the system, and normally performs such tasks as checking the mail spooler for new mail and displaying the message of the day from the /etc/motd file. The following text is an example of the /etc/profile. See Chapter 8, "The Interactive Bourne Shell," for a complete explanation of each line of /etc/profile.

```
EXAMPLE
# The profile that all logins get before using their own .profile
    trap " " 2 3
    export LOGNAME PATH  # Initially set by /bin/login
    if [ "$TERM" = " " ]
    then
       if /bin/i386
       then     # Set the terminal type
          TERM=AT386
       else
          TERM=sun
       fi
       export TERM
    fi
    # Login and −su shells get /etc/profile services.
    # −rsh is given its environment in the .profile.
    case "$0" in
    −sh | −ksh | −jsh )
        if [ ! −f .hushlogin ]
        then
          /usr/sbin/quota
       # Allow the user to break the Message−Of−The−Day only.
          trap "trap ' ' 2" 2
          /bin/cat −s /etc/motd
          # Display the message of the day
          trap " " 2
          /bin/mail −E
          case $? in
          0)        # Check for new mail
              echo "You have new mail. "
                   ;;
          2)  echo "You have mail. "
                   ;;
          esac
       fi
    esac
    umask 022
    trap 2 3
```

The .profile File. The .profile file is a user−defined initialization file, that is executed once at login (by the Bourne and Korn shells) and is found in your home directory. It gives you the ability to customize and modify your working environment. Environment variables and terminal settings are normally set here, and if a window application or dbm is to be initiated, it is started here. If the .profile file contains a special variable called ENV, the filename that is assigned to that variable will be executed next. The ENV file is often named .kshrc; it contains aliases and set –o commands. The ENV file is executed every time a ksh subshell is spawned. The lines from the following files may not be meaningful to you now, but all of the concepts, such as exporting variables, history, the search path, and so on, will be discussed in detail throughout the text of this book.

Example 10.1

```
1   set −o allexport
2   TERM=vt102
3   HOSTNAME=$(uname −n)
4   HISTSIZE=50
5   EDITOR=/usr/ucb/vi
6   ENV=$HOME/.kshrc
7   PATH=$HOME/bin:/usr/ucb:/usr/bin:\
    /usr/local:/etc:/bin:/usr/bin:/usr/local\
    /bin:/usr/hosts:/usr/5bin:/usr/etc:/usr/bin:.
```

```
8   PS1="$HOSTNAME ! $ "
9   set +o allexport
10  alias openwin=/usr/openwin/bin/openwin
11  trap '$HOME/.logout' EXIT
12  clear
```

EXPLANATION

1. By setting the allexport option, all variables created will automatically be exported (made available to subshells).
2. The terminal is set to vt102.
3. The variable HOSTNAME is assigned the name of this machine, $(uname –n).
4. The HISTSIZE variable is assigned 50; 50 lines from the history file will be displayed on the terminal when the user types history.
5. The EDITOR variable is assigned the pathname for the vi editor. Programs such as mail allow you to select an editor in which to work.
6. The ENV variable is assigned the path to the home directory ($HOME) and the name of the file that contains further Korn shell customization settings. After the .profile is executed, the ENV file is executed. The name of the ENV file is your choice; it is commonly called .kshrc.
7. The search path is defined. It is a colon−separated list of directories used by the shell in its search for commands typed at the prompt or in a script file. The shell searches each element of the path from left to right for the command. The dot at the end represents the current working directory. If the command cannot be found in any of the listed directories, the shell will look in the current directory.
8. The primary prompt, by default a dollar sign ($), is set to the name of the host machine, the number of the current command in the history file, and a dollar sign ($).
9. The allexport option is turned off.
10. An alias is a nickname for a command. The alias for openwin is assigned the full pathname of the openwin command, which starts Sun's window application.
11. The trap command will execute the .logout file when you exit this shell, that is, when you log out. The .logout file is a user−defined file containing commands that are executed at the time of logging out. For example, you may want to record the time you log out, clean up a temporary file, or simply say So long.
12. The clear command clears the screen.

The ENV File. The ENV variable is assigned the name of a file that will be executed every time an interactive ksh or ksh program (script) is started. The ENV variable is set in the .profile and is assigned the name of the file that will contain special ksh variables and aliases. The name is conventionally .kshrc, but you can call it anything you want. (The ENV file is not processed when the privileged option is on. See Table 10.1.)

Example 10.2

```
1   set −o trackall
2   set −o vi
3   alias l='ls −laF'
    alias ls='ls −aF'
    alias hi='fc −l'
    alias c=clear
4   function pushd { pwd > $HOME/.lastdir.$$ ; }
    function popd { cd $(< $HOME/.lastdir.$$) ;
           rm $HOME/.lastdir.$$; pwd; }
    function psg { ps −ef | egrep $1 | egrep −v egrep; }
    function vg { vgrind −s11 −t $* | lpr −t ; }
```

EXPLANATION

1. The set option for tracked aliases is turned on. (For a complete description, see "Aliases".)
2. The set option for the vi editor is turned on for in−line editing of the history file. (See "Command Line History".)
3. The aliases (nicknames) for the commands are defined.
4. The functions are named and defined. (See "Functions".)

The set –o Options. The set command can take options if the –o switch is used. Options allow you to customize the shell environment. They are either on or off, and are normally set in the ENV file.

FORMAT

```
set −o option  Turns on the option.
set +o option  Turns off the option
set −[a−z] Abbreviation for an option; the minus turns it on
set +[a−z] Abbreviation for an option; the plus turns it off
```

Example 10.3

```
set −o allexport
set +o allexport
set −a
set +a
```

EXPLANATION

1. Sets the allexport option. This option causes all variables to be automatically exported to subshells.
2. Unsets the allexport option. All variables will now be local to the current shell.
3. Sets the allexport option. Same as 1. Not every option has an abbreviation (see Table 10.1).
4. Unsets the allexport option. Same as 2.

Table 10.1. Options

Name of Option	Abbreviation	What It Does
allexport	–a	Causes variables set to be automatically exported.
bgnice		Background jobs are run with a lower priority.
emacs		For command line editing, uses the emacs built−in editor.
errexit	–e	If a command returns a nonzero exit status (fails), executes the ERR trap, if set, and exits. Not set when reading initialization files.
gmacs		For command editing, uses the gmacs built−in editor.
ignoreeof		Prevents logout with ^D; must type exit to exit the shell.
markdirs		Puts a trailing backslash (/) on directory names when filename expansion is used.
monitor	–m	Allows job control.
noclobber		Protects files from being overwritten when redirection is used.
noexec	–n	Reads commands, but does not execute them. Used to check the syntax of scripts. Not on when running interactively.
noglob	–f	Disables pathname expansion; i.e., turns off wildcards.
nolog		Does not store function definitions in the history file.
notify		Notifies user when background job finishes (only in versions newer than 1988).
nounset		Displays an error when expanding a variable that has not been set.
privileged	–p	When set, the shell does not read the .profile or ENV file; used with setuid scripts.
trackall		Enables alias tracking.
verbose	–v	Turns on the verbose mode for debugging.
vi		For command line editing, uses the vi built−in editor.
xtrace	–x	Turns on the echo mode for debugging.

10.1.3 The Prompts

The Korn shell provides four prompts.The primary and secondary prompts are used when the Korn shell is running interactively. You can change these prompts. The variable PS1 is the primary prompt, set initially to a dollar sign ($). It appears when you log on and waits for you to type commands. The variable PS2 is the secondary prompt, initially set to the > character. It appears if you have partially typed a command and then pressed Enter. You can change the primary and secondary prompts.

The Primary Prompt. $ is the default primary prompt. You can change your prompt. Normally, prompts are defined in .profile.

Example 10.4

```
1   $ PS1="$(uname –n) ! $ "
2   jody 1141 $
```

EXPLANATION

1. The default primary prompt is a $. The PS1 prompt is being reset to the name of the machine $(uname –n), the number of the current history number, and the $. The exclamation point evaluates to the current history number. (To print an exclamation point, type two exclamation points (!!) in the PS1 definition.)
2. The new prompt is displayed.

The Secondary Prompt. The PS2 prompt is the secondary prompt. Its value is displayed to standard error (the screen). This prompt appears when you have not completed a command and have pressed the carriage return.

Example 10.5

```
1   $ print "Hello
2   > there"
3   Hello
    there
4   $

5   $ PS2="----> "
6   $ print "Hi
7   ------>
    ------>
    ------> there"
    Hi


    there
    $
```

EXPLANATION

1. The double quotes must be matched after the string "Hello.
2. When a newline is entered, the secondary prompt appears. Until the closing double quotes are entered, the secondary prompt will be displayed.
3. The output of the print command is displayed.
4. The primary prompt is displayed.

5. The secondary prompt is reset.
6. The double quotes must be matched after the string "Hi.
7. When a newline is entered, the new secondary prompt appears. Until the closing double quotes are entered, the secondary prompt will be displayed.

10.1.4 The Search Path

To execute a command typed at the command line or within a shell script, the Korn shell searches the directories listed in the PATH variable. The PATH is a colon−separated list of directories, searched by the shell from left to right. The dot in the PATH represents the current working directory. If the command is not found in any of the directories listed in the path, the shell sends the message ksh: filename: not found to standard error. It is recommended that the path be set in the .profile file. To speed up the searching process, the Korn shell has implemented tracked aliases. See "Tracked Aliases" on page 455.

Example 10.6

```
$ echo $PATH
/home/gsa12/bin:/usr/ucb:/usr/bin:/usr/local/bin:.
```

EXPLANATION

The Korn shell will search for commands starting in /home/gsa12/bin. If the command is not found there, /usr/ucb is searched, then /usr/bin, /usr/local/bin, and finally the user's home directory represented by the period.

The Dot Command. The dot command (.) is a built−in Korn shell command. It takes a scriptname as an argument. The script will be executed in the environment of the current shell. A child process will not be started. The dot command is normally used to reexecute the .profile file or the ENV file, if either of those files has been modified. For example, if one of the settings in either file has been changed after you have logged on, you can use the dot command to reexecute the initialization files without logging out and then logging back in.

Example 10.7

```
$ . .profile
$ . .kshrc
$ . $ENV
```

EXPLANATION

Normally a child process is started when commands are executed. The dot command executes each of the initialization files, .profile, the ENV file (.kshrc), in the current shell. Local and global variables in these files are defined within this shell. Otherwise, the user would have to log out and log back in to cause these files to be executed for the login shell. The dot command makes that unnecessary.

10.1.5 The Command Line

After logging in, the Korn shell displays its primary prompt, a dollar sign by default. The shell is your command interpreter. When the shell is running interactively, it reads commands from the terminal and breaks the command line into words. A command line consists of one or more words (or tokens), separated by whitespace (blanks and/or tabs), and terminated with a newline, generated by pressing Enter. The first word is the command, and subsequent words are the command's arguments. The command may be a UNIX executable program such as ls or pwd, a built−in command such as cd or jobs, or a shell script. The command may contain special characters, called metacharacters, which the shell must interpret while parsing the command line. If a command line is too long, the backslash character, followed by a newline, will allow you to continue typing on the next line. The secondary prompt will appear until the command line is terminated.

The Order of Processing Commands. The first word on the command line is the command to be executed. The command may be a keyword, a special built−in command or utility, a function, a script, or an executable program. The command is executed according to its type in the following order:[1]

1. Keyword (such as if, while, until).
2. Aliases (see typeset –f).
3. Built−in commands.
4. Functions.
5. Scripts and executables.

The special built−in commands and functions are defined within the shell, and therefore are executed from within the current shell, making them much faster in execution. Scripts and executable programs such as ls and pwd are stored on disk, and the shell must locate them within the directory hierarchy by searching the PATH environment variable; the shell then forks a new shell that executes the script. To find out the type of command you are using, use the built−in command, whence –v , or its alias, type. (See Example 10.8.)

Example 10.8

```
$ type print
print is a shell builtin
$ type test
test is a shell builtin
$ type ls
ls is a tracked alias for /usr/bin/ls
$ type type
type is an exported alias for whence −v
$ type bc
bc is /usr/bin/bc
$ type if
if is a keyword
```

The Exit Status. After a command or program terminates, it returns an exit status to the parent process. The exit status is a number between 0 and 255. By convention, when a program exits, if the status returned is zero, the command was successful in its execution. When the exit status is nonzero, the command failed in some way. The Korn shell status variable ? is set to the value of the exit status of the last command that was executed. Success or failure of a program is determined by the programmer who wrote the program. In shell scripts, you can explicitly control the exit status by using the exit command.

Example 10.9

```
1   $ grep "ellie" /etc/passwd
    ellie:GgMyBsSJavd16s:9496:40:Ellie Quigley:/home/jody/ellie
2   $ echo $?
    0

3   $ grep "nicky" /etc/passwd
4   $ echo $?
    1

5   $ grep "scott" /etc/passsswd
```

```
    grep: /etc/passsswd: No such file or directory
6   $ echo $?
    2
```

EXPLANATION

1. The grep program searches for the pattern ellie in the /etc/passwd file and is successful. The line from /etc/passwd is displayed.
2. The ? variable is set to the exit value of the grep command. Zero indicates success.
3. The grep program cannot find user nicky in the /etc/passwd file.
4. If the grep program cannot find the pattern, it returns an exit status of one.
5. The grep fails because the file /etc/passsswd cannot be opened.
6. If grep cannot find the file, it returns an exit status of two.

Multiple Commands and Command Grouping. A command line can consist of multiple commands. Each command is separated by a semicolon, and the command line is terminated with a newline.

Example 10.10

```
$ ls; pwd; date
```

EXPLANATION

The commands are executed from left to right until the newline is reached. Commands may also be grouped so that all of the output is either piped to another command or redirected to a file.

Example 10.11

```
$ ( ls ; pwd; date ) > outputfile
```

EXPLANATION

The output of each of the commands is sent to the file called outputfile.

Conditional Execution of Commands. With conditional execution, two command strings are separated by two special metacharacters, && and ||. The command on the right of either of these metacharacters will or will not be executed based on the exit condition of the command on the left.

Example 10.12

```
$ cc prgm1.c –o prgm1 && prgm1
```

EXPLANATION

If the first command is successful (has a zero exit status), the command after the && is executed.

Example 10.13

```
$ cc prog.c >& err || mail bob < err
```

EXPLANATION

If the first command fails (has a nonzero exit status), the command after the || is executed.

Commands in the Background. Normally, when you execute a command, it runs in the foreground, and the prompt does not reappear until the command has completed execution. It is not always convenient to wait for the command to complete. By placing an ampersand (&) at the end of the command line, the shell will return the shell prompt immediately and execute the command in the background concurrently. You do not have to wait to start up another command. The output from a background job will be sent to the screen as it processes. Therefore, if you intend to run a command in the background, the output of that command should be redirected to a file or piped to another device such as a printer so that the output does not interfere with what you are doing.

Example 10.14

```
1   $ man ksh | lp&
2   [1]     1557
3   $
```

EXPLANATION

1. The output of the manual pages for the Korn shell is piped to the printer. The ampersand at the end of the command line puts the job in the background.
2. Two numbers appear on the screen: the number in square brackets indicates that this is the first job to be placed in the background; the second number is the PID, the process identification number, of this job.
3. The Korn shell prompt appears immediately. While your program is running in the background, the shell is waiting for another command in the foreground.

10.1.6 Command Line History

The history mechanism keeps a numbered record of the commands that you have typed at the command line in a history file. You can recall a command from the history file and reexecute it without retyping the command. The history built−in command displays the history list. The default name for the history file is .sh_history, and it is located in your home directory.

The HISTSIZE variable, accessed when ksh first accesses the history file, specifies how many commands can be accessed from the history file. The default size is 128. The HISTFILE variable specifies the name of the command history file (~/.sh_history is the default) where commands are stored. The history file grows from one login session to the next; it becomes very large unless you clean it out. The history command is a preset alias for the fc –l command.

The history Command/Redisplay Commands. The built−in history command lists previously typed commands preceded by a number. The command can take arguments to control the display.

Example 10.15

```
1   $ history            # Same as fc –l
    1 ls
    2 vi file1
    3 df
    4 ps –eaf
    5 history
    6 more /etc/passwd
```

```
    7 cd
    8 echo $USER
    9 set
    10 history

2   $ history –n         # Print without line numbers
    ls
    vi file1
    df
    ps –eaf
    history
    more /etc/passwd
    cd
    echo $USER
    set
    history
    history –n

3   $ history 8          # List from 8th command to present
    8   echo $USER
    9   set
    10  history
    11  history –n
    12  history 8

4   $ history –3         # List this command and the 3 preceding it
    10  history
    11  history –n
    12  history 8
    13  history –3

5   $ history –1 –5      # List last 5 commands, preceding this one
    13  history –3       # in reversed order.
    12  history 8
    11  history –n
    10  history
    9   set

6   $ history –5 –1      # Print last 5 commands, preceding this one
    10  history          # in order.
    11  history –n
    12  history 8
    13  history –3
    14  history –1 –5

7   $ history            # (Different history list)
    78  date
    79  ls
    80  who
    81  echo hi
    82  history

8   $ history ls echo     # Display from most recent ls command to
    79  ls                # most recent echo command.
    80  who
    81  echo hi

9   $ history –r ls echo      # –r reverses the list
    81  echo hi
    80  who
    79  ls
```

EXPLANATION

Reexecuting Commands with the r Command. The r command redoes the last command typed at the command line. If the r command is followed by a space and a number, the command at that number is reexecuted. If the r command is followed by a space and a letter, the last command that began with that letter is executed. Without any arguments, the r command reexecutes the most previous command on the history list.

Example 10.16

```
1   $ r date
    date
    Mon Feb 15 12:27:35 PST 2001

2   $ r 3   redo command number 3
    df
    Filesystem   kbytes     used      avail     capacity    Mounted on
    /dev/sd0a    7735       6282      680       90%         /
    /dev/sd0g    144613     131183    0         101%        /usr
    /dev/sd2c    388998     211395    138704    60%         /home.

3   $ r vi         # Redo the last command that began with pattern vi.
4   $ r vi file1=file2    # Redo last command that began with vi
                          # and substitute the first occurrence of
                          # file1 with file2.
```

EXPLANATION

1. The last command, date, is reexecuted.
2. The third command in the history file is executed.
3. The last command, starting with the string vi, is executed.
4. The string file1 is replaced with the string file2. The last command, vi file1, is replaced with vi file2.

Command Line Editing. The Korn shell provides two built−in editors, emacs and vi, that allow you to interactively edit your history list. To enable the vi editor, add the set command listed below and put this line in your .profile file. The emacs built−in editor works on lines in the history file one line at a time, whereas the vi built−in editor works on commands consisting of more than one line. To set vi, type

```
set –o vi

  or

VISUAL=vi

  or

EDITOR=/usr/bin/vi
```

If using emacs, type

```
set –o emacs

   or

VISUAL=emacs

   or
```

```
EDITOR=/usr/bin/emacs
```

Note that set –o vi overrides VISUAL, and VISUAL overrides EDITOR.

The vi Built−In Editor. To edit the history list, press the Esc key and use the standard keys that you would use in vi for moving up and down, left and right, deleting, inserting, and changing text. See Table 10.2. After making the edit, press the Enter key. The command will be executed and added to the bottom of the history list. To scroll upward in the history file, press the Esc key and then the K key.

Table 10.2. vi Commands

Command Function Moving Through the History FileEsc k or +Move up the history list.Esc j or −Move down the history list.GMove to first line in history file.5GMove to fifth command in history file for string./stringSearch upward through history file.?String search downward through history file. Moving Around on a LinehMove left on a line.lMove right on a line.bMove backward a word.e or wMove forward a word.^ or 0Move to beginning of first character on the line.$Move to end of line. Editing with via AAppend text.i IInsert text. Editing with vidd dw xDelete text into a buffer (line, word, or character).cc CChange text.u UUndo.yy YYank (copy a line into buffer).p PPut yanked or deleted line down below or above the line.r RReplace a letter or any amount of text on a line.

The emacs Built−In Editor. To start moving backward through the history file, press ^P. To move forward, press ^N . Use emacs editing commands to change or correct text, then press Enter and the command will be reexecuted. See Table 10.3.

Table 10.3. emacs Commands

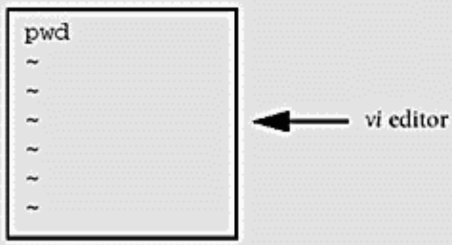
Command Function Moving Through the History FileCtrl−PMove up history file.Ctrl−NMove down history file.Ctrl−BMove backward one character.Ctrl−RSearch backwards for string.Esc BMove back one word.Ctrl−FMove forward one character.Esc FMove forward one word.Ctrl−AMove to the beginning of the line.Ctrl−EMove to the end of the line.Esc <Move to the first line of the history file.Esc >Move to the last line of the history file. Editing with emacsCtrl−UDelete the line.Ctrl−YPut the line back.Ctrl−KDelete from cursor to the end line.Ctrl−DDelete a letter.Esc DDelete one word forward.Esc HDelete one word backward.Esc spaceSet a mark at cursor position.Ctrl−X Ctrl−XExchange cursor and mark.Ctrl−P Ctrl−YPush region from cursor to mark into a buffer (Ctrl−P) and put it down (Ctrl−Y).

FCEDIT[2] and Editing Commands. The fc command is a built−in command that can be used with the FCEDIT variable (typically set in the .profile file) to invoke the editor of your choice for editing the history file. This can be any editor on your system. The FCEDIT variable is set to the full pathname of your favorite editor. If FCEDIT is not set, the default editor, /bin/ed, is invoked when you type the fc command.

The FCEDIT variable should be set to the chosen editor. You can specify a number of items from the history list that you want to edit. After you edit the commands, the Korn shell will execute the whole file. Any commands that are preceded by a pound sign (#) will be treated as comments and will not be executed. See Table 10.4 for more on commenting and filename expansion.

Example 10.17

```
1   $ FCEDIT=/usr/bin/vi
2   $ pwd
3   $ fc
<Starts up the full-screen vi editor with the pwd command on line 1>
```




```
4   $ history
    1 date
    2 ls -l
    3 echo "hello"
    4 pwd

5   $ fc -3 -1        # Start vi, edit, write/quit, and execute
                      # last 3 commands.
```

EXPLANATION

1. The FCEDIT variable can be assigned the pathname for any of the UNIX text editors you have on your system, such as vi, emacs, textedit, etc. If not set, the ed editor is the default.
2. The pwd command is typed at the command line. It will be placed in the history file.
3. The fc command caused the editor (set in FCEDIT) to be invoked with the last command typed in the editor window. If the user writes and quits the editor, any commands typed there will be executed.
4. The history command lists recently typed commands.
5. The fc command is used to start up the editor with the last three commands from the history file in the editor's buffer.

10.1.7 Commenting and Filename Expansion

Filename expansion is a mechanism that allows the user to type part of a filename and press the escape key to see the rest of the filename(s). In the examples, [Esc] represents the escape key.

Table 10.4. Using the Esc Key and Filename Expansion

Combination Resultcommand [Esc]## precedes command with a #; puts it on the history list commented; command will not be executed.command [Esc]_Underscore inserts the last word of the last command at the cursor position.command [Esc] 2_Inserts the second word of the last command at the cursor position.word[Esc] **replaces the current word with all files matched.word[Esc] \\ replaces the current word with the first filename that starts with the same characters; filename expansion.word[Esc]=Displays all filenames beginning with the same character as the current word and displays them in a numbered list.

Example 10.18

```
    (Press the Esc Key for [Esc].

1   $ ls a[Esc]=
    1) abc
    2) abc1
    3) abc122
    4) abc123
    5) abc2

2   $ ls a[Esc]*
    ls abc abc1 abc122 abc123 abc2
    abc   abc1  abc122 abc123 abc2

3   $ print apples pears peaches
    apples pears peaches

4   $ print [Esc]_
    print peaches
    peaches

5   $ print apples pears peaches plums
   apples pears peaches

6   $ print [Esc]2_
    print pears
    pears
```

EXPLANATION

1. By typing an a, followed by the Esc key and an equal sign (=), all files starting with a are numbered and listed. (The numbers do not really serve any special purpose.)
2. By typing an a, then the Esc key and an asterisk (*), the filenames starting with a are displayed.
3. The print command displays its arguments: apples, pears, and peaches.
4. The Esc key, followed by an underscore (_), is replaced with the last argument.
5. The print command displays its arguments: apples, pears, and peaches.
6. The Esc key, followed by the number 2 and an underscore, is replaced by the second argument. The command (print) is the first argument, starting at word zero.

10.1.8 Aliases

An alias is a Korn shell or user−defined abbreviation for a command. The alias name contains alphanumeric characters. Default aliases are provided by the shell and can be redefined or unset. Unlike the C shell aliases, the Korn shell does not support passing arguments. (If you need to use arguments, see "Functions".)

Aliases can be exported to subshells by storing them in the ENV file. (The commands in the ENV file are executed every time a new shell is spawned.) In the 1988 version of the Korn shell, the –x option allows aliases to be exported to subshells as long as the new shell is not a separate invocation of ksh. Tracked aliases are provided by the Korn shell to speed up the time it takes the shell to search the path. Aliases can alias themselves; that is, they are recursive.

Listing Aliases. The alias built−in command lists all set aliases.

Example 10.19

```
1   $ alias
2   autoload=typeset –fu
3   false=let 0
4   functions=typeset –f
5   hash=alias –t
6   history=fc –l
7   integer=typset –i
8   r=fc –e –
9   stop=kill –STOP
10  suspend=kill –STOP $$
11  true=:
12  type=whence –v
```

EXPLANATION

1. The alias command, without arguments, lists all aliases. This is a list of preset aliases, including those you have set.
2. The autoload alias is used for invoking functions dynamically.
3. The false alias is used in expressions testing for a false condition.
4. The functions alias lists all functions and their definitions.
5. The hash alias lists all tracked aliases.
6. The history alias lists all commands in the history file, .sh_history, preceded by a number.
7. The integer alias allows you to create integer−type variables.
8. The r alias lets you redo a previous command from the history list.
9. The stop alias causes a process to be suspended if a job number or PID is provided to the kill command. The job can be resumed in the foreground by typing fg.
10. The suspend alias suspends the current job by sending the STOP signal and the PID ($$) of this process to the kill command.
11. The true alias is set to the do−nothing command, often used to start an infinite loop.
12. The type alias indicates the type of command you are executing: an alias, a binary executable, and so forth.

Creating an Alias. The user can create aliases in the Korn shell. An alias is a nickname for an existing command or commands. The real command(s) is substituted for the alias when the shell evaluates the command line.

Example 10.20

```
1   $ alias cl='clear'
2   $ alias l='ls –laF'
3   $ alias ls='ls –aF'
4   $ \ls ..
```

EXPLANATION

1. The alias cl is an alias for clear.
2. The alias is l. The letter l is a nickname for the command ls –laF.
3. The alias ls is assigned the command ls –aF.
4. The backslash turns off the meaning of the alias for the execution of this line. The real ls command, not the alias, is executed.

Removing an Alias. The unalias command deletes an alias.

Example 10.21

```
unalias cl
```

EXPLANATION

The alias cl is removed from the list of set aliases.

Tracked Aliases. To reduce the amount of time needed to do a search of the path, the Korn shell creates an alias when a command is first encountered and sets the alias equal to the full pathname of the command. This is called a tracked alias.[3]

The Korn shell has some preset tracked aliases that are defined when it is installed. To use tracked aliases, the set –o trackall command is issued; it is normally set in the ENV file. To see all tracked aliases, type alias –t.

Example 10.22

```
$ alias –t
chmod=/bin/chmod
ls=/bin/ls
vi=/usr/ucb/vi
who=/bin/who
```

EXPLANATION

The –t option to the built−in alias command displays those commands that have been aliased via the tracking mechanism. When the user types any of these commands, the shell will not search the path, but use the alias definition to invoke the command.

10.1.9 Job Control

Job control is used to control the execution of background and foreground jobs.

To use Korn shell job control, the monitor option (set –o monitor) must be set on systems that do not support job control. See Table 10.5 for job control commands.

Example 10.23

```
1   $ vi
    [1]  + Stopped           # vi

2   $ sleep 25&
    [2] 4538


3   $ jobs
    [2] +  Running           # sleep 25&
    [1] –  Stopped           # vi

4   $ jobs –l
    [2] + 4538   Running     # sleep 25&
    [1] – 4537   Stopped     # vi

5   $ fg %1
```

EXPLANATION

1. After the vi editor is invoked, you can press ^Z (Control−Z) to suspend the vi session. The editor will be suspended in the background, and after the message Stopped appears, the shell prompt will appear immediately.
2. The ampersand at the end of the command causes the sleep command, with an argument of 25, to execute in the background. The notation [2] means that this is the second job to be run in the background and the PID of this job is 4538.
3. The jobs command displays the jobs currently in the background.
4. The jobs command with the –l option displays the processes (jobs) running in the background and the PID numbers of those jobs.
5. The fg command followed by a percent sign and the job number will bring that numbererd job into the foreground. Without a number, fg brings the most recently backgrounded job back into the foreground.

Table 10.5. Job Control Commands

Command MeaningjobsLists all unfinished processes in a numerically ordered list where the number of the job is enclosed in brackets.jobs –lSame as jobs, but includes the PID number of the job.^ZStops the current job.fg %nRuns background job in foreground.bg %nRuns job in background.wait %nWaits for job number n to finish.kill %nKills job number n.

10.1.10 Metacharacters

Metacharacters are special characters used to represent something other than themselves. Table 10.6 lists some common Korn shell metacharacters and their functions.

Table 10.6. Shell Metacharacters

Command Function\Literal interpretation of the following character.&Background processing.;Command separator.$Variable substitution.?Match for a single character.[abc]Match for one from a set of characters.[!abc]Match for one not from the set of characters.*Match for zero or more characters.(cmds)Execute commands in a subshell.{cmds}Execute commands in current shell.

Example 10.24

```
1   $ ls −d *    all files are displayed
    abc   abc122   abc2  file1.bak file2.bak nonsense  nothing one
    abc1 abc123   file1   file2   none    noone

2   $ print hello \     # The carriage return is escaped
    > there
    hello there

3   $ rusers&           # Process the rusers command in the background
    [1]   4334
    $

4   $ who; date; uptime     # Commands are executed one at a time
    ellie  console Feb 10 10:46
```

```
    ellie  ttyp0   Feb 15 12:41
    ellie  ttyp1   Feb 10 10:47
    ellie  ttyp2   Feb 5  10:53
    Mon Feb 15 17:16:43 PST 2001
    5:16pm up 5 days, 6:32, 1 user, load average: 0.28, 0.23, 0.01

5   $ print $HOME       # The value of the HOME variable is printed
    /home/jody/ellie

6   $ print $LOGNAME  # The value of the LOGNAME variable is printed
    ellie

7   $ ( pwd; cd / ; pwd )
    /home/jody/ellie
    /
    $ pwd
    /home/jody/ellie

8   $ { pwd; cd /; pwd; }
    /home/jody/ellie
    /
    $ pwd
    /

9   $ ( date; pwd; ls ) > outfile
    $ cat outfile
    Mon Feb 15 15:56:34 PDT 2001
    /home/jody/ellie
    foo1
    foo2
    foo3
```

EXPLANATION

1. The asterisk matches all the files in the current directory. (The –d option to the ls command prevents the contents of subdirectories from being displayed.)
2. The backslash escapes the newline so that the command line can be continued on the next line.
3. The ampersand (&) causes the rusers program to be executed in the background; the shell prompt returns immediately. Both processes will run concurrently.
4. Each command is separated by a semicolon. Each command will be executed one at a time.
5. If a dollar sign precedes the variable, the shell will perform variable substitution. The value of the env variable, HOME, is displayed. The HOME variable contains the full pathname of the user's home directory.
6. Again, the dollar sign precedes the variable name. The value of the LOGNAME variable is the user's login name.
7. The parentheses indicate that the enclosed commands will be executed in a subshell. The cd command is built into the shell, so that each shell that is invoked has its own copy of cd. The pwd command prints the present working directory, /home/jody/ellie. After cding to the root directory, the pwd command displays that the new directory is root. After the subshell exits, the output of the pwd command in the parent shell indicates that the directory is still set to /home/jody/ellie as it was before entering the subshell.
8. The curly braces indicate that the enclosed commands will be executed in the current shell. The pwd command prints the present working directory, /home/jody/ellie. After cding to the root directory, the pwd command displays that the new directory is root. After

the commands within the curly braces exit, the output of the pwd command indicates that the directory is still set to the root directory.

9. The parentheses are used to group the commands so that the output of all three commands is sent to outfile.

10.1.11 Filename Substitution (Wildcards)

When evaluating the command line, the shell uses metacharacters to abbreviate filenames or pathnames that match a certain set of characters, often called wildcards. The filename substitution metacharacters listed in Table 10.7 are expanded into an alphabetically listed set of filenames. The process of expanding a metacharacter into filenames is also called filename substitution, or globbing. If a metacharacter is used and there is no filename that matches it, the Korn shell treats the metacharacter as a literal character.

Table 10.7. Shell Metacharacters and Filename Substitution

Metacharacter Meaning*Matches zero or more characters.?Matches exactly one character.[abc]Matches one character in the set, a, b, or c.[a–z]Matches one character in the range: any character in the set between a and z.~Substitutes the user's home directory for ~.\Escapes or disables the metacharacter.

The Asterisk. The asterisk is a wildcard that matches for zero or more of any character in a filename.

Example 10.25

```
1   $ ls *
    abc abc1 abc122 abc123 abc2 file1 file1.bak file2 file2.bak none
    nonsense noone nothing nowhere one

2   $ ls *.bak
    file1.bak file2.bak

3   $ print a*c
    abc
```

EXPLANATION

1. The asterisk expands to all of the files in the present working directory. All of the files are passed to ls and displayed.
2. All files starting with zero or more characters and ending with .bak are matched and listed.
3. All files starting with a, followed by zero or more characters, and ending in c are matched and passed as arguments to the print command.

The Question Mark. The question mark represents a single character in a filename. When a filename contains one or more question marks, the shell performs filename substitution by replacing the question mark with the character it matches in the filename.

Example 10.26

```
1   $ ls
    abc abc1 abc122 abc123 abc2 file1 file1.bak file2 file2.bak
    none nonsense noone nothing nowhere one

2   $ ls a?c?
    abc1 abc2

3   $ ls ??
```

```
    ?? not found

4   $ print abc???
    abc122 abc123

5   $ print ??
    ??
```

EXPLANATION

1. The files in the current directory are listed.
2. Filenames containing four characters are matched and listed if the filename starts with an a, followed by a single character, followed by a c and a single character.
3. Filenames containing exactly two characters are listed. There are none, so the two question marks are treated as literal characters. Since there is no file in the directory called ??, the shell sends the message ?? not found.
4. Filenames containing six characters are matched and printed, starting with abc and followed by exactly three of any character.
5. The ksh print function gets the two question marks as an argument. The shell tries to match for any filenames with exactly two characters. There are no files in the directory that contain exactly two characters. The shell treats the question mark as a literal question mark if it cannot find a match. The two literal question marks are passed as arguments to the print command.

The Square Brackets. Brackets are used to match filenames containing one character from a set or range of characters.

Example 10.27

```
1   $ ls
    abc abc1 abc122 abc123 abc2 file1 file1.bak file2 file2.bak
    none nonsense noone nothing nowhere one
2   $ ls abc[123]
    abc1 abc2

3   $ ls abc[1–3]
    abc1 abc2

4   $ ls [a–z][a–z][a–z]
    abc one

5   $ ls [!f–z]???
    abc1 abc2

6   $ ls abc12[2–3]
    abc122 abc123
```

EXPLANATION

1. All of the files in the present working directory are listed.
2. All four−character names are matched and listed if the filename starts with abc, followed by 1, 2, or 3. Only one character from the set in the brackets is matched for a filename.
3. All four−character filenames are matched and listed if the filename starts with abc, and is followed by a number in the range from 1 to 3.

4. All three−character filenames are matched and listed, if the filename contains exactly three lowercase alphabetic characters.
5. All four−character files are listed if the first character is not a letter between f and z, followed by three of any character (???).
6. Files are listed if the filenames contain abc12, followed by 2 or 3.

Escaping the Metacharacters. To use a metacharacter as a literal character, use the backslash to prevent the metacharacter from being interpreted.

Example 10.28

```
1   $ ls
    abc file1 youx

2   $ print How are you?
    How are youx

3   $ print How are you\?
    How are you?

4   $ print When does this line \
    > ever end\?
    When does this line ever end?
```

EXPLANATION

1. The files in the present working directory are listed. Note the file youx.
2. The shell will perform filename expansion on the question mark. Any files in the current directory starting with y−o−u and followed by exactly one character are matched and substituted in the string. The filename youx will be substituted in the string to read, How are youx (probably not what you wanted to happen).
3. By preceding the question mark (?) with a backslash, it is escaped, meaning that the shell will not try to interpret it as a wildcard.
4. The newline is escaped by preceding it with a backslash. The secondary prompt is displayed until the string is terminated with a newline. The question mark (?) is escaped to protect it from filename expansion.

Tilde and Hyphen Expansion. The tilde character was adopted by the Korn shell (from the C shell) for pathname expansion. The tilde by itself evaluates to the full pathname of the user's home directory. When the tilde is appended with a username, it expands to the full pathname of that user

The hyphen character refers to the previous working directory; OLDPWD also refers to the previous working directory.

Example 10.29

```
1   $ echo ~
    /home/jody/ellie

2   $ echo ~joe
    /home/joe

3   $ echo ~+
    /home/jody/ellie/perl

4   $ echo ~−
```

```
    /home/jody/ellie/prac

5   $ echo $OLDPWD
    /home/jody/ellie/prac

6   $ cd –
    /home/jody/ellie/prac
```

EXPLANATION

1. The tilde evaluates to the full pathname of the user's home directory.
2. The tilde preceding the username evaluates to the full pathname of joe's home directory.
3. The ~+ notation evaluates to the full pathname of the working directory.
4. The ~– notation evaluates to the previous working directory.
5. The OLDPWD variable contains the previous working directory.
6. The hyphen refers to the previous working directory; cd to go to the previous working directory and display the directory.

New ksh Metacharacters. The new Korn shell metacharacters are used for filename expansion in a way that is similar to the regular expression metacharacters of egrep and awk. The metacharacter preceding the characters enclosed in parentheses controls what the pattern matches. See Table 10.8.

Example 10.30

```
1   $ ls
    abc abc1 abc122 abc123 abc2 file1 file1.bak file2 file2.bak none
    nonsense noone nothing nowhere one

2   $ ls abc?(1|2)
    abc  abc1 abc2

3   $ ls abc*([1–5])
    abc   abc1  abc122 abc123 abc2

4   $ ls abc+([1–5])
    abc1  abc122 abc123 abc2

5   $ ls no@(thing|ne)
    none   nothing

6   $ ls no!(one|nsense)
    none  nothing nowhere
```

EXPLANATION

1. All the files in the present working directory are listed.
2. Matches filenames starting with abc and followed by zero characters or one of either of the patterns in parentheses. Matches abc , abc1, or abc2.
3. Matches filenames starting with abc and followed by zero or more numbers between 1 and 5. Matches abc, abc1, abc122, abc123, and abc2.
4. Matches filenames starting with abc and followed by one or more numbers between 1 and 5. Matches abc1, abc122, abc123, and abc2.
5. Matches filenames starting with no and followed by exactly thing or ne. Matches nothing or none.

6. Matches filenames starting with no and followed by anything except one or nsense. Matches none, nothing, and nowhere.

Table 10.8. Regular Expression Wildcards

Regular Expression Meaningabc?(2|9)1? matches zero or one occurrences of any pattern in the parentheses. The vertical bar represents an or condition; e.g., either 2 or 9. Matches abc21, abc91, or abc1.abc*([0–9])* matches zero or more occurrences of any pattern in the parentheses. Matches abc followed by zero or more digits; e.g., abc, abc1234, abc3, abc2, etc.abc+([0–9])+ matches one or more occurrences of any pattern in the parentheses. Matches abc followed by one or more digits; e.g., abc3, abc123, etc.no@(one|ne)@ matches exactly one occurrence of any pattern in the parentheses. Matches noone or none. no!(thing|where)! matches all strings except those matched by any of the pattern in the parentheses. Matches no, nobody, or noone, but not nothing or nowhere.

The noglob Variable. If the noglob variable is set, filename substitution is turned off, meaning that all metacharacters represent themselves; they are not used as wildcards. This can be useful when searching for patterns containing metacharacters in programs like grep, sed, or awk. If noglob is not set, all metacharacters must be escaped with a backslash if they are not to be interpreted.

Example 10.31

```
1   % set −o noglob       # or set −f

2   % print * ?? [] ~ $LOGNAME
    * ?? [] /home/jody/ellie ellie

3   % set +o noglob   # or set +f
```

EXPLANATION

1. The noglob variable is set. It turns off the special meaning of the wildcards for filename expansion. You can use the –f option to set the command to achieve the same results.
2. The filename expansion metacharacters are displayed as themselves without any interpretation. Note that the tilde and the dollar sign are still expanded.
3. The noglob option is reset. Filename metacharacters will be expanded.

10.1.12 Variables

Local Variables. Local variables are given values that are known only to the shell in which they are created. Variable names must begin with an alphabetic or underscore character. The remaining characters can be alphabetic, decimal digits zero to nine, or an underscore character. Any other characters mark the termination of the variable name.

Setting and Referencing Local Variables. When assigning a value to a variable, there can be no whitespace surrounding the equal sign. To set the variable to null, the equal sign is followed by nothing. If more than one word is assigned to a variable, it must be quoted to protect the whitespace; otherwise, the shell prints an error message and the variable is undefined.

If a dollar sign is prepended to the variable name, the value assigned to that variable can be referenced. If other characters are attached to a variable name, curly braces are used to shield the name of the variable from the extra characters.

Example 10.32

```
1   $ state=Cal
    $ echo $state
    Cal
2   $ name="Peter Piper"
    $ echo $name
    Peter Piper

3   $ x=
    $ echo $x
# Blank line appears when a variable is either unset or set to null

    $
4   $ state=Cal
    $ print ${state}ifornia
    California
```

EXPLANATION

1. The variable state is assigned the value Cal . When the shell encounters the dollar sign preceding a variable name, it performs variable substitution. The value of the variable is displayed.
2. The variable name is assigned the value "Peter Piper". The quotes are needed to hide the whitespace so that the shell will not split the string into separate words when it parses the command line. The value of the variable is displayed.
3. The variable x is not assigned a value. It will be assigned a null string. The null value, an empty string, is displayed. The same output would be displayed if the variable had not been set at all.
4. The variable state is assigned the value Cal. The variable is enclosed in curly braces to shield it from the characters that are appended. The value of the variable Cal is displayed with ifornia appended.

The Scope of Local Variables. A local variable is known only to the shell in which it was created. It is not passed on to subshells. The $$ variable is a special variable containing the PID (process identification number) of the current shell.

Example 10.33

```
1   $ echo $$
    1313

2   $ round=world
    $ echo $round
    world

3   $ ksh     # Start a subshell

4   $ echo $$
    1326

5   $ echo $round

6   $ exit       # Exits this shell, returns to parent shell
```

```
7   $ echo $$
    1313

8   $ echo $round
    world
```

EXPLANATION

1. The value of the $$ variable evaluates to the PID of the current shell. The PID of this shell is 1313.
2. The local variable round is assigned the string value world and the value of the variable is displayed.
3. A new Korn shell is invoked. This is called a subshell, or child shell.
4. The PID of this shell is 1326. The parent shell's PID is 1313.
5. The variable round is not defined in this shell.
6. The exit command terminates this shell and returns to the parent shell. If the ignoreeof option is not set, Control−D will also exit this shell.
7. The parent shell returns. Its PID is displayed.
8. The value of the variable is displayed.

Setting Read−Only Variables. A read−only variable cannot be redefined or unset. It can be set with the readonly or typeset –r built−in commands. You may want to set variables to readonly for security reasons when running in privileged mode.

Example 10.34

```
1   $ readonly name=Tom
    $ print $name
    Tom

2   $ unset name
    ksh: name: is read only

3   $ name=Joe
    ksh name: is read only

4   $ typeset −r PATH
    $ PATH=${PATH}:/usr/local/bin
    ksh: PATH: is read only
```

EXPLANATION

1. The readonly local variable name is assigned the value Tom.
2. A readonly variable cannot be unset.
3. A readonly variable cannot be redefined.
4. The PATH variable is set to be readonly. Any effort to unset or change the variable will produce an error message.

Environment Variables. Environment variables are available to the shell in which they are created and any subshells or processes spawned from that shell. By convention, environment variables are capitalized.

The shell in which a variable is created is called the parent shell. If a new shell is started from the parent shell, it is called the child shell. Some of the environment variables, such as HOME, LOGNAME, PATH, and SHELL, are set before you log in by the /bin/login program. Normally, environment variables are set in the .profile file in the user's home directory.

Setting Environment Variables. To set environment variables, the export command is used either after assigning a value or when the variable is set. All variables in a script can be exported by turning on the allexport option to the set command.

Example 10.35

```
1   $ TERM=wyse ; export TERM
2   $ export NAME ="John Smith"
    $ print $NAME
    John Smith
3   $ print $$
    319
4   $ ksh
5   $ print $$
    340
6   $ print $NAME
    John Smith
7   $ NAME="April Jenner"
    $ print $NAME
    April Jenner
8   $ exit
9   $ print $$
    319
10  $ print $NAME
    John Smith
```

EXPLANATION

1. The TERM variable is assigned wyse. The variable is exported. Now processes started from this shell will inherit the variable.
2. The variable is exported and defined in the same step. (New with the Korn shell.)
3. The value of this shell's PID is printed.
4. A new Korn shell is started. The new shell is called the child. The original shell is its parent.
5. The PID of the new Korn shell, stored in the $$ (340) variable, is printed.
6. The variable was exported to the new shell and is displayed.
7. The variable is reset to April Jenner and displayed.
8. This Korn child shell is exited. The parent shell will return.
9. The PID of the parent, 319, is displayed again.
10. The variable NAME contains its original value. Variables retain their values when exported from parent to child. The child cannot change the value of a variable for its parent.

Special Environment Variables. The Korn shell assigns default values to the environment variables, PATH, PS1, PS2, PS3, PS4, MAILCHECK, FCEDIT, TMOUT, and IFS. The SHELL, LOGNAME, USER, and HOME are set by the /bin/login program. You can change the values of the defaults and set the others listed in Table 10.9.

Table 10.9. Korn Shell Environment Variables

Variable Name Meaning_ (underscore)The last argument of the previous command.CDPATHThe search path for the cd command. A colon−separated list of directories used to find a directory if the / , ./, or ../ is not at the beginning of the pathname.COLUMNSIf set, defines the width of the edit window for shell edit modes and the select command.EDITORPathname for a built−in editor: emacs, gmacs, or vi.ENVA variable set to the name of a file, containing functions and aliases, that the Korn shell will invoke when the ksh program is invoked. On versions newer than 1988, this file is only executed when ksh is invoked interactively, not for noninteractive shells. The variable is not expanded if the privileged option is turned on.ERRNOSystem error number. Its value is the error number of the most recently failed system call.FCEDITDefault editor name for the fc command. On versions newer than 1988, this variable is called HISTEDIT, and the fc command is hist.FPATHA colon−separated list of directories that defines the search path for directories containing auto−loaded functions.HISTEDITFor versions of the Korn shell newer than 1988, the new name for FCEDIT.HISTFILESpecifies file in which to store command history.HISTSIZEMaximum number of commands from the history that can be accessed; default is 128.HOMEHome directory; used by cd when no directory is specified.IFSInternal field separators, normally SPACE, TAB, and NEWLINE, used for field splitting of words resulting from command substitution, lists in loop constructs, and reading input.LINENOCurrent line number in script.LINESUsed in select loops for vertically displaying menu items; default is 24.MAILIf this parameter is set to the name of a mail file and the MAILPATH parameter is not set, the shell informs the user of the arrival of mail in the specified file.MAILCHECKThis parameter specifies how often (in seconds) the shell will check for the arrival of mail in the files specified by the MAILPATH or MAIL parameters. The default value is 600 seconds (10 minutes). If set to zero, the shell will check before issuing each primary prompt.MAILPATHA colon−separated list of filenames. If this parameter is set, the shell informs the user of the arrival of mail in any of the specified files. Each filename can be followed by a % and a message that will be printed when the modification time changes. The default message is You have mail.OLDPWDLast working directory.PATHThe search path for commands; a colon−separated list of directories the shell uses to search for the command you want to execute.PWDPresent working directory; set by cd.PPIDProcess ID of the parent process.PS1Primary prompt string, by default $.PS2Secondary prompt string, by default >.PS3Selection prompt string used with the select command, by default #?.PS4Debug prompt string used when tracing is turned on, by default +.RANDOMRandom number generated each time the variable is referenced.REPLYSet when read is not supplied arguments.SHELLWhen the shell is invoked, it scans the environment for this name. The shell gives default values to PATH, PS1, PS2, MAILCHECK, and IFS. HOME and MAIL are set by login.TMOUTSpecifies number of seconds to wait for input before exiting.VISUALSpecifies editor for in−line command editing: emacs, gmacs, or vi.

Listing Set Variables. There are three built−in commands that print the value of variables: set, env, and typeset. The set command prints all variables, local and global. The env command prints only global variables. The typeset command prints all variables, integers, functions, and exported variables. The set −o command prints all options set for the Korn shell.

Example 10.36

```
1   $ env       # Partial list
    LOGNAME=ellie
    TERMCAP=sun-cmd:te=\E[>4h:ti=\E[>4l:tc=sun:
    USER=ellie
    DISPLAY=:0.0
    SHELL=/bin/ksh
    HOME=/home/jody/ellie
    TERM=sun-cmd
    LD_LIBRARY_PATH=/usr/local/OW3/lib
    PWD=/home/jody/ellie/perl

2   $ typeset
    export MANPATH
    export PATH
    integer ERRNO
    export FONTPATH
    integer OPTIND
    function LINENO
```

```
    export OPENWINHOME
    export LOGNAME
    function SECONDS
    integer PPID
    PS3
    PS2
    export TERMCAP
    OPTARG
    export USER
    export DISPLAY
    function RANDOM
    export SHELL
    integer TMOUT
    integer MAILCHECK

3   $ set
    DISPLAY=:0.0
    ERRNO=10
    FCEDIT=/bin/ed
    FMHOME=/usr/local/Frame-2.1X
    FONTPATH=/usr/local/OW3/lib/fonts
    HELPPATH=/usr/local/OW3/lib/locale:/usr/local/OW3/lib/help
    HOME=/home/jody/ellie
    IFS=
    LD_LIBRARY_PATH=/usr/local/OW3/lib
    LINENO=1
    LOGNAME=ellie
    MAILCHECK=600
    MANPATH=/usr/local/OW3/share/man:/usr/local/OW3/man:/
    usr/local/man:/usr/local/doctools/man:/usr/man
    OPTIND=1
    PATH=/home/jody/ellie:/usr/local/OW3/bin:/usr/ucb:/
    usr/local/doctools/bin:/usr/bin:/usr/local:/usr/etc:/etc:/
    usr/spool/news/bin:/home/jody/ellie/bin:/usr/lo
    PID=1332
    PS1=$
    PS2=>
    PS3=#?
    PS4=+
    PWD=/home/jody/ellie/kshprog/joke
    RANDOM=4251
    SECONDS=36
    SHELL=/bin/ksh
    TERM=sun-cmd
    TERMCAP=sun-cmd:te=\E[>4h:ti=\E[>4l:tc=sun:
        TMOUT=0
    USER=ellie
    _=pwd
    name=Joe
    place=San Francisco
    x=

4   set -o
    allexport      off
    bgnice        on
    emacs         off
    errexit       off
    gmacs         off
    ignoreeof     off
    interactive   on
    keyword       off
    markdirs      off
```

```
monitor       on
noexec        off
noclobber     off
noglob        off
nolog         off
nounset       off
privileged    off
restricted    off
trackall      off
verbose       off
viraw         off
xtrace        off
```

EXPLANATION

1. The env command lists all environment (exported) variables. These variables are, by convention, named with uppercase letters. They are passed from the process in which they are created to any of the child processes.
2. The typeset command displays all variables and their attributes, functions, and integers. The typeset command with the + option displays only the names of the variables.
3. The set command, without options, prints all set variables, local and exported, including variables set to null.
4. The set command with the –o option lists all built−in variables that are set to on or off. To turn options off, use the plus sign (+), and to turn options on, use the minus sign (−); for example, set −o allexport turns on the allexport option.

Unsetting Variables. Both local and environment variables can be unset by using the unset command (unless the variables are set to readonly).

Example 10.37

```
unset name; unset TERM
```

EXPLANATION

The variables name and Term are no longer defined for this shell.

Printing the Values of Variables. The echo command (used in Bourne and C shells) is still effective in this shell, but the print command has more options and is more efficient. Both the echo command and print command are built−in to the shell. The print command has a number of options to control its output. They are listed in Table 10.10.

Table 10.10. Print Options

Option Meaning–rPrevents escape sequences.–RPrevents ksh from treating a –2 or –x as a print argument; turns off the dash if preceding an argument (except –n); \t, \c, \c are not recognized as special and appear unchanged when printed without the \.–unRedirects output to file descriptor n.–nNo newline in output; like echo –n.–pSends output to a coprocess or pipe (&|) rather than to standard output.–sOutput is appended to the history file as a command rather than to standard output.–Any arguments that follow are not print options. The dash allows arguments that contain a hyphen, e.g., –2.–fFor versions newer than 1988, used to emulate printf.

Example 10.38

```
1   $ print Hello my friend and neighbor!
    Hello my friend and neighbor!

2   $ print "Hello         friends"
    Hello       friends

3   $ print –r "\n"
    \n

4   $ print −s "date +%H"
    $ history −2
    132 print −s "date +%H"
    133 date +%H
    134 history −2
    $ r 133
    09

5   $ print –n $HOME
    /home/jody/ellie

6   $ var=world
    $ print ${var}wide
    worldwide

7   $ print –x is an option
    ksh: print: bad option(s)

8   $ print  – –x is an option
    –x is an option
```

EXPLANATION

1. The shell parses the command line, breaks the command line into words (tokens) separated by space, and passes the words as arguments to the print command. The shell removes all the extra whitespace between words.
2. The quotes create a single string. The shell evaluates the string as a single word and the whitespace is preserved.
3. This is the raw option. Any escape sequences, such as \r, are not interpreted.
4. The –s option appends the print command's arguments to the history file as a command. The string "date +%H" is the argument to the print command. The date string is appended to the history list as a command and then executed with the r command (history's redo command).
5. The –n option suppresses the newline. The Korn shell prompt is on the same line as the output from the print command.
6. The local variable is assigned the value world. The braces insulate the variable from characters appended to it.
7. When the first argument to the print function begins with a dash, the print command interprets the argument as one of its options, unless an additional preceding dash is provided.
8. The dash as an option allows you to use a dash as the first character in the string to be printed.

Escape Sequences. Escape sequences consist of a character preceded by a backslash and have a special meaning when enclosed within quotes. (See Table 10.11.)

The print command, without the −r and −R options, formats output when any of the following escape sequences are placed within a string. The string must be enclosed in double or single quotes.

Example 10.39

```
1   $ print '\t\t\tHello\n'
           Hello

    $

2   $ print "\aTea \tTime!\n\n"
    Ding ( bell rings ) Tea     Time!
```

EXPLANATION

1. The backslash characters must be quoted with either single or double quotes. The \t escape sequence represents a tab, and \n represents a newline. The output is three tabs, followed by the string Hello, and a newline.
2. The \a escape sequence causes a bell to ring (\07) and the \t creates a tab. The two \n sequences will print two newline characters.

Table 10.11. Escape Sequences

Backslash Character Meaning\aBell character.\bBackspace.\cSuppress newline and ignore any arguments that follow \c.\fFormfeed.\nNewline.\rReturn.\tTab.\vVertical tab.\\Backslash.\0xEight−bit character with a 1−, 2−, or 3−digit ASCII value, as in print \0124.\EOnly on versions newer than 1988; used for an escape sequence.

Variable Expressions and Expansion Modifiers. Variable expressions can be tested and modified by using special modifiers. The modifier provides a shortcut conditional test to check whether a variable has been set, and then, depending on the modifier, may assign a default value to the variable. These expressions can be used with conditional constructs such as if and elif. See Table 10.12.

The colon does not have to be used with the modifier. Using the colon with the modifier checks whether the variable is not set or is null; without the colon, a variable set to null is considered a set variable.

Table 10.12. Variable Expressions and Modifiers

Expression Function ${variable:–word}If variable is set and is nonnull, substitute its value; otherwise, substitute word. ${variable:=word}If variable is not set or is null, set it to word; the value of variable is substituted permanently. Positional parameters may not be assigned in this way.${variable:+word}If variable is set and is nonnull, substitute word; otherwise substitute nothing.${variable:?word}If variable is set and is nonnull, substitute its value; otherwise, print word and exit from the shell. If word is omitted, the message parameter null or not set is printed.

Example 10.40

```
(Using Temporary Default Values)
1   $ fruit=peach
```

```
2   $ print ${fruit:–plum}
    peach

3   $ print ${newfruit:–apple}
    apple

4   $ print $newfruit

5   $ print ${TERM:–vt120}
    sun–cmd
```

EXPLANATION

1. The variable fruit is assigned the value peach.
2. The special modifier will check to see if the variable fruit has been set. If it has, the value peach is printed; if not, plum is printed.
3. The variable newfruit has not been set. The value apple will be printed.
4. The variable newfruit was not set, so nothing prints. In step 3, the expression was simply replaced with the word apple and printed.
5. If the TERM variable has not been set, a default value vt120 will be displayed. In this example, the terminal has already been set to sun–cmd, a Sun workstation.

Example 10.41

```
(Assigning Permanent Default Values)
1   $ name=

2   $ print ${name:=Patty}
    Patty

3   $ print $name
    Patty

4   $ print ${TERM:=vt120}
    vt120

    $ print $TERM
    vt120
```

EXPLANATION

1. The variable name is assigned the value null.
2. The special modifier := will check to see if the variable name has been set to some value other than null. If it has been set, it will not be changed; if it is either null or not set, it will be assigned the value to the right of the equal sign. Patty is assigned to name since the variable is set to null. The setting is permanent.
3. The variable name still contains the value Patty.
4. If the variable TERM is not set, it will be assigned the default value vt120 permanently.

Example 10.42

```
(Assigning Temporary Alternate Value)
1   $ foo=grapes
2   $ print ${foo:+pears}
    pears
    $ print $foo
    grapes
```

EXPLANATION

1. The variable foo has been assigned the value grapes.
2. The special modifier :+ will check to see if the variable has been set. If it has been set, it will temporarily be reset to grapes. If it has not been set, null is returned.

Example 10.43

```
(Creating Error Messages Based on Default Values)
1   $ print ${namex:?"namex is undefined"}
    ksh: namex: namex is undefined

2   $ print ${y?}
    ksh: y: parameter null or not set
```

EXPLANATION

1. The :? modifier will check to see if the variable has been set. If not, the string to the right of the ? is printed to standard error, after the name of the variable. If in a script, the script exits.
2. If a message is not provided after the ?, the Korn shell sends a default message to standard error. Without the colon, the ? modifier would consider a variable set to null a set variable, and the message would not be printed.

Example 10.44

```
(Line from a System Script)
if [ "${uid:=0}" −ne 0 ]
```

EXPLANATION

If the UID (user ID) has a value, it will not be changed; if it does not have a value, it will be assigned the value zero (superuser). The value of the variable will be tested for nonzero. This line was taken from the /etc/shutdown program (SVR4/Solaris 2.5). It is here to give you an example of how variable modifiers are used.

Variable Expansion of Substrings. Pattern matching arguments are used to strip off certain portions of a string from either the front or end of the string. The most common use for these operators is stripping off pathname elements from the head or tail of the path. See Table 10.13.

Table 10.13. Variable Expansion Substrings

Expression	Function
${variable%pattern}	Matches the smallest trailing portion of the value of variable to pattern and removes it.
${variable%%pattern}	Matches the largest trailing portion of the value of variable to pattern and removes it.
${variable#pattern}	Matches the smallest leading portion of the value of variable to pattern and removes it.
${variable##pattern}	Matches the largest leading portion of the value of variable to pattern and removes it.

Example 10.45

```
1   $ pathname="/usr/bin/local/bin"
2   $ print ${pathname%/bin*}
    /usr/bin/local
```

EXPLANATION

1. The local variable pathname is assigned /usr/bin/local/bin.
2. The % removes the smallest trailing portion of pathname containing the pattern /bin, followed by zero or more characters; that is, it strips off /bin.

Example 10.46

```
1   $ pathname="usr/bin/local/bin"
2   $ print ${pathname%%/bin*}
    /usr
```

EXPLANATION

1. The local variable pathname is assigned /usr/bin/local/bin.
2. The %% removes the largest trailing portion of pathname containing the pattern /bin, followed by zero or more characters; that is, it strips off /bin/local/bin

Example 10.47

```
1   $ pathname=/home/lilliput/jake/.cshrc
2   $ print ${pathname#/home}
    /lilliput/jake/.cshrc
```

EXPLANATION

1. The local variable pathname is assigned /home/liliput/jake/.cshrc.
2. The # removes the smallest leading portion of pathname containing the pattern /home; that is, /home is stripped from the beginning of the path variable.

Example 10.48

```
1   $ pathname=/home/liliput/jake/.cshrc
2   $ print ${pathname##*/}
    .cshrc
```

EXPLANATION

1. The local variable pathname is assigned /home/liliput/jake/.cshrc.
2. The ## removes the largest leading portion of pathname containing zero or more characters up to and including the last slash; that is, it strips off /home/lilliput/jake from the path variable.

Variable Attributes: The typeset Command. The attributes of a variable, such as its case, width, and left or right justification, can be controlled by the typeset command. When the typeset command changes the attributes of a variable, the change is permanent. The typeset function has a number of other functions. See Table 10.14.

Example 10.49

```
1   $ typeset –u name="john doe"
    $ print "$name"
    JOHN DOE             # Changes all characters to uppercase.

2   $ typeset –l name
```

```
    $ print $name
    john doe             # Changes all characters to lowercase.

3   $ typeset -L4 name
    $ print $name
    john              # Left-justified fixed-width 4-character field.
4   $ typeset -R2 name
    $ print $name     # Right-justified fixed-width 2-character field.
    hn

5   $ name="John Doe"
    $ typeset -Z15 name        # Null-padded sting, 15-space field.
           width
    $ print "$name"
     John Doe

6   $ typeset -LZ15 name       # Left-justified, 15-space field width.
    $ print "$name$name"
    John Doe       John Doe

7   $ integer n=25
    $ typeset -Z15 n            # Left-justified, zero-padded integer.
    $ print "$n"
    000000000000025

8   $ typeset -lL1 answer=Yes   # Left justify one lowercase letter.
    $ print $answer
    y
```

EXPLANATION

1. The –u option to the typeset command converts all characters in a variable to uppercase.
2. The –l option to the typeset command converts all characters in a variable to lowercase.
3. The –L option to the typeset command converts the variable name to a left−justified, four−character string, john.
4. The –R option to the typeset command converts the variable name to a right−justified, two−character string, hn.
5. The variable name is set to John Doe. The –Z option to the typeset command will convert the string to a null−padded, 15−space string. The variable is quoted to preserve whitespace.
6. The variable name is converted to a left−justified, 15−space, null−padded string.
7. The variable n is an integer (see typeset –i, Table 10.14) assigned the value 25. The typeset command will convert the integer n to a zero−filled, 15−space, left−justified number.
8. The variable answer is assigned the value Yes and converted to a lowercase, left−justified, one−character string. (This can be very useful when handling user input in a script.)

Table 10.14. Other Uses of the typeset Command

Command	**What It Does**
typeset	Displays all variables.
typeset –i num	Will only accept integer values for num.
typeset –x	Displays exported variables.
typeset a b c	If defined in a function, creates a, b, and c to be local variables.
typeset –r x=foo	Sets x to foo and then makes it read−only.

Positional Parameters. Normally, the special built−in variables, often called positional parameters, are used in shell scripts when passing arguments from the command line, or used in functions to hold the value of arguments passed to the function. The variables are called positional parameters because they are referenced by numbers 1, 2, 3, and so on, representing their respective positions in the parameter list. See Table 10.15.

The name of the shell script is stored in the $0 variable. The positional parameters can be set and reset with the set command.

Table 10.15. Positional Parameters

Expression	Function
$0	References the name of the current shell script.
$1–$9	Positional parameters 1–9.
${10}	Positional parameter 10.
$#	Evaluates to the number of positional parameters.
$*	Evaluates to all the positional parameters.
$@	Same as $*, except when double quoted.
"$*"	Evaluates to "$1 $2 $3", etc.
"$@"	Evaluates to "$1" "$2" "$3", etc.

Example 10.50

```
1   $ set tim bill ann fred
    $ print $*           # Prints all the positional parameters.
    tim bill ann fred

2   $ print $1           # Prints the first position.
    tim

3   $ print $2 $3        # Prints the second and third position.
    bill ann

4   $ print $#           # Prints the total number of positional
    4                    # parameters.

5   $ set a b c d e f g h i j k l m
    $ print $10          # Prints the first positional parameter
    a0                   # followed by a 0.

    $ print ${10} ${11}  # Prints the 10th and 11th positions.
    j k

6   $ print $#
    13

7   $ print $*
    a b c d e f g h i j k l m

8   $ set file1 file2 file3
    $ print \$$#
    $3

9   $ eval print \$$#
    file3
```

EXPLANATION

1. The set command assigns values to positional parameters. The $* special variable contains all of the parameters set.
2. The value of the first positional parameter, tim, is displayed.

3. The value of the second and third parameters, bill and ann, are displayed.
4. The $# special variable contains the number of positional parameters currently set.
5. The set command resets all of the positional parameters. The original parameter list is cleared. To print any positional parameters beyond 9, the curly braces are used to keep the two digits together. Otherwise, the value of the first positional parameter is printed, followed by the number appended to it.
6. The number of positional parameters is now 13.
7. The values of all the positional parameters are printed.
8. The dollar sign is escaped; $# is the number of arguments. The print command displays $3, a literal dollar sign followed by the number of positional parameters.
9. The eval command parses the command line a second time before executing the command. The first time parsed by the shell, the print would display $3; the second time, after eval, the print displays the value of $3, file3.

10.1.13 Other Special Variables

The Korn shell has some special built−in variables, as shown in Table 10.16.

Table 10.16. Special Variables

Variable	**Meaning**
$$	PID of the shell.
$–	ksh options currently set.
$?	Exit value of last executed command.
$!	PID of last job put in background.

Example 10.51

```
1   $ print The pid of this shell is $$
    The pid of this shell is 4725

2   $ print The options for this korn shell are $–
    The options for this korn shell are ismh

3   $ grep dodo /etc/passwd
    $ print $?
    1

4   $ sleep 25&
    [1]    400
    $ print $!
    400
```

EXPLANATION

1. The $$ variable holds the value of the PID for this process.
2. The $– variable lists all options for this interactive Korn shell.
3. The grep command searches for the string dodo in the /etc/passwd file. The ? variable holds the exit status of the last command executed. Since the value returned from grep is one, grep is assumed to have failed in its search. An exit status of zero indicates a successful exit.
4. The & appended to the sleep command causes the command to be executed in the background. The $! variable holds the PID number of the last command placed in the background.

10.1.14 Quotes

Quotes are used to protect special metacharacters from interpretation. They can cause major debugging hassles in all shell scripts. Single quotes must be matched. They protect special metacharacters from being interpreted by the shell. Double quotes also must be matched. They protect most characters from interpretation by the shell, but allow variable and command substitution characters to be processed. Single quotes will protect double quotes, and double quotes will protect single quotes. The Korn shell, unlike the Bourne shell, will inform you if you have mismatched quotes by sending an error message to standard error with the line where it detects that the quotes were mismatched.

The Backslash. The backslash is used to protect (or escape) a single character from interpretation.

Example 10.52

```
1   $ print Where are you going\?
    Where are you going?
2   $ print Start on this line and \
    > go to the next line.
    Start on this line and go to the next line.
```

EXPLANATION

1. The special metacharacter ? is escaped with the backslash. It will not be interpreted for filename expansion by the shell.
2. The newline is escaped. The next line will become part of the first line. The > is the Korn shell's secondary prompt.

Single Quotes. Single quotes must be matched. They protect all metacharacters from interpretation. To print a single quote, it must be enclosed in double quotes or escaped with a backslash.

Example 10.53

```
    $ print 'hi there
    > how are you?
    > When will this end?
    > When the quote is matched
    > oh'
    hi there
    how are you?
    When will this end?
    When the quote is matched
    oh

2   $ print 'Do you need $5.00?'
    Do you need $5.00?

3   $ print 'Mother yelled, "Time to eat!"'
    Mother yelled, "Time to eat!"
```

EXPLANATION

1. The single quote is not matched on the line. The Korn shell produces a secondary prompt. It is waiting for the quote to be matched.
2. The single quotes protect all metacharacters from interpretation. In this example, the $ and

the ? are protected from the shell and will be treated as literals.
3. The single quotes protect the double quotes in this string. The double quotes here are conversational quotes.

Double Quotes. Double quotes must be matched, will allow variable and command substitution, and protect any other special metacharacters from being interpreted by the shell.[4]

Example 10.54

```
1   $ name=Jody
2   $ print "Hi $name, I'm glad to meet you!"
    Hi Jody, I'm glad to meet you!

3   $ print "Hey $name, the time is 'date'"
    Hey Jody, the time is Fri Dec 18 14:04:11 PST 2001
```

EXPLANATION

1. The variable name is assigned the string Jody.
2. The double quotes surrounding the string will protect all special metacharacters from interpretation, with the exception of $ in $name. Variable substitution is performed within double quotes.
3. Variable substitution and command substitution are both performed when enclosed within double quotes. The variable name is expanded and the command in backquotes, date, is executed.

10.1.15 Command Substitution

Command substitution is used when assigning the output of a command to a variable, or when substituting the output of a command into a string. The Bourne and C shells use backquotes to perform command substitution. The Korn shell does allow the backquote format (calling it "obsolescent"), but placing the command in parentheses is the preferred method because it has simpler quoting rules and makes nesting commands easier.

FORMAT

```
'Unix command'      # Old method with backquotes

$(Unix command)     # New method
```

Example 10.55

```
(Old Way)
1   $ print "The hour is 'date +%H'"
    The hour is 09

2   $ name='nawk –F: ''{print $1}' database'
    $ print $name
    Ebenezer Scrooge

3   $ ls 'ls /etc'
    shutdown

4   $ set 'date'

5   $ print $*
    Sat Oct 13 09:35:21 PDT 2001
```

```
6   $ print $2 $6
    Oct 2001
```

EXPLANATION

1. The output of the date command is substituted into the string.
2. The output of the nawk command is assigned to the variable name, and displayed.
3. The output of the ls command, enclosed in backquotes, is a list of files from the /etc directory. The filenames will be arguments to the first ls command. All files with the same name in /etc as are in the current directory are listed.
4. The set command assigns the output of the date command to positional parameters. Whitespace separates the list of words into its respective parameters.
5. The $* variable holds all of the parameters. The output of the date command was stored in the $* variable. Each parameter is separated by whitespace.
6. The second and sixth parameters are printed.

The ksh alternate for using backquotes in command substitution is presented in Example 10.56.

Example 10.56

```
(The New ksh Way)
1   $ d=$(date)
    print $d
    Sat Oct 20 09:35:21 PDT 2001

2   $ line = $(< filex)

3   $ print The time is $(date +%H)
    The time is 09
4   $ machine=$(uname –n)
    $ print $machine
    jody

5   $ dirname="$(basename $(pwd)) "      # Nesting commands
    $ print $dirname
    bin
```

EXPLANATION

1. The date command is enclosed within parentheses. The output of the command is returned to the expression, assigned to the variable d, and displayed.
2. The input from the file is assigned to the variable line. The < filex notation has the same effect as `'`cat filex`'`. Command substitution is performed within the parentheses when the parentheses are preceded with a dollar sign.
3. The UNIX date command and its hour argument, +%H, are enclosed within parentheses. Command substitution is performed, and the results are placed within the print string.
4. Command substitution has been performed. The output of the UNIX uname command is assigned to the variable machine.
5. To set the variable dirname to the name (only) of the present working directory, command substitution is nested. The pwd command is executed first, passing the full pathname of the present working directory as an argument to the UNIX command basename. The basename command strips off all but the last element of a pathname. Nesting commands within backquotes is not allowed.

10.1.16 Functions

This section introduces functions so that you can use them interactively or store them in your initialization files. Later, when discussing scripts, functions will be covered in more depth. Functions can be used when an alias is not enough, that is, for passing arguments. Functions are often defined in the user's initialization file, .profile. They are like mini−scripts, but unlike scripts, functions run in the current environment; that is, the shell does not fork a child process to execute a function. All variables are shared with the shell that invoked the function. Often functions are used to improve the modularity of a script. Once defined, they can be used repeatedly and even stored in another directory.

Functions must be defined before they are invoked; there are two formats used to define them. One format came from the Bourne shell and the other is new with the Korn shell. Functions can be exported from one invocation of the shell to the next. The typeset function and unset command can be used to list and unset functions. See Table 10.17.

Table 10.17. The typeset Command and Functions

Command Functiontypeset –fLists functions and their definitions; functions is an alias for typeset –f.typeset +fLists only function names.unset –f nameUnset a function.

Defining Functions. There are two acceptable formats for defining functions: the Bourne shell format (still allowed for upward compatibility) and the new Korn shell format. A function must be defined before it can be used.

FORMAT

```
(Bourne Shell)
functionname() { commands ; commands; }[5]

(Korn Shell)
function functionname { commands; commands; }
```

Example 10.57

```
1   $ function fun { pwd; ls; date; }

2   $ fun
    /home/jody/ellie/prac
    abc      abc123   file1.bak  none      nothing  tmp
    abc1     abc2     file2      nonsense  nowhere  touch
    abc122   file1    file2.bak  noone     one
    Tue Feb 9 11:15:48 PST 2001

3   $ function greet { print "Hi $1 and $2"; }

4    greet tom joe              # Here $1 is tom and $2 is joe
    Hi tom and joe

5   $ set jane nina lizzy
6   $ print $*
    jane nina lizzy

7   $ greet tom joe
    Hi tom and joe
```

```
8   $ print $1 $2
    jane nina
```

EXPLANATION

1. The function fun is named and defined. The name is followed by a list of commands enclosed in curly braces. Each command is separated by a semicolon. There must be a space after the first curly brace or you will get a syntax error such as ksh: syntax error: `}' unexpected. A function must be defined before it can be used.
2. The function behaves like a script or an alias when invoked. Each of the commands in the function definition is executed in turn.
3. There are two positional parameters used in the function greet. When arguments are given to the function, the positional parameters are assigned those values.
4. The arguments to the function tom and joe are assigned to $1 and $2, respectively. The positional parameters in a function are private to the function and will not interfere with any used outside the function.
5. The positional parameters are set at the command line. These variables have nothing to do with the ones set in the function.
6. $* displays the values of the currently set positional parameters.
7. The function greet is called. The values assigned to the positional parameters $1 and $2 are tom and joe, respectively.
8. The positional variables assigned at the command line are unaffected by those set in the function.

Functions and Aliases. When processing the command line, the shell looks for aliases before special built−in commands and for special built−ins before functions. If a function has the same name as a built−in, the built−in will take priority over the function. An alias for a special built−in can be defined, and then the function name can be given the name of the alias to override the order of processing.

Example 10.58

```
(The ENV File)
1   alias cd=_cd
2   function _cd {
3   \cd $1
4   print $(basename $PWD)
5   }

(The Command Line)
$ cd /
/
$ cd $HOME/bin
bin
$ cd ..
ellie
```

EXPLANATION

1. The alias for cd is assigned _cd.
2. The function _cd is defined. The opening curly brace marks the start of the function definition.
3. If an alias is preceded by a backslash, alias substitution is not performed. The backslash

precedes cd to execute the built−in cd command, not the alias. Without the backslash, the function would be recursive and the shell would display an error message: cd_: recursion too deep. $1 is the argument (name of a directory) passed to cd.
4. The name of the directory (not the full pathname) is printed.
5. The closing curly brace marks the end of the function definition.

Listing Functions. To list functions and their definitions, use the typeset command.

Example 10.59

```
(The Command Line)
1   $ typeset –f
    function fun
    {
    pwd; ls; date; }
    function greet
    {
    print "hi $1 and $2"; }

2   $ typeset +f
    fun
    greet
```

EXPLANATION

1. The typeset command, with the –f option, lists the function and its definition.
2. The typeset command, with the +f option, lists only the names of defined functions.

Unsetting Functions. When a function is unset, it will be removed from the shell's memory.

Example 10.60

```
(The Command Line)
1   $ typeset –f
    function fun
    {
        pwd; ls; date; }
    function greet
    {
    print "hi $1 and $2"; }
2   $ unset −f fun

3   $ typeset –f
    function greet
    {
    print "hi $1 and $2"; }
```

EXPLANATION

1. The typeset –f command displays the function and its definition. Two functions, fun and greet, are displayed.
2. The built−in command unset, with the –f option, undefines the fun function, removing it from the shell's memory.
3. The fun function is no longer shown as one of the functions defined when the typeset –f command is executed.

10.1.17 Standard I/O and Redirection

The shell opens three files (called streams) whenever a program is started: stdin, stdout, and stderr. Standard input normally comes from the keyboard and is associated with file descriptor 0. Standard output normally goes to the screen, file descriptor 1. Standard error normally goes to the screen, file descriptor 2. Standard input, output, and error can be redirected to or from a file. See Table 10.18 for a list of redirection operators.

Table 10.18. Redirection

Operator Function<Redirect input.>Redirect output.>>Append output.2>Redirect error.1>&2Redirect output to where error is going.2>&1Redirect error to where output is going.

Example 10.61

```
(The Command Line)
1   $ tr '[A−Z]' '[a−z]' < myfile   # Redirect input

2   $ ls > lsfile         # Redirect output
    $ cat lsfile
    dir1
    dir2
    file1
    file2
    file3

3   $ date >> lsfile      # Redirect and append output
    $ cat lsfile
    dir1
    dir2
    file1
    file2
    file3
    Mon Sept 17 12:57:22 PDT 2001

4   $ cc prog.c 2> errfile           # Redirect error

5   $ find . −name \*.c −print > founditfile 2> /dev/null

6   $ find . −name \*.c −print > foundit 2>&1

7   $ print "File needs an argument" 1>&2

8   $ function usage { print "Usage: $0 [−y] [−g] filename" 1>&2 ;
           exit 1; }
```

EXPLANATION

1. The standard input is redirected from the file myfile to the UNIX tr command. All uppercase letters are converted to lowercase letters.
2. The ls command redirects its output to the file lsfile.
3. The output of the date command is redirected and appended to lsfile.
4. The file prog.c is compiled. If the compile fails, standard error is redirected to errfile.
5. The find command starts searching in the current working directory for filenames ending in .c and prints the files to a filenamed founditfile. Errors from the find command are sent to /dev/null.

6. The find command starts searching in the current working directory for filenames ending in .c and prints the files to a filenamed foundit. The standard error (file descriptor 2) is being sent to the same place that the standard output (file descriptor 1) is being sent, to the file called foundit.
7. The print command sends its message to standard error. Standard output is merged with standard error; that is, standard output is being redirected to the place where standard error goes, the terminal. This makes it possible to separate error messages from "good" output.
8. The function usage is defined. This function, when called, will print a usage message, send the output to standard error, and exit. This type of function is often used in scripts.

The exec Command and Redirection. The exec command can be used to replace the current program with the one being execed. Another use for the exec command is to change standard output or input without creating a subshell. If a file is opened with exec, subsequent read commands will move the file pointer down the file a line at a time until end of file. The file must be closed to start reading from the beginning again. However, if using UNIX utilities such as cat and sort, the operating system closes the file after each command has completed. See Table 10.19 for exec functionality.

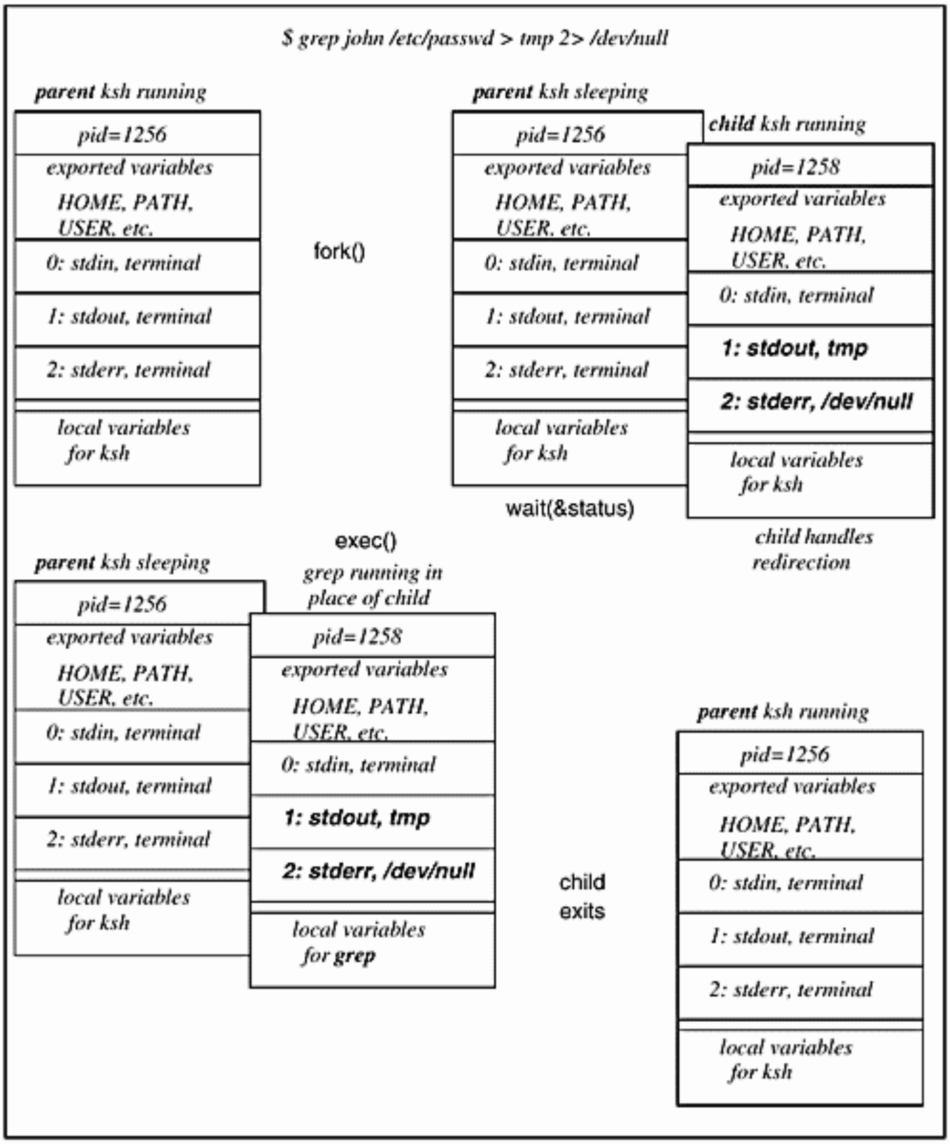
Table 10.19. exec Commands

Command	Function
exec ls	ls will execute in place of the shell. When ls is finished, the shell in which it was started does not return.
exec < filea	Open filea for reading standard input.
exec > filex	Open filex for writing standard output.
exec 2> errors	Open errors for writing standard error.
exec 2> /dev/console	Sends all error messages to the console.
exec 3< datfile	Open datfile as file descriptor 3 for reading input.
sort <&3	datfile is sorted.
exec 4>newfile	Open newfile as file descriptor 4 for writing.
ls >&4	Output of ls is redirected to newfile.
exec 5<&4	Make fd 5 a copy of fd 4. Both descriptors refer to newfile.
exec 3<&–	Close file descriptor 3, datfile.

10.1.18 Redirection and the Child Shell

When the output of a command is redirected from the screen to a file, the Korn shell creates a child (fork) shell to rearrange the file descriptors, as shown in Figure 10.2.

Figure 10.2. Redirection of standard output and errors.



10.1.19 Pipes

A pipe takes the output from the command on the left−hand side of the pipe symbol and sends it to the input of a command on the right−hand side of the pipe symbol. A pipeline can consist of more than one pipe.

Example 10.62

```
1   $ who > tmp

2   $ wc −l tmp
    4 tmp

3   $ rm tmp

4   $ who | wc −l      # Using the pipe
```

EXPLANATION

The purpose of lines 1 through 3 is to count the number of people logged on (who), save the output of the command in a file (tmp), use the wc –l to count the number of lines in the tmp file (wc –l), and then remove the tmp file; that is, find the number of people logged on. The pipe performs the same task in one command.

1. The output of the who command is redirected to the tmp file.
2. The wc –l command displays the number of lines in tmp.
3. The tmp file is removed.
4. With the pipe facility, you can perform all three of the above steps, 1,2, and 3, in one step. The output of the who command is sent to an anonymous kernel buffer (instead of to a temporary file that requires disk space); the wc –l command reads from the buffer and sends its output to the screen.

Example 10.63

```
1   $ ls | more
    < lists (ls) all files one page at a time (more) >

2   $ du ~ | sort –n | sed –n '$p'
    72388  /home/jody/ellie

3   $ cat | lp or  cat | lpr
```

EXPLANATION

1. The ls output is piped to the more command, which accepts input. Output is displayed one page at a time.
2. The output of the du command (disk usage) is sorted numerically and piped to the sed command (stream editor), which displays only the last line ($p).
3. The cat command reads from standard input; its output is piped to the line printer (lp in SVR4 and lpr in BSD).

10.1.20 The here document and Redirecting Input

A here document captures in−line input for programs such as mail, sort, and cat. Input is placed between two words or symbols. The first word is preceded by a UNIX command and the << symbol. The next line(s) consist of the input to be received by the command. The last line consists of a second word that exactly matches the first word. This word is called the final terminator and marks the end of input. It is used in the same way Control−D is used to terminate input. There can be no spaces surrounding the final terminator. If the first word is preceded by the <<–, leading tabs (and only tabs) may precede the final terminator. Normally, here documents are used in shell scripts, rather than interactively. A good use for a here document is to create a menu in a script.

FORMAT

```
UNIX command << TERMINATOR
   lines of input
   input
TERMINATOR
```

Example 10.64

```
(The Command Line)
1   $ cat << FINISH# FINISH is a user−defined terminator
2   > Hello there $LOGNAME
3   > The time is $(date)
    > I can't wait to see you!!!
4   > FINISH
5   Hello there ellie
    The time is Sun Feb 7 19:42:16 PST 2001
    I can't wait to see you!!
6   $
```

EXPLANATION

1. The UNIX cat program will accept input until the word FINISH appears on a line by itself.
2. Variable substitution is performed within the here document. The > is the Korn shell's secondary prompt.
3. Command substitution is performed within the here document.
4. The user−defined terminator, FINISH, marks the end of input for the cat program. It cannot have any spaces before or after it and is on a line by itself.
5. The output from the cat program is displayed.
6. The shell prompt reappears.

Example 10.65

```
(From the .profile File)
1   print "Select a terminal type"
2   cat << EOF
      [1] sun
      [2] ansi
      [3] wyse50
3   EOF
4   read TERM
    ...
```

EXPLANATION

1. The user is asked to select a terminal type.
2. The menu will appear on the screen. This is a here document, meaing from here until the matching EOF on line 3 is reached, input will be given to the cat command. You could use a series of echo commands to get the same results, but visually, the here document is nicer.
3. EOF is a user−defined terminator, marking the end of the here document. It must be at the left margin with no spaces surrounding it.
4. The user input will be read in from the keyboard and assigned to TERM.

Example 10.66

```
(The Command Line)
1   $ cat <<− DONE
    >Hello there
    >What's up?
    >Bye now The time is $(date).

2   >    DONE
```

```
3   Hello there
    What's up?
    Bye now The time is Sun Feb 7 19:48:23 PST 2001.
```

EXPLANATION

1. The cat program accepts input until DONE appears on a line by itself. The <<– operator allows the final terminator to be preceded by one or more tabs. (The > is the shell's secondary prompt.)
2. The final matching DONE terminator is preceded by a tab. From the first DONE on line 1 to the last DONE on this line, the text in between is sent as input to the cat command.
3. The output of the cat program is displayed on the screen.

10.1.21 Timing Commands

The time Command. The time command is a ksh built−in command. The time command prints the following to standard error: elapsed time, the user time, and the system time used to execute a command.

Example 10.67

```
1   $ time sleep 3
    real  0m3.15s   took 3.15 seconds to run
    user  0m0.01s   sleep used its own code for .01 seconds
    sys   0m0.08s   and kernel code for .08 seconds

2   $ time ps –ef | wc –l    # time is measured for all commands in
    38                       # the pipeline
    real  0m1.03s
    user  0m0.01s
    sys   0m0.10s
```

EXPLANATION

1. The time command will display the total amount of time elapsed to run the command, the time the user part of the program took to run, and the time the kernel spent running the program. The sleep command took 3.15 seconds to run.
2. The time is measured for the ps command and wc command.

10.1.22 The TMOUT Variable

The TMOUT variable is an integer type. It can be set to force users to type commands within a certain period of time. TMOUT, by default, is set to zero, allowing the user an infinite amount of time to type commands after the PS1 prompt. If TMOUT is set to a value greater than zero, the shell will terminate after the time has expired. Sixty additional seconds will be allotted as the grace period before actually exiting the shell.

Example 10.68

```
$ TMOUT=600
time out in 60 seconds due to inactivity
ksh: timed out waiting for input
```

EXPLANATION

The TMOUT variable is set to 600 seconds. If the user does nothing for 600 seconds, a message will appear on the screen and then an additional 60 seconds grace period will be allotted before the shell exits. If you do this at the prompt, your current shell exits.

10.2 Programming with the Korn Shell

Writing shell scripts requires a few steps, as outlined in the following section.

10.2.1 The Steps in Creating a Shell Script

A shell script is normally written in an editor and consists of commands interspersed with comments. Comments are preceded by a pound sign.

The First Line. At the top−left corner, to indicate the program that will be executing the lines in the script, #!/bin/ksh is commonly used. The #! is called a magic number and is used by the kernel to identify the program that should be interpreting the lines in the script. This line must be the top line of your script. The Korn shell also provides a number of invocation options that control how the shell behaves. These options are listed at the end of this chapter.

Comments. Comments are lines preceded by a pound sign. They are used to document your script. It is sometimes difficult to understand what the script is supposed to do if it is not commented. Although comments are important, they are often too sparse or not even used at all. Try to get used to commenting what you are doing, not only for someone else, but also for yourself.

Executable Statements and Korn Shell Constructs. A Korn shell program consists of a combination of UNIX commands, Korn shell commands, programming constructs, and comments.

Naming and Storing Scripts. When naming scripts, it is a good idea to give the script a meaningful name and one that does not conflict with other UNIX commands or aliases. For example, you may want to call the script test because it is merely performing some simple test procedure, but test is a built−in command and you may find you are executing the wrong test. Additionally, if you name the file foo, goo, boobar, and so forth, in a few days or even hours you may not have any idea what is in that script!

After you have tested your script and found it "bug−free," make a directory where you can store the scripts, then set the path so that your scripts can be executed from anywhere in the directory hierarchy.

Example 10.69

```
1   $ mkdir ~/bin
2   $ mv myscript ~/bin

(In .profile)
3   export PATH=${PATH}:~/bin

4   $ . .profile
```

EXPLANATION

1. A common place to store scripts is in a directory under your home directory called bin.
2. The script, called myscript, is moved into the new bin directory.
3. The new directory is added to the PATH variable in the .profile initialization file.
4. The dot command causes the .profile file to be executed in the current environment so that you do not have to log out and then back in to enable the new setting.

Making a Script Executable. When you create a file, it is not automatically given execute permission (regardless of how umask is set). You need this permission to run your script. Use the chmod command to turn on execute permission.

Example 10.70

```
1   $ chmod +x myscript
2   $ ls −lF myscript
    −rwxr−−xr−−x  1 ellie      0 Jul 12 13:00 joker*
```

EXPLANATION

1. The chmod command is used to turn on execute permission for the user, group, and others.
2. The output of the ls command indicates that all users have execute permission on the joker file. The asterisk at the end of the filename also indicates that this is an executable program.

Using a Script as an Argument to ksh. If you don't make a script executable, you can execute it by passing it as an argument to the ksh command:

Example 10.71

```
(The Command Line)
$ ksh myscript
```

EXPLANATION

If the ksh program is given a scriptname as its argument, it will execute the script and the #! line is not necessary or even used.

A Scripting Session. In Example 10.72, the user will create a script in the editor. After saving the file, the execute permissions are turned on, and the script is executed. If there are errors in the program, the Korn shell will respond immediately.

Example 10.72

```
(The Script)
1   #!/bin/ksh
2   # This is the first Korn shell program of the day.
    # Scriptname: greetings
    # Written by: Karen Korny
3   print "Hello $LOGNAME, it's nice talking to you."
4   print "Your present working directory is $(pwd)."
    print "You are working on a machine called $(uname −n)."
    print "Here is a list of your files."
5   ls     # List files in the present working directory
```

```
    print "Bye for now $LOGNAME. The time is $(date +%T)!"

(The Command Line)
    $ chmod +x greetings
    $ greetings
3   Hello karen, it's nice talking to you.
4   Your present working directory is /home/lion/karen/junk
    Your are working on a machine called lion.
    Here is a list of your files.
5   Afile        cplus  letter    prac
    Answerbook  cprog   library   prac1
    bourne       joke   notes     perl5
    Bye for now karen. The time is 18:05:07!
```

EXPLANATION

1. The first line of the script, #!/bin/ksh, lets the kernel know what interpreter will execute the lines in this program.
2. The comments are nonexecutable lines preceded by a #. They can be on a line by themselves or inserted in a line after a command.
3. The print command displays the line on the screen, after variable substitution is performed by the shell.
4. The print command displays the line on the screen, after command substitution is performed by the shell.
5. The ls command is executed. The comment, any text on the line after the pound sign (#), will be ignored by the shell.

10.2.2 Reading User Input

The read command is used to take input from the terminal or from a file until the newline is reached. The Korn shell provides some additional options for the read command. See Table 10.20 for different read formats. See Table 10.21 for read options.

Table 10.20. The read Format

Format Meaningread answerReads a line from standard input and assigns it to the variable answer.read first lastReads a line from standard input to the first whitespace or newline, putting the first word typed into the variable first and the rest of the line into the variable last.read response?"Do you feel okay?"Displays the string Do you feel okay? to standard error and waits for user to type a reply, then puts the reply in the variable response. This form of read requires and accepts only one variable. Whatever the user types, until the newline, will be stored in response.read –u3 lineReads a line from file descriptor 3 into variable line.readReads input into a built−in variable, REPLY.

Table 10.21. The read Options

Options Meaning–rTreats newline character, the \n, as a literal.–sCopies a line into the history file.–unReads from file descriptor n; the default is fd 0, or standard input.–pReads a line of input from a coprocess. On Versions of ksh Newer than 1988:–AStores the fields as an array, index starting at zero.–t secPuts a limit of seconds on the user's response time.–d charUsed as an alternate delimiter for terminating input; newline is the default.

Example 10.73

```
(The Script)
    #!/bin/ksh
    # Scriptname: nosy
    print –n "Are you happy? "
1   read answer
    print "$answer is the right response."
    print –n "What is your full name? "

2   read first middle last
    print "Hello $first"
    print –n "Where do you work? "
3   read

4   print I guess $REPLY keeps you busy!

5   read place?"Where do you live? "
    # New ksh read and print combined
    print Welcome to $place, $first $last


(The Output)
    $ nosy
    Are you happy? Yes
1   Yes is the right response.
2   What is your full name? Jon Jake Jones
    Hello Jon
3   Where do you work? Tandem
4   I guess Tandem keeps you busy!
5   Where do you live? Timbuktu
    Welcome to Timbuktu, Jon Jones
```

EXPLANATION

1. The read command accepts a line of user input and assigns the input to the variable answer.
2. The read command accepts input from the user and assigns the first word of input to the variable first, assigns the second word of input to the variable middle, and all the rest of the words to the end of the line to the variable last.
3. The read command, without an argument, accepts a line of input from the user and assigns the input to the built−in variable REPLY.
4. After the shell has performed variable substitution, the print function prints the string, showing the value of the built−in REPLY variable.
5. If the variable following the read command is appended with a question mark (?), the string after the question mark is displayed as a prompt. The user input is stored in the variable place.

Read and File Descriptors. When the system boots up, three files called streams (stdin, stdout, and stderr) are opened and assigned to an array of file descriptors. The first three file descriptors, 0, 1, and 2, are for standard input, standard output, and standard error, respectively. The next file descriptor available is file descriptor 3. The –u option allows the read command to read directly from the file descriptor.

Example 10.74

```
(The Command Line)
1   $ cat filex
```

```
    Captain Kidd
    Scarlett O'Hara

2   $ exec 3< filex
    # filex is assigned to file descriptor 3 for reading

3   $ read –u3 name1
    # read from filex and store input in variable, name1

4   $ print $name1
    Captain Kidd

5   $ read –u3 name2
    $ print $name2
    Scarlett O'Hara

6   $ exec 3<&–              # Close file descriptor 3

7   $ read –u3 line
    ksh: read: bad file unit number
```

EXPLANATION

1. The contents of filex are displayed.
2. The exec command is used to open file descriptor 3 for reading from filex.
3. The read command reads one line directly from unit 3 (file descriptor 3, filex) and assigns that line to the variable name1.
4. The line stored in name1 is printed.
5. The file filex is still open, and this read command reads the next line from the file and stores that line in the variable name2.
6. File descriptor 3 (unit 3) is closed. filex is no longer open.
7. Since file descriptor 3 (filex) has been closed, the read command fails when attempting to read input from that descriptor into variable line.

Reading through Files. Example 10.75 uses the read command with a while loop. The loop will iterate through the file one line at a time. When end of file is reached, the loop terminates. The files are opened with descriptors (units) for reading.

Example 10.75

```
(The Files)
1   $ cat names
    Merry Melody
    Nancy Drew
    Rex Allen
    $ cat addresses
    150 Piano Place
    5 Mystery Lane
    130 Cowboy Terrace
------------------------------------------------------------------
(The Script)
    #!/bin/ksh
    # Scriptname: readit
2   while read –u3 line1 && read –u4 line2
    do
3      print "$line1:$line2"
4   done 3<$1 4<$2
------------------------------------------------------------------
```

```
(The Command Line)
5   $ readit names addresses
    Merry Melody:150 Piano Place
    Nancy Drew:5 Mystery Lane
    Rex Allen:130 Cowboy Terrace
---------------------------------------------------------------
```

EXPLANATION

1. The contents of two files, names and addresses, are displayed.
2. The while loop is started. The read command reads a line of input from file descriptor 3 (unit 3) and, if successful, reads another line from file descriptor 4. The file descriptors (units) are assigned filenames on line 4. The filenames are being passed as arguments, or positional parameters 1 and 2.
3. The value of the first variable, a colon, and the value of the second variable are displayed.
4. The input assigned to file descriptor 3 is the first command line argument, names. The input assigned to file descriptor 4 is the second command line argument, addresses.
5. The script is executed with command line arguments (the names of two files).

10.2.3 Arithmetic

The Korn shell supports both integer and floating point arithmetic, but floating point arithmetic is available only on versions of the Korn shell newer than 1988. The typeset command is used for assigning types. See Table 10.22 for the typeset command.

Table 10.22. typeset and Arithmetic

typeset Command Alias Meaningtypeset –i variableinteger variableVariable is only allowed integer assignment.typeset –i# # is the base number for the integer. On Versions of ksh Newer than 1988:typeset –F variable Floating point number assignment.typeset –E variablefloat variableFloating point number assignment.

The Integer Type. Variables can be declared as integers with the typeset –i command or its alias, integer. If you attempt to assign any string value, ksh returns an error. If you assign a floating point number, the decimal point and the fractional value will be truncated. The integer alias can be used instead of typeset –i. Numbers can also be represented in different bases such as binary, octal, and hex.

Example 10.76

```
1   $ typeset –i num or integer num      # integer is an alias for
                                         # typeset –i
2   $ num=hello
    /bin/ksh: hello: bad number

3   $ num=5 + 5
    /bin/ksh: +: not found

4   $ num=5+5
    $ echo $num
    10

5   $ num=4*6
    $ echo $num
    24
```

```
6   $ num="4 * 6"
    $ echo $num
    24

7   $ num=6.789
    $ echo $num
    6
```

EXPLANATION

1. The typeset command with the –i option creates an integer variable num.
2. Trying to assign the string hello to the integer variable num causes an error.
3. The whitespace must be quoted or removed unless the (( )) operators are used (see "Arithmetic Operators and the let Command" on page 511).
4. The whitespace is removed and arithmetic is performed.
5. Multiplication is performed and the result assigned to num.
6. The whitespace is quoted so that the multiplication can be performed and to keep the shell from expanding the wildcard (*).
7. Since the variable is set to integer, the fractional part of the number is truncated.

Using Different Bases. Numbers can be represented in decimal (base 10), octal (base 8), and so forth, by using the typeset command and with the –i option and the base number.[6]

Example 10.77

```
1   $ num=15
2   $ typeset –i2 num    # binary
    $ print $num
    2#1111

3   $ typeset –i8 num    # octal
    $ print $num
    8#17

4   $ typeset –i16 num   # hex
    $ print $num
    16#f

5   $ read number
    2#1101
    $ print $number
    2#1101

6   $ typeset –i number
    $ print $number
    2#1101

7   $ typeset –i10 number   # decimal
    $ print $number
    13

8   $ typeset –i8 number    # octal
    $ print $number
    8#15
```

EXPLANATION

1. The variable num is assigned the value 15.
2. The typeset command converts the number to a binary format. The display is the base of the number (2), followed by a pound sign (#), and the value of the number in binary.
3. The typeset command converts the number to an octal format and displays the value of the number in base 8.
4. The typeset command converts the number to hexadecimal format and displays the value of the number in base 16.
5. The read command accepts input from the user. The input is entered in binary format, stored in the variable number, and displayed in binary format.
6. The typeset command converts number to an integer. It still displays in binary format.
7. The typeset command converts number to a decimal integer and displays it.
8. The typeset command converts number to octal and displays its value in base 8.

Listing Integers. The typeset command with only the –i argument will list all preset integers and their values, as shown in the following display.

```
$ typeset –i
ERRNO=2
LINENO=1
MAILCHECK=600
OPTIND=1
PPID=4881
RANDOM=25022
SECONDS=47366
TMOUT=0
n=5
number=#15
```

Arithmetic Operators and the let Command. The let command is a Korn shell built−in command that is used to perform integer arithmetic. This replaces the Bourne shell integer testing. The alternative and preferred way to use the let command is with the (( )) operator.

Table 10.23. let Operators

Operator Meaning–Unary minus.!Logical not.~Bitwise not.* / %Multiply, divide, remainder.+ –Add, subtract.<< >>Bitwise left shift, right shift.<= >= < > == !=Comparison operators.& ^ |Bitwise and; exclusive or.&& || !Logical and; logical or; unary not.=Assignment.*= /= %= += –= <<= >>= &= ^= |=Shortcut assignment.

Note

The ++ and – – operators are supported on versions of ksh that are newer than 1988.

Example 10.78

```
1   $ i=5

2   $ let i=i+1
    $ print $i
    6

3   $ let "i = i + 2"
```

```
    $ print $i
    8

4   $ let "i+=1"
    $ print $i
    9
```

EXPLANATION

1. The variable i is assigned the value 5.
2. The let command will add 1 to the value of i. The $ (dollar sign) is not required for variable substitution when performing arithmetic.
3. The quotes are needed if the arguments contain whitespace.
4. The shortcut operator, +=, is used to add 1 to the value of i.

Example 10.79

```
(The Command Line)
1   $ (( i = 9 ))

2   $ (( i = i * 6 ))
    $ print $i
    54

3   $ (( i > 0 && i <= 10 ))

4   $ print $?
    1
    $ j=100

5   $ (( i < j || i == 5 ))

6   $ print $?
    0

7   $ if (( i < j && i == 54 ))
    > then
    > print True
    >fi
    True
    $
```

EXPLANATION

1. The variable i is assigned the value 9. The (( )) operators are an alternate form of the let command. Since the expression is enclosed in double parentheses, spaces are allowed between the operators.
2. The variable i is assigned the product of i*6.
3. The numeric expressions are tested. If both expressions are true, zero exit status is returned.
4. The special ? variable holds the exit status of the last command (the let command) executed. Since the value is one, the command failed (evaluated as false).
5. The numeric expressions are tested. If one of the expressions is true, zero exit status is returned.
6. The special ? variable holds the exit status of the last command (the let command) executed. Since the value is zero, the command succeeded (evaluated as true).

7. The if conditional command precedes the let command. The secondary prompt appears while waiting for the command to be completed. If the exit status is zero, the commands after the then statement are executed; otherwise, the primary prompt returns.

10.2.4 Positional Parameters and Command Line Arguments

Command line arguments can be referenced in scripts with positional parameters; for example, $1 is set to the first argument, $2 to the second argument, and $3 to the third argument. Positional parameters can be reset with the set command. See Table 10.24.

Table 10.24. Positional Parameters

Variable Function$0References the name of the script.$#Holds the value of the number of positional parameters.$*Contains a list of all the positional parameters.$@Means the same as $*, except when enclosed in double quotes."$*"Expands to a single argument, e.g., "$1 $2 $3"."$@"Expands to separate arguments, e.g., "$1" "$2" "$3".

The set Command and Positional Parameters. The set command sets the positional parameters. If the positional parameters have already been set, the set command will reset them, removing any values in the old list. To unset all of the positional parameters, use set – –.

Example 10.80

```
    (The Script)
    $ cat args
    #!/bin/ksh
    # Script to test command line arguments
1   print The name of this script is $0.
2   print The arguments are $*.
3   print The first argument is $1.
4   print The second argument is $2.
5   print The number of arguments is $#.
6   oldparameters=$*
7   set Jake Nicky Scott
8   print All the positional parameters are $*.
9   print The number of positional parameters is $#.
10  print $oldparameters
11  set ––
12  print Good–bye for now, $1.
13  set $oldparameters
14  print $*

    (The Output)
    $ args a b c d
1   The name of this script is args.
2   The arguments are a b c d.
3   The first argument is a.
4   The second argument is b.
5   The number of arguments is 4.
8   All the positional parameters are Jake Nicky Scott.
9   The number of positional parameters is 3.
10  a b c d
12  Good–bye for now ,.
14  a b c d
    $
```

EXPLANATION

1. The name of the script is stored in the $0 variable.
2. $* (and $@) both represent all of the positional parameters.
3. $1 represents the first positional parameter (command line argument).
4. $2 represents the second positional parameter.
5. $# is the total number of positional parameters (command line arguments).
6. The variable oldparameters is assigned all of the positional parameters ($*). Later on, if you want to get back your original parameters, you can do so by typing set $oldparameters.
7. Reset positional parameters with the set command. The set command completely clears all previously set parameters. Jake is assigned to $1, Nicky is assigned to $2, and Scott is assigned to $3.
8. The new positional parameters are printed.
9. The number of positional parameters is printed.
10. The original parameters were stored in the variable oldparameters. They are printed.
11. All parameters are unassigned.
12. $1 has no value. The parameters list was cleared with the set – – command.
13. A new parameter list is assigned by substituting the values in oldparameters to the parameter list with the set command.
14. All the positional parameters are printed.

Example 10.81

```
(How $* and $@ Differ)
1   $ set 'apple pie' pears peaches
2   $ for i in $*
    > do
    > echo $i
    > done
    apple
    pie
    pears
    peaches

3   $ set 'apple pie' pears peaches
4   $ for i in "$*"
    > do
    > echo $i
    > done
    apple pie pears peaches

5   $ set 'apple pie' pears peaches
6   $ for i in $@
    > do
    > echo $i
    > done
    apple
    pie
    pears
    peaches

7   $ set 'apple pie' pears peaches
8   $ for i in "$@"            # At last!!
    > do
    > echo $i
    > done
```

```
apple pie
pears
peaches
```

EXPLANATION

1. The positional parameters are set. When the $* is expanded, the quotes are stripped and apple pie becomes two separate words. The for loop assigns each of the words, in turn, to the variable i and then prints the value of i. Each time through the loop, the word on the left is shifted off, and the next word is assigned to i.
2. If $* is surrounded by double quotes, all of the words in the list become one single string, and the whole string is assigned to the variable i.
3. The positional parameters are set.
4. By enclosing $* in double quotes, the entire parameter list becomes one string.
5. The positional parameters are set.
6. Unquoted, the $@ behaves the same way as the $*.
7. The positional parameters are set.
8. By surrounding $@ with double quotes, each of the positional parameters is treated as a quoted string. The list would consist of "apple pie," "pears," and "peaches." Each of the quoted words is assigned to i, in turn, as the loop goes through each iteration.

10.2.5 Testing Exit Status and the $? Variable

The ? variable contains a number value (between 0 and 255) representing the exit status of the last command that exited. If the exit status is zero, the command exited with success; if nonzero, the command failed in some way. You can test the exit status of commands and use the test command to test the exit status of expressions.

The following examples illustrate how the exit status is tested. The single brackets are used in the Bourne shell, and although perfectly acceptable in the Korn shell, Dr. Korn provides you with the new double−bracket notation for testing expressions.

Example 10.82

```
    (The Command Line)
1   $ name=Tom
2   $ grep "$name" datafile
    Tom Savage:408−124−2345
3   $ print $?
    0                         # Success!

4   $ test $name = Tom

5   $ print $?
    0                         # Success

6   $ test $name != Tom
    $ print $?
    1                         # Failure

7   $ [ $name = Tom ]         # Brackets instead of the test command
8   $ print $?
    0

9   $ [[ $name = [Tt]?m ]]    # New ksh test command
10  $ print $?
```

0

EXPLANATION

1. The string Tom is assigned to the variable name.
2. The grep command will search for string Tom in the datafile, and if successful in its search, will display the line found.
3. The ? variable, accessed by $?, contains the exit status of the last command executed, in this case, the exit status of grep. If grep is successful in finding the string Tom, it will return an exit status of zero. The grep command was successful.
4. The test command is used to evaluate strings and numbers, and to perform file testing. It returns an exit status of zero if the expression is true, and an exit status of one if the expression fails. There must be spaces surrounding the equal sign.
5. The value of name is tested to see if it is equal to Tom. The test command returns an exit status of 0, meaning that $name does evaluate to Tom.
6. The value of name is tested to see if it is equal to Tom. The test command returns an exit status of 1, meaning that name is not equal to Tom.
7. The brackets are an alternate notation for the test command. There must be spaces after the first bracket. The expression is tested to see if $name evaluates to the string Tom.
8. The exit status of the test is zero. The test was successful because $name is equal to Tom.
9. The new Korn shell test command, [[, is used. The new test allows shell metacharacter expansion. If the variable matches Tom, tom, Tim, tim, and so on, the test will return a successful status, zero.
10. The variable name did match a string beginning with T or t and ending in m, resulting in a successful exit status ($?) of 0.

10.2.6 Conditional Constructs and Flow Control

Conditional commands allow you to perform some task(s) based on whether or not a condition succeeds or fails. The if command is the simplest form of decision making. The if/else commands allow a two−way decision construct, and the if/elif/else commands allow a multiway decision construct.

The Korn shell expects a command to follow an if. The command can be a system command or a built−in command. The exit status of the command is used to evaluate the condition. To evaluate an expression, the built−in test command is used. This command is also linked to the [and the [[symbols. The Bourne shell encloses an expression in a set of single brackets: [and]. The Korn shell has a more sophisticated method for testing expressions. The expression is enclosed in double brackets: [[and]]. In the single brackets, the expansion of wildcards is not allowed; with the double brackets (Korn shell only), wildcard expansion is supported and a new set of operators have been added. The result of a command is tested, with zero status indicating success, and nonzero status indicating failure.

The Old test Command. The test command is used to evaluate conditional expressions, returning true or false. It returns zero exit status for true, and nonzero exit status for false. Either the test command or the brackets can be used. The Korn shell introduced a new way of testing expressions with double brackets. For backward−compatibility with the Bourne shell, the older form of test can be used with either the test command or the single brackets. However, the preferred method for Korn shell programmers is the new test with double brackets. A complete list to test operators (both old and new style) are listed in Table 10.25.

Table 10.25. Testing and Logical Operators

test Tests For String Testing:string1 = string2string1 is equal to string2.string1 != string2string1 is not equal to string2.stringstring is not null.–z stringlength of string is zero.–n stringlength of string is nonzero.

Examples:

test –n $word or [–n $word]

test tom = sue or [tom = sue]

Integer Testing (Old−Style test Used with Bourne Shell):int1 –eq int2int1 is equal to int2.int1 –ne int2int1 is not equal to int2.int1 –gt int2int1 is greater than int2.int1 –ge int2int1 is greater than or equal to int2.int1 –lt int2int1 is less than int2.int1 –le int2int1 is less than or equal to int2. Logical Operators (Old−Style test):!Not operator.–aAnd operator.–oOr operator. File Testing (Old−Style test):–b filenameBlock special file.–c filenameCharacter special file.–d filenameDirectory existence.–f filenameFile existence and not a directory.–g filenameSet−group−ID is set.–h filenameSymbolic link.–k filenameSticky bit is set.–p filenameFile is a named pipe.–r filenameFile is readable.–s filenameFile is nonzero size.–u filenameSet−user−ID bit is set.–w filenameFile is writeable.–x filenameFile is executable.

The New test Command. With the [[…]] compound test command, additional operators are available. Wildcards can be used in string−matching tests, and many of the errors from the old test have been eliminated. New string test operators are listed in Table 10.26.

Table 10.26. String Testing (New−Style Test)

String Testing Operator Tests Forstring = patternstring matches pattern.[a]string != patternstring does not match pattern.string1 < string2ASCII value of string1 is less than string2.string1 > string2ASCII value of string1 is greater than string2.–z stringstring is zero in length, null parameter.–n stringstring is nonzero in length, nonnull parameter.

[a] On versions newer than 1988, the == operator is permitted.

Example 10.83

```
(The Script)
    read answer
1   if [[ $answer = [Yy]* ]]     # Test for Yes or yes or Y or y, etc.
    then...

    Example:
    (The Script)
    guess=Noone
2   if [[ $guess != [Nn]o@(one|body) ]]        # Test for Noone, noone
    then. . .                                  # or Nobody, nobody...

    Example:
    (The Command Line)
3   [[ apples < oranges ]]
    print $?
    0
4   [[ apples > oranges ]]
    print $?
    1
```

```
5   $ name="Joe Shmoe"
    $ [ $name = "Abe Lincoln" ]            # old style
    ksh: Shmoe: unknown test operator

6   $ [[ $name = "Abe Lincoln" ]]          # new style
    $ echo $?
    1
```

EXPLANATION

1. The answer read in from the user is tested to see if it matches anything starting with Y or y.
2. The variable guess is tested. If it is not equal to a string starting with N or n, followed by an o, and exactly one or body, for example, noone or nobody, the then command would be executed.
3. The string apples is tested to see if it comes before oranges in the ASCII collating sequence. It does.
4. The string apples is tested to see if it comes after oranges in the ASCII collating sequences. It does not.
5. In the old−style test, the variable name is split into separate words. Since the = operator expects a single string as its left operand, the test command fails. To fix the problem, the variable should be enclosed in double quotes.
6. In the new−style test, the variable is not split up into separate words; therefore, double quotes are not required around $name.

File Testing with Binary Operators. The binary operators for testing files require two operands (i.e., a file on either side of the operator). See Table 10.27 for a list of binary file testing operators.

Table 10.27. Binary File Testing and Logical Operators

Operators Tests For Binary File Testingfile1 –nt file2True if file1 is newer than file2.file1 –ot file2True if file1 is older than file2.file1 –ef file2True if file1 is another name for file2.

Logical Operators. The Korn shell, like C, provides logical testing of the truth or falsity of expressions. They are listed in Table 10.28.

Table 10.28. Logical Operators

Operators Tests For&&The and operator evaluates the expression on the left−hand side of &&; if true, the expression on the right side of && is tested and must also be true. If one expression is false, the expression is false. The && operator replaces –a; e.g., ((($x && $y) > 5)).||The or operator evaluates the expression on the left−hand side of the || operator; if true, the expression is true; if false, the expression on the right−hand side of the || is evaluated; if true, the expression is true. Only if both expressions are false will the expression evaluate to false. The || operator replaces –o; e.g., ((($x || $y).

File Testing. The Korn shell provides a number of built−in test commands for checking the attributes of files, such as existence, type, permissions, etc. The file testing options (also called flags) are listed in Table 10.29.

Table 10.29. File Testing (New test Flags)

test Flag Tests For Korn Shell Only:–a filefile exists.–e filefile exists (versions newer than 1988).–L filefile exists and is a symbolic link.–O fileYou are the owner of file.–G fileYour group ID is the same as file's.–S filefile exists and is a socket. Bourne and Korn Shells:–r filefile exists and is readable.–w flefile exists and is writeable.–x filefile exists and is executable.–f filefile exists and is not a directory.–d filefile exists and is a directory.–b filefile exists and is a block special file.–c filefile exists and is a character special file.–p filefile exists and is a named pipe.–u filefile exists and is setuid.–g filefile exists and is setgid.–k filefile exists and sticky bit is set.–s filefile has a nonzero size.

Example 10.84

```
    (The Script)
1   file=/etc/passwd
2   if [[ –f $file && (–r $file || –w $file) ]]
    then
3     print $file is a plain file and is either readable or writeable
    fi
```

EXPLANATION

1. The variable file is assigned /etc/passwd.
2. The file test operators test if the file is a plain file and is either readable or writeable. The parentheses are used for grouping. In the old test, the parentheses had to be escaped with a backslash.
3. If both of the tests are true, the file is a plain file, and it is either readable or writeable, this line is executed.

The if Command. The simplest form of conditional is the if command. The command following the if keyword is executed and its exit status is returned. If the exit status is zero, the command succeeded and the statement(s) after the then keyword are executed.

In the C shell and C language, the expression following the if command is a Boolean−type expression. But in the Bourne and Korn shells, the statement following the if is a command or group of commands. The exit status of the last command of the if line is used to determine whether or not to continue and execute commands under the then statement. If the exit status of the last command on the if line is zero, the commands under the then statement are executed. The fi terminates the command list to be executed after the then. If the exit status is nonzero, meaning that the command failed in some way, the statement(s) after the then statement are ignored and control goes to the line directly after the fi statement.

Conditional commands can be nested. Every if must have a corresponding fi. The fi is paired with the closest if. Using indentation to format your if blocks helps when debugging your programs.

FORMAT

```
if command
then     # Testing command exit status
    command
    command
fi
------------------------------------

if test expression
```

```
then     # Using the test command to test expressions
    command
fi

            or

if [ expression ]
then                  # Using the old-style test command--
    command           # brackets replace the word test
fi
----------------------------------

if [[ expression ]]
then                  # New-style brackets for testing expressions
    command
fi
----------------------------------------------
if command
then
...
    if command
    then
    ...
        if command         # Nested conditionals
        then
        ...
        fi
    fi
fi
```

Example 10.85

```
1   if ypmatch $name passwd > /dev/null 2>&1
2   then
          echo Found $name!
3   fi
```

EXPLANATION

1. The ypmatch command is an NIS command that searches for its argument, name, in the NIS passwd database on the server machine. Standard output and standard error are redirected to /dev/null, the UNIX bit bucket.
2. If the exit status of the ypmatch command is zero, the program goes to the then statement and executes commands until fi is reached.
3. The fi terminates the list of commands following the then statement.

Using the Old−Style Bourne test. If you have been programming in the Bourne shell, the Korn shell is backward−compatible, allowing your Bourne shell scripts to be executed properly by the Korn shell. Many Bourne shell programmers, when converting to Korn shell, still use the old−style test command when evaluating expressions. If you are reading or maintaining scripts, you may find the old syntax alive and well. Therefore, a brief discussion of the old syntax may help you, even if you are writing your own scripts with the new Korn shell test command.

Example 10.86

```
    #!/bin/ksh
    # Scriptname: are_you_ok
1   print "Are you ok (y/n) ?"
```

```
    read answer
2   if [ "$answer" = Y −o "$answer" = y ]     # Old−style test
    then
       print "Glad to hear it."
3   fi
```

EXPLANATION

1. The user is asked the question, Are you ok (y/n) ?. The read command causes the program to wait for user input.
2. The test command, represented by a [, is used to test expressions and returns an exit status of zero if the expression is true and nonzero if the expression is false. If the variable answer evaluates to Y or y, the commands after the then statement are executed. (The test command does not allow the use of wildcards when testing expressions.)
3. The fi terminates the list of commands following the then statement.

Using the New−Style Korn test. The new Korn shell−style testing allows expressions to contain shell metacharacters and Korn shell operators such as && and ||.

Example 10.87

```
    #!/bin/ksh
    # Scriptname: are_you_ok2
1   print "Are you ok (y/n) ?"
    read answer
2   if [[ "$answer" = [Yy]* ]]          # New−style test
    then
         print "Glad to hear it."
3   fi
```

EXPLANATION

1. The user is asked the question, Are you ok (y/n) ?. The read command causes the program to wait for user input.
2. The [[ ]] is a special Korn shell construct used to test expressions. If the answer evaluates to Y or y followed by any number of characters, the commands after the then statement are executed.
3. The fi statement terminates the if.

Using the Old−Style Bourne test with Numbers. To test numeric expressions, the old−style Bourne shell test command and its operators are still acceptable in the Korn shell, but the new−style let command is preferred.

Example 10.88

```
1   if [ $# −lt 1 ]
    then
        print "$0: Insufficient arguments " 1>&2
        exit 1
2   fi
```

EXPLANATION

1. The statement reads: If the number of arguments is less than 1, print the error message and send it to standard error. Then exit the script. The old style of testing integers is used with

the test command.
2. The fi marks the end of the block of statements after then.

The let Command and Testing Numbers. Although it is still acceptable to use single square brackets and old−style Bourne shell numeric operators for testing numeric expressions, the preferred Korn shell method is to use the double parentheses and the new C−language–style numeric operators when testing numeric expressions. Note that the double brackets are only used for testing string expressions and for file tests (see Table 10.29).

Example 10.89

```
1   if (( $# < 1 ))
    then
         print "$0: Insufficient arguments " 1>&2
         exit 1
2   fi
```

EXPLANATION

1. The statement reads: If the number of arguments is less than 1, print the error message and send it to standard error. Then exit the script. This is the preferred way to perform numeric tests in the Korn shell.
2. The fi marks the end of the block of statements after then.

The if/else Command. The if/else command allows a two−way decision−making process. If the command after the if fails, the commands after the else are executed.

FORMAT

```
if command
then
   command(s)
else
   command(s)
fi
```

Example 10.90

```
1   if ypmatch "$name" passwd > /dev/null 2>&1
2   then
          print Found $name!
3   else
4       print "Can't find $name."
        exit 1
5   fi
```

EXPLANATION

1. The ypmatch command searches for its argument, $name, in the NIS passwd database. Standard output and standard error are redirected to /dev/null, the UNIX bit bucket.
2. If the exit status of the ypmatch command is zero, program control goes to the then statement and executes commands until else is reached.
3. The commands under the else statement are executed if the ypmatch command fails to find name in the passwd database; that is, the exit status of ypmatch must be nonzero for

the commands in the else block to be executed.

4. The print function sends output to the screen and the program exits.
5. This marks the end of the if construct.

The if/elif/else Command. The if/elif/else command allows a multiway decision−making process. If the command following the if fails, the command following the elif is tested. If that command succeeds, the commands under its then statement are executed. If the command after the elif fails, the next elif command is checked. If none of the commands succeed, the else commands are executed. The else block is called the default.

FORMAT

```
if command
then
   command(s)
elif command
then
   commands(s)
elif command
then
   command(s)
else
   command(s)
fi
```

FORMAT

```
if [[ string expression ]]      or       if (( numeric expression ))
then
   command(s)
elif [[ string expression  ]]   or       elif (( numeric expression ))
then
   commands(s)
elif [[ string expression ]]    or       elif(( numeric expression ))
then
   command(s)
else
   command(s)
fi
```

Example 10.91

```
(The Script)
    #!/bin/ksh
    # Scriptname: tellme
1   read age?"How old are you? "
2   if (( age < 0 || age > 120 ))
    then
       print "Welcome to our planet! "
       exit 1
    fi
3   if (( age >= 0 && age < 13 ))
    then
       print "A child is a garden of verses"
    elif (( age > 12 && age < 20 ))
```

```
    then
       print "Rebel without a cause"
    elif (( age >= 20 && age < 30 ))
    then
       print "You got the world by the tail!!"
    elif (( age >= 30 && age < 40 ))
    then
       print "Thirty something..."
4   else
       print "Sorry I asked"
5   fi

(The Output)
$ tellme
How old are you? 200
Welcome to our planet!

$ tellme
How old are you? 13
Rebel without a cause

$ tellme
How old are you? 55
Sorry I asked
```

EXPLANATION

1. The user is asked for input. The input is assigned to the variable age.
2. A numeric test is performed within the double parentheses. If age is less than zero or greater than 120, the print command is executed and the program terminates with an exit status of one. The interactive shell prompt will appear. Note that the dollar sign ($) is not required to perform variable substitution when using the (( )) operators.
3. A numeric test is performed within the double parentheses. If age is greater than zero and less than 13, the let command returns exit status zero, true.
4. The else construct is the default. If none of the above statements are true, the else commands will be executed.
5. The fi terminates the initial if statement.

The exit Command. The exit command is used to terminate the script and get back to the command line. You may want the script to exit if some condition does not test true. The argument to the exit command is an integer, ranging from zero to 255. When the program exits, the exit number is stored in the shell's ? variable.

Example 10.92

```
(The Script)
    #!/bin/ksh
    # Scriptname: filecheck
    # Purpose: Check to see if a file exists,what type it is,
    # and its permissions.

1   file=$1      # Variable is set to first command line argument
2   if [[ ! -a $file ]]
    then
       print "$file does not exist"
       exit 1
    fi
3   if [[ -d $file ]]
    then
```

```
       print "$file is a directory"
4   elif [[ −f $file ]]
    then
5       if [[ −r $file && −w $file && −x $file ]]
        then
           print "You have read, write, and execute permission on
           file $file"
        else
6          print "You don't have the correct permissions"
           exit 2
        fi
    else
7       print "$file is neither a file nor a directory. "
        exit 3
8   fi

(The Command Line)
9   $ filecheck testing
    testing does not exist
10  $ echo $?
    1
```

EXPLANATION

1. The first command line argument passed to this program ($1) is assigned to the variable file.
2. The test command follows the if. If $file (after variable substitution) is a file that does not exist (note the not operator, !), the commands under the then keyword are executed. An exit value of one means that the program failed in some way (in this case, the test failed).
3. If the file is a directory, print that it is a directory.
4. If the file is not a directory, else if the file is a plain file, then…
5. If the file is readable, writeable, and executable, then…
6. The fi terminates the innermost if command. The program exits with an argument of two if the file does not have read, write, and execute permission.
7. The else commands are executed if lines 2 and 3 fail. The program exits with a value of three.
8. This fi goes with the if on line 3 in the example.
9. The file called testing does not exist.
10. The $? variable holds the exit status, one.

The null Command. The null command is a colon. It is a built−in, do−nothing command that returns an exit status of zero. It is used as a placeholder after an if command when you have nothing to say, but need a command or the program will produce an error message because it requires something after the then statement. Often the null command is used as an argument to the loop command to make the loop a forever loop or for testing variable expression modifiers such as {EDITOR:–/bin/vi}.

Example 10.93

```
(The Script)
1   name=Tom
2   if grep "$name" databasefile > /dev/null 2>&1
    then
3       :
4   else
        print "$1 not found in databasefile"
        exit 1
    fi
```

EXPLANATION

1. The string Tom is assigned to the variable name.
2. The if command tests the exit status of the grep command. If Tom is found in databasefile, the null command is executed and does nothing.
3. The colon is the null command. It always exits with a zero exit status.
4. What we really want to do is print an error message and exit if Tom is not found. The commands after the else will be executed if the grep command fails.

Example 10.94

```
(The Script)
1   : ${EDITOR:=/bin/vi}
2   echo $EDITOR
```

EXPLANATION

1. The colon command takes an argument that is evaluated by the shell. The expression ${EDITOR:=/bin/vi} is used as an argument to the colon command. If the variable EDITOR has been previously set, its value will not be changed; if it has not been set, the value /bin/vi will be assigned to it. The Korn shell would have responded with an error such as ksh: /bin/vi: not found if the colon command had not preceded the expression.
2. The value of the EDITOR variable is displayed.

10.2.7 The case Command

The case command is a multiway branching command used as an alternative to the if/elif commands. The value of the case variable is matched against value1, value2, and so forth until a match is found. When a value matches the case variable, the commands following the value are executed until the double semicolons are reached. Then, instruction starts after the word esac (case spelled backwards).

If a case variable is not matched, the program executes commands after the *) , the default value, until the double semicolons or esac is reached. The *) value serves the same purpose as the else statement in if/else conditionals. The case values can use shell wildcards and the vertical bar (pipe symbol) for oring two values.

FORMAT

```
case variable
value1)
    command(s);;
value2)
    command(s);;
*)
    command(s);;
esac
```

Example 10.95

```
(The Script)
    #!/bin/ksh
    # Scriptname: xtermcolor
    # Sets the xterm foreground color (the color of the prompt and
    # input typed for interactive windows.
1   read color?"Choose a foreground color for your terminal?"
```

```
2   case "$color" in
3   *[Bb]l??)
4       xterm −fg blue −fn terminal &
5           ;;
6   *[Gg]reen)
         xterm −fg darkgreen −fn terminal &
            ;;
7   red | orange)                   # The vertical bar means "or"
       xterm −fg "$color" −fn terminal &
           ;;
8   *)  xterm −fn terminal &        # default
           ;;
9   esac
10  print "Out of case..."
```

EXPLANATION

1. The user is asked for input. The input is assigned to the variable color.
2. The case command evaluates the expression $color.
3. If color begins with a B or b, followed by the letter l and any two characters, the case expression matches the first value. The value is terminated with a single closed parenthesis. The wildcards are shell metacharacters.
4. The statement is executed if the value in line 3 matches the case expression.The xterm command sets the foreground color to blue.
5. The double semicolons are required after the last command in this block of commands. Control branches to line 10, after the semicolons are reached.
6. If the case expression matches a G or g, followed by the letters r−e−e−n, the xterm window foreground color is set to dark green.The double semicolons terminate the block of statements and control branches to line 10.
7. The vertical bar is used as an or conditional operator. If the case expression matches either red or orange, the xterm command is executed.
8. This is the default value. If none of the above values match the case expression, the command(s) after the *) value are executed. The default color for the terminal foreground is black.
9. The esac statement (case spelled backwards) terminates the case command.
10. After one of the values is matched, execution continues here.

The case Command and the here document. Often the here document is used to create a menu. After the user has selected a choice from the menu, the case command is used to match against one of the choices. The Korn shell also provides a select loop for creating menus.

Example 10.96

```
(The .profile File)
    print "Select a terminal type "
1   cat << EOF
        1) vt120
        2) wyse50
        3) ansi
        4) sun
2   EOF
3   read TERM
4   case "$TERM" in
    1)  export TERM=vt120
        ;;
    2)  export TERM=wyse50
```

```
        ;;
    3)  export TERM=ansi
        ;;
    *)  export TERM=sun
        ;;
5   esac
    print "TERM is $TERM"
```

EXPLANATION

1. A here document is used to display a menu of choices.
2. EOF is the user−defined terminator. Input for the here document stops here.
3. The read command waits for user input and assigns it to the TERM variable.
4. The case command evaluates the variable TERM and matches it against one of the numbers in the list. If a match is found, the terminal is set.
5. The case command terminates with esac.

10.2.8 Looping Commands

The looping commands are used to execute a command or group of commands a set number of times, or until a certain condition is met. The Korn shell has four types of loops: the for loop, while loop, until loop, and select loop.

The for Command. The for looping command is used to execute commands for each member of a set of arguments. You might use this loop to execute the same commands on a list of files or usernames. The for command is followed by a user−defined variable, the keyword in, and a list of words. The first time in the loop, the first word from the wordlist is assigned to the variable, and then shifted off. The next time around the loop, the second word is assigned to the variable, and so on. The body of the loop starts at the do keyword and ends at the done keyword. When all of the words in the list have been shifted off, the loop ends and program control continues after the done keyword.

FORMAT

```
for variable in wordlist
do
    command(s)
done
```

Example 10.97

```
(The Script)
1   for pal in Tom Dick Harry Joe
2   do
3       print "Hi $pal"
4   done
5   print "Out of loop"

(The Output)
    Hi Tom
    Hi Dick
    Hi Harry
    Hi Joe
    Out of loop
```

EXPLANATION

1. This for loop will iterate through the list of names, Tom, Dick, Harry, and Joe, shifting each one off (to the left) after it is assigned to the variable pal. As soon as all of the words are shifted and the wordlist is empty, the loop ends and execution starts after the done keyword. The word following the for command, pal, is a variable that will be assigned the value after the in keyword, one at a time, for each iteration of the loop. The first time in the loop, the variable pal will be assigned the word Tom. The second time through the loop, pal will be assigned Dick, the next time pal will be assigned Harry, and the last time, pal will be assigned Joe.
2. The do keyword is required after the wordlist. If it is used on the same line, the list must be terminated with a semicolon. For example:

   for pal in Tom Dick Harry Joe; do
3. This is the body of the loop. After Tom is assigned to the variable pal, the commands in the body of the loop, that is, all commands between the do and the done keywords, are executed.
4. The done keyword ends the loop. If there are no words left to be processed in the wordlist on line 1, the loop exits, and execution starts at line 5.
5. This line is executed when the loop terminates.

Example 10.98

```
(The Command Line)
1   $ cat mylist
    tom
    patty
    ann
    jake
-------------------------------------------------------------


(The Script)
2   for person in $(< mylist)   #same as for person in 'cat mylist'
    do
3         mail $person < letter
          print $person was sent a letter.
4   done
5   print "The letter has been sent."
```

EXPLANATION

1. The contents of a file, called mylist, are displayed.
2. Command substitution is performed and the contents of mylist become the wordlist. The first time in the loop, tom is assigned to the variable person, and then shifted off, to be replaced with patty, and so on.
3. In the body of the loop, each user is mailed a copy of a file called letter.
4. The done keyword marks the end of this loop iteration.
5. When all of the users in the list have been sent mail, the loop will exit, and this line will be executed.

Example 10.99

```
1   for file in *.c
2   do
        if [[ -f $file ]] ; then
           cc $file -o ${file%.c}
        fi
    done
```

EXPLANATION

1. The wordlist will consist of all files in the current working directory ending with the extension .c (C source files). Each filename will be assigned to variable file, in turn, for each iteration of the loop.
2. When the body of the loop is entered, the file will be tested to make sure it exists and is a real file. If so, it will be compiled. ${file%.c} expands to the filename without its extension.

The $* and $@ Variables in Wordlists. When expanded, the $* and $@ are the same unless enclosed in double quotes. "$*" evaluates to one string, whereas "$@" evaluates to a list of separate words.

Example 10.100

```
(The Script)
    #!/bin/ksh
1   for name in $*     # or for name in $@
2   do
        echo Hi $name
3   done
-----------------------------------------------------------------
(The Command Line)
$ greet Dee Bert Lizzy Tommy
Hi Dee
Hi Bert
Hi Lizzy
Hi Tommy
```

EXPLANATION

1. $* and $@ expand to a list of all the positional parameters, in this case, the arguments passed in from the command line: Dee, Bert, Lizzy, and Tommy. Each name in the list will be assigned, in turn, to the name variable in the for loop.
2. The commands in the body of the loop are executed until the list is empty.
3. The done keyword marks the end of the loop body.

The while Command. The while evaluates the command immediately following it, and if its exit status is zero, the commands in the body of the loop (commands between do and done) are executed. When the done keyword is reached, control is returned to the top of the loop and the while command checks the exit status of the command again. Until the exit status of the command being evaluated by the while becomes nonzero, the loop continues. When the exit status reaches nonzero, program execution starts after the done keyword. If the exit status never becomes nonzero, the loop goes around and around infinitely. (Of course, pressing Control−C or Control−\ will stop the looping.)

FORMAT

```
while command
do
   command(s)
done
```

Example 10.101

```
(The Script)
1   num=0                   # Initialize num
2   while (( num < 10 ))    # Test num with the let
    do
       print −n $num
3      (( num=num + 1 ))      # Increment num
    done
    print "\nAfter loop exits, continue running here"

(The Output)
0123456789
After loop exits, continue running here
```

EXPLANATION

1. This is the initialization step. The variable num is assigned zero.
2. The while command is followed by the let command. If the value of num is less than 10, the body of the loop is entered.
3. In the body of the loop, the value of num is incremented by one. If the value of num was never changed, the loop would iterate infinitely or until the process was killed.

Example 10.102

```
(The Script)
    #!/bin/ksh
    # Scriptname: quiz
1   read answer?"Who was the U.S. President in 1992? "
2   while [[ $answer != "Bush" ]]
3   do
        print "Wrong try again!"
4       read answer
5   done
6   print Good guess!

(The Output)
$ quiz
Who was the U.S. President in 1992? George
Wrong try again!
Who was the U.S. President in 1992? I give up
Wrong try again!
Who was the U.S. President in 1992? Bush
Good guess!
```

EXPLANATION

1. The read command prints the string after the question mark (?), Who was the U.S. President in 1992?, and waits for input from the user. The input will be stored in the

variable answer.
2. The while loop is entered and the test command, [[, evaluates the expression. If the variable answer does not equal the string Bush, the body of the loop is entered and commands between the do and done are executed.
3. The do keyword is the start of the loop body.
4. The user is asked to reenter input.
5. The done keyword marks the end of the loop body. Control is returned to the top of the while loop, and the expression is tested again. As long as $answer does not evaluate to Bush, the loop will continue to iterate. When the user's input is Bush, the loop ends. Program control goes to line 6.

Example 10.103

```
(The Script)
1   go=1
    print Type q to quit.
2   while let go or (( go ))
    do
       print I love you.
       read word
3      if [[ $word = [qQ]* ]]
       then
           print "I'll always love you"
4          go=0
        fi
5    done

(The Output)
$ sayit
Type q to quit.
I love you.
I love you.
I love you.
I love you.
I love you.
q
I'll always love you
$
```

EXPLANATION

1. The variable go is assigned 1.
2. The loop is entered. The let command tests the expression. The expression evaluates to one. The program goes into the body of the while loop and executes commands from the do keyword to the done keyword.
3. If the user enters a q or Q as input to the variable word, the commands between then and fi are executed. Anything else will cause I love you. to be displayed.
4. The variable go is assigned zero. When program control starts at the top of the while loop, the expression will be tested. Since the expression evaluates to false, the loop exits and the script starts execution after the done keyword on line 5.
5. The done marks the end of the body of the loop.

The until Command. The until command is used like the while command, but evaluates the exit status in the opposite way. The until evaluates the command immediately following it, and if its exit status is not zero, the commands in the body of the loop (commands between do and done) are executed. When the done keyword is reached, control is returned to the top of the loop and the until command checks the exit status of the command again. Until the exit status of the command being evaluated by until becomes zero, the loop continues. When the exit status reaches zero, program execution starts after the done keyword.

FORMAT

```
until command
do
   command(s)
done
```

Example 10.104

```
    #!/bin/ksh
1   until who | grep linda
2   do
       sleep 5
3   done
    talk linda@dragonwings
```

EXPLANATION

1. The until loop tests the exit status of the last command in the pipeline, grep. The who command lists who is logged on this machine and pipes its output to grep. The grep command will return zero exit status (success) only when it finds user linda.
2. If user linda has not logged in, the body of the loop is entered and the program sleeps for 5 seconds.
3. When linda logs on, the exit status of the grep command will be zero and control will go to the statements following the done keyword.

Example 10.105

```
    #!/bin/ksh
1   hour=0
2   until (( hour > 23 ))
    do
3      case "$hour" in
       [0−9]|1[0−1]) print "Good morning!"
              ;;
       12) print "Lunch time"
              ;;
       1[3−7]) print "Siesta time"
              ;;
       *) print "Good night"
              ;;
       esac
4      (( hour+=1 ))
5   done
```

EXPLANATION

1. The hour variable is assigned zero. The variable must be initialized before being used in the until loop.
2. The until command is followed by the let command. If the hour is not greater than 23, that is, the exit status is nonzero, the loop body is entered.

3. The case command matches the value of the hour variable against one of the hour values, or matches the default, executing the command that applies.
4. The hour is incremented by one; otherwise, the hour will never become greater than 23 and the loop will never exit. Control is returned to the until command and the hour is evaluated again.
5. The done keyword marks the end of the loop. When the hour is greater than 23, control will go to the line under the done, if there is one; otherwise, the program is exited.

The select Command and Menus. The here document is an easy method for creating menus, but the Korn shell introduces a new loop, called the select loop, which is used primarily for creating menus. A menu of numerically listed items is displayed to standard error. The PS3 prompt is used to prompt the user for input; by default, PS3 is #?. After the PS3 prompt is displayed, the shell waits for user input. The input should be one of the numbers in the menu list. The input is stored in the special Korn shell REPLY variable. The number in the REPLY variable is associated with the string to the right of the parentheses in the list of selections.[7]

The case command is used with the select command to allow the user to make a selection from the menu and, based on that selection, execute commands. The LINES and COLUMNS variables can be used to determine the layout of the menu items displayed on the terminal. The output is displayed to standard error, each item preceded by a number and closing parenthesis, and the PS3 prompt is displayed at the bottom of the menu. Since the select command is a looping command, it is important to remember to use either the break command to get out of the loop, or the exit command to exit the script.

FORMAT

```
select var in wordlist
do
   command(s)
done
```

Example 10.106

```
(The Script)
    #!/bin/ksh
    # Program name: goodboys
1   PS3="Please choose one of the three boys : "
2   select choice in tom dan guy
3   do
4       case $choice in
        tom)
            print Tom is a cool dude!
5           break;;         # break out of the select loop
6        dan | guy )
            print Dan and Guy are both sweethearts.
            break;;
         *)
7           print " $REPLY is not one of your choices" 1>&2
            print "Try again."
            ;;
8       esac
9   done

(The Command Line)
$ goodboys
1) tom
2) dan
```

```
3) guy
Please choose one of the three boys : 2
Dan and Guy are both sweethearts.

$ goodboys
1) tom
2) dan
3) guy
Please choose one of the three boys : 4
4 is not one of your choices
Try again.
Please choose one of the three boys : 1
Tom is a cool dude!
$
```

EXPLANATION

1. The PS3 variable is assigned the prompt that will appear below the list of menu selections. After the prompt is displayed, the program waits for user input. The input is stored in the built−in variable called REPLY.
2. The select command is followed by the variable choice. This syntax is similar to that of the for loop. The variable choice is assigned, in turn, each of the items in the list that follows it, in this case, tom, dan, and guy. It is this wordlist that will be displayed in the menu, preceded by a number and a right parenthesis.
3. The do keyword indicates the start of the body of the loop.
4. The first command in the body of the select loop is the case command. The case command is normally used with the select loop. The value in the REPLY variable is associated with one of the choices: 1 is associated with tom, 2 is associated with dan, and 3 is associated with guy.
5. If tom is the choice, after printing the string Tom is a cool dude!, the break command causes the select loop to be exited. Program control starts after the done keyword.
6. If either menu item, 2 (dan) or 3 (tom), is selected, the REPLY variable contains the user's selection. If the selection is not 1, 2, or 3, an error message is sent to standard error. The user is asked to try again and control starts at the beginning of the select loop.
7. The end of the case command.
8. The end of the select loop.

Example 10.107

```
(The Script)
    #!/bin/ksh
    # Program name: ttype
    # Purpose: set the terminal type
    # Author: Andy Admin
1   COLUMNS=60
2   LINES=1
3   PS3="Please enter the terminal type: "
4   select choice in wyse50 vt200 vt100 sun
    do
5      case $REPLY in
       1)
6          export TERM=$choice
           print "TERM=$choice"
           break;;               # break out of the select loop
       2 | 3 )
           export TERM=$choice
           print "TERM=$choice"
```

```
            break;;
        4)
            export TERM=$choice
            print "TERM=$choice"
            break;;
        *)
7           print "$REPLY is not a valid choice. Try again" 1>&2
                 ;;
         esac
8   done

(The Command Line)
$ ttype
1) wyse50    2) vt200   3) vt100    4) sun
Please enter the terminal type : 4
TERM=sun

$ ttype
1) wyse50    2) vt200   3) vt100    4) sun
Please enter the terminal type : 3
TERM=vt100

$ ttype
1) wyse50    2) vt200   3) vt100    4) sun
Please enter the terminal type : 7
7 is not a valid choice. Try again.
Please enter the terminal type: 2
TERM=vt200
```

EXPLANATION

1. The COLUMNS variable is set to the width of the terminal display in columns for menus created with the select loop. The default is 80.
2. The LINES variable controls the vertical display of the select menu on the terminal. The default is 24 lines. By changing the LINES value to 1, the menu items will be printed on one line, instead of vertically as in the last example.
3. The PS3 prompt is set and will appear under the menu choices.
4. The select loop will print a menu with four selections: wyse50, vt200, vt100, and sun. The variable choice will be assigned one of these values based on the user's response held in the REPLY variable. If REPLY is 1, wyse50 is assigned to choice; if REPLY is 2, vt200 is assigned to choice; if REPLY is 3, vt100 is assigned to choice; and if REPLY is 4, sun is assigned to choice.
5. The REPLY variable evaluates to the user's input selection.
6. The terminal type is assigned, exported, and printed.
7. If the user does not enter a number between 1 and 4, he or she will be prompted again. Note that the menu does not appear, just the PS3 prompt. To make the menu reappear, set the REPLY variable to null. Type above line 8: REPLY =
8. The end of the select loop.

Looping Commands. If some condition occurs, you may want to break out of a loop, return to the top of the loop, or provide a way to stop an infinite loop. The Korn shell provides loop control commands to control loops.

The shift Command. The shift command shifts the parameter list to the left a specified number of times. The shift command without an argument shifts the parameter list once to the left. Once the list is shifted, the parameter is removed permanently. Often the shift command is used in while loops when iterating through a list of positional parameters.

FORMAT

```
shift [n]
```

Example 10.108

```
(Without a Loop)
(The Script)
    #!/bin/ksh
    # Scriptname: doit0
1   set joe mary tom sam
2   shift
3   print $*
4   set $(date)
5   print $*
6   shift 5
7   print $*
8   shift 2

(The Output)
    $ doit0
3   mary tom sam
5   Sun Sep 9 10:00:12 PDT 2001
7   2001
8   ksh: shift: bad number
```

EXPLANATION

1. The set command sets the positional parameters. $1 is assigned joe, $2 is assigned mary, $3 is assigned tom, and $4 is assigned sam.
2. The shift command shifts the positional parameters to the left; joe is shifted off.
3. The parameter list is printed after the shift. $* represents all of the parameters.
4. The set command resets the positional parameters to the output of the UNIX date command.
5. The new parameter list is printed.
6. This time the list is shifted five times to the left.
7. The new parameter list is printed.
8. By attempting to shift more times than there are parameters, the shell sends a message to standard error.

Example 10.109

```
(With a Loop)
(The Script)
    #!/bin/ksh
    # Usage: doit [args]
1   while (( $# > 0 ))
    do
2      print $*
3      shift
4   done
(The Command Line)
$ doit a b c d e
a b c d e
b c d e
```

```
c d e
d e
e
```

EXPLANATION

1. The while command tests the numeric expression. If the number of positional parameters ($#) is greater than zero, the body of the loop is entered. The positional parameters are coming from the command line as arguments. There are five.
2. All the positional parameters are printed.
3. The parameter list is shifted once to the left.
4. The body of the loop ends here; control returns to the top of the loop. The parameter list has decreased by one. After the first shift, $# is four. When $# has been decreased to zero, the loop ends.

The break Command. The built−in break command is used to force immediate exit from a loop, but not from a program. (To leave a program, the exit command is used.) After the break command is executed, control starts after the done keyword. The break command causes an exit from the innermost loop, so if you have nested loops, the break command takes a number as an argument, allowing you to exit out of any number of outer loops. The break is useful for exiting from an infinite loop.

Format

```
break [n]
```

Example 10.110

```
1   while true; do
2       read answer? Are you ready to move on\?
3       if [[ $answer = [Yy]* ]]; then
            break
4       else
            ....commands...
        fi
5   done
6   print 'Here we are'
```

EXPLANATION

1. The true command is a UNIX command, and an alias for the colon command in the Korn shell. It always exits with zero status and is often used to start an infinite loop. (The null command (:) can be used to do the same thing.) The body of the loop is entered.
2. The user is asked for input. The user's input is assigned to the variable answer.
3. If answer evaluates to Y, y, Yes, Yup, or Ya (anything beginning with Y or y), the break command is executed and control goes to line 6. The line Here we are is printed. Until the user answers something that starts with a Y or y, the program will continue to ask for input. This could go on forever!
4. If the test fails in line 3, the else commands are executed. When the body of the loop ends at the done keyword, control starts again at the top of the while at line 1.
5. The end of the loop body.
6. Control starts here after the break command is executed.

The continue Command. The continue command starts back at the top of the loop if some condition becomes true. All commands below the continue will be ignored. The continue command returns control to the top of the innermost loop; if nested within a number of loops, the continue command may take a number as its argument. Control can be started at the top of any number of outer loops.

FORMAT

```
continue [n]
```

Example 10.111

```
(The Mailing List)
$ cat mail_list
ernie
john
richard
melanie
greg
robin

(The Script)
    # Scriptname: mailtomaillist
    #!/bin/ksh
1   for name in $(< mail_list)
    do
2     if [[ "$name" = "richard" ]] then
3          continue
      else
4          mail $name < memo
      fi
5   done
```

EXPLANATION

1. The for loop will iterate through a list of names stored in a file called mail_list. Each time a name from the list is assigned to the variable name, it is shifted off the list and replaced by the next name on the list.
2. The name matches richard; the continue command is executed. Since richard has already been shifted off, the next user, melanie, is assigned to the variable name.
3. The continue command returns control to the top of the loop, skipping any commands in the rest of the loop body.
4. All users in the list, except richard, will be mailed a copy of the file memo.
5. The end of loop body.

Nested Loops. If using nested loops, the break and continue commands let you control which loop to terminate.

Example 10.112

```
(The Script)
    #!/bin/ksh
1   while true ; do
            < Commands here>
2       for user in tom dick harry joe
        do
            if [[ $user = [Dd]* ]]
            then
3               continue 2
                    < Commands here >
4                   while true
                    do
                        < Commands here>
5                       break 3
6                   done
7           fi
        done
8   done
9   print Out of loop
```

EXPLANATION

1. The true command always returns an exit status of zero. The loop is designed to go forever unless you use loop control commands.
2. The for loop is entered.
3. The for loop will loop through each of the names in the list. If the user variable begins with a D or d, the continue command causes control to go to the top of the while loop. Without an argument, the continue command would start control at the top of the for loop. The argument 2 tells the shell to go to the top of the second enclosing loop and restart execution there.
4. The while loop is nested. The true command always exits with zero status. The loop will go forever.
5. The break command terminates the outermost while loop. Execution starts at line 9.
6. The done keyword marks the end of the innermost while loop.
7. This done keyword marks the end of the for loop.
8. This done keyword marks the end of outermost while loop.
9. Out of the loop.

I/O Redirection and Loops. The Korn shell allows you to use redirection and pipes in loops. Unlike the Bourne shell, the loop runs in this shell, not a subshell. Variables set within the loop will still be set when the loop exits.

Redirect the Output of a Loop to a File. Instead of sending the output of a loop to the screen, it can be redirected to a file or a pipe. See Example 10.113.

Example 10.113

```
    (The Command Line)
1   $ cat memo
    abc
    def
    ghi
------------------------------------------------------------------
(The Script)
    #!/bin/ksh
    # Program name: numberit
```

```
    # Put line numbers on all lines of memo
2   if (( $# < 1 ))
    then
        print "Usage: $0 filename " >&2
        exit 1
    fi
3   integer count=1              # Initialize count
4   cat $1 | while read line     # Input is coming from memo
    do
5       (( count == 1 )) && print "Processing file $1..." > /dev/tty
6       print $count $line
7       (( count+=1 ))
8   done > tmp$$                 # Output is going to a temporary file
9   mv tmp$$ $1

(The Command Line)
10  $ numberit memo
    Processing file memo...

11  $ cat memo
    1 abc
    2 def
    3 ghi
```

EXPLANATION

1. The contents of file memo are displayed.
2. If the number of arguments is less than one, a usage message is sent to standard error, the screen.
3. The count variable is declared an integer and is assigned the value 1.
4. The UNIX cat command displays the contents of the filename stored in $1, and the output is piped to the while loop. The read command is assigned the first line of the file the first time in the loop, the second line of the file the next time through the loop, and so forth.
5. The output of this print statement is sent to /dev/tty, the screen. If not explicitly redirected to /dev/tty, the output will be redirected to tmp$$ on line 8.
6. The print function prints the value of count, followed by the line in the file.
7. The count variable is incremented by 1.
8. The output of this entire loop, with the exception of line 3, is redirected to the file tmp$$ (where $$ evaluates to the PID of this process). The tmp file is given a unique name by appending the PID of this process to its name.
9. The tmp file is renamed to the name of the file that was assigned to $1.
10. The program is executed. The file to be processed is called memo.
11. The file is displayed with line numbers.

Pipe the Output of a Loop to a UNIX Command. The output of a loop can be redirected from the screen to a pipe. See Example 10.114.

Example 10.114

```
(The Script)
1   for i in 7 9 2 3 4 5
2   do
       print $i
3   done | sort –n

(The Output)
2
```

```
3
4
5
7
9
```

EXPLANATION

1. The for loop iterates through a list of unsorted numbers.
2. In the body of the loop, the numbers are printed. This output will be piped into the UNIX sort command.
3. The pipe is created after the done keyword.

Running Loops in the Background. If the loop is going to take a while to process, it can be run as a background job so that the rest of the program can continue.

Example 10.115

```
1   for person in bob jim joe sam
    do
2      mail $person < memo
3   done &
```

EXPLANATION

1. The for loop shifts through each of the names in the wordlist: bob, jim, joe, and sam. Each of the names is assigned to the variable person, in turn.
2. In the body of the loop, each person is sent the contents of the file memo.
3. The ampersand at the end of the done keyword causes the loop to be executed in the background. The program will continue to run while the loop is executing.

The exec Command and Loops. The exec command can be used to close standard input or output without creating a subshell.

Example 10.116

```
(The File)
1   cat tmp
    apples
    pears
    bananas
    peaches
    plums
-----------------------------------------------------------
(The Script)
    #!/bin/ksh
    # Scriptname: speller
    # Purpose: Check and fix spelling errors in a file
    #

2   exec < tmp         # Opens the tmp file
3   while read line    # Read from the tmp file
    do
4       print $line
5       print –n "Is this word correct? [Y/N] "
6       read answer < /dev/tty    # Read from the terminal
        case $answer in
```

```
        [Yy]*)
            continue
               ;;
        *)
            print "New word? "
7           read word < /dev/tty
            sed "s/$line/$word/" tmp > error
            mv error tmp

8           print $word has been changed.
                ;;
        esac
    done
```

EXPLANATION

1. The contents of the tmp file are displayed.
2. The exec command changes standard input (file descriptor 0), so that instead of input coming from the keyboard, it is coming from the tmp file.
3. The while loop starts. The read command gets a line of input from the tmp file.
4. The value stored in the line variable is printed to the screen.
5. The user is asked if the word is correct.
6. The read command gets the user's response from the terminal, /dev/tty. If the input is not redirected directly from the terminal, it will continue to be read from the file tmp, still opened for input.
7. The user is again asked for input, and the input is redirected from the terminal, /dev/tty.
8. The new word is displayed.

The IFS and Loops. The IFS, the shell's internal field separator, evaluates to spaces, tabs, and the newline character. It is used as a word (token) separator for commands that parse lists of words such as read, set, for, and select. It can be reset by the user if a different separator will be used in a list. It is a good idea to save the original value of the IFS in another variable before changing it. Then it is easy to return to its default value.

Example 10.117

```
(The Script)
    #!/bin/ksh
    # Script is called runit.
    # IFS is the internal field separator and defaults to
    # spaces, tabs, and newlines.
    # In this script it is changed to a colon.
1   names=Tom:Dick:Harry:John
2   OLDIFS="$IFS"             # Save the original value of IFS
3   IFS=":"
4   for persons in $names
    do
5       print Hi $persons
    done
6   IFS="$OLDIFS"             # Reset the IFS to old value

7   set Jill Jane Jolene      # Set positional parameters
8   for girl in $*
    do
        print Howdy $girl
    done

(The Output)
$ runit
```

```
Hi Tom
Hi Dick
Hi Harry
Hi John
Howdy Jill
Howdy Jane
Howdy Jolene
```

EXPLANATION

1. The names variable is set to the string Tom:Dick:Harry:John. Each of the words is separated by a colon.
2. The value of IFS is assigned to another variable, OLDIFS. Since the value of the IFS is whitespace, it must be quoted to preserve the whitespace.
3. The IFS is assigned a colon. Now the colon is used to separate words.
4. After variable substitution, the for loop will iterate through each of the names using the colon as the internal field separator between the words.
5. Each of the names in the wordlist is displayed.
6. IFS is reassigned its original values, stored in OLDIFS.
7. The positional parameters are set. $1 is assigned Jill, $2 is assigned Jane, and $3 is assigned Jolene.
8. $* evaluates to all the positional parameters, Jill, Jane, and Jolene. The for loop assigns each of the names to the girl variable, in turn, through each iteration of the loop.

10.2.9 Arrays

Korn shell arrays are one−dimensional arrays that may contain up to 1,024 (size varies) elements consisting of words or integers. The index starts at zero. Each element of an array can be set or unset individually. Values do not have to be set in any particular order. For example, you can assign a value to the tenth element before you assign a value to the first element. An array can be set using the set command with the –A option.

Associative arrays are supported under versions of the Korn shell that are more recent than 1988.

Example 10.118

```
(The Command Line)
1   $ array[0]=tom
    $ array[1]=dan
    $ array[2]=bill

2   $ print ${array[0]}     # Curly braces are required.
    tom

3   $ print ${array[1]}
    dan

4   $ print ${array[2]}
    bill

5   $ print ${array[*]}     # Display all elements.
    tom dan bill

6   $ print ${#array[*]}    # Display the number of elements.
    3
```

EXPLANATION

1. The first three elements of the array are assigned values. The index starts at zero.
2. The value of the first array element, tom, is printed. Make sure you remember to surround the variable with curly braces. $array[0] would print tom[0].
3. The value of the second element of the array, dan, is printed.
4. The value of the third element of the array, bill, is printed.
5. All elements in the array are printed.
6. The number of elements in the array are printed. An array can be declared with typeset if you know the size and type.

Example 10.119

```
(At The Command Line)
1  $ typeset –i ints[4]     # Declare an array of four integers.
2  $ ints[0]=50
   $ ints[1]=75
   $ ints[2]=100
3  $ ints[3]=happy
   ksh: happy: bad number
```

EXPLANATION

1. The typeset command creates an array of 4 integers.
2. Integer values are assigned to the array.
3. A string value is assigned to the fourth element of the array, and the Korn shell sends a message to standard error.

Creating Arrays with the set Command. You can assign the values of an array using the set command. The first word after the –A option is the name of the array; the rest of the words are the elements of the array.

Example 10.120

```
(The Command Line)
1   $ set –A fruit apples pears peaches

2   $ print ${fruit[0]}
    apples

3   $ print ${fruit[*]}
    apples pears peaches

4   $ fruit[1]=plums

5   $ print ${fruit[*]}
    apples plums peaches
```

EXPLANATION

1. The set command with the –A option creates an array. The name of the array, fruit, follows the –A option. Each of the elements of the fruit array follow its name.
2. Subscripts start at zero. Curly braces are required around the variable for it to be evaluated properly. The first element of the array is printed.
3. When the asterisk is used as a subscript, all elements of the array are displayed.

4. The second element of the array is reassigned the value plums.
5. All elements of the array are displayed.

10.2.10 Functions

Korn shell functions are similar to those used in the Bourne shell, and are used to modularize your program. A function is a collection of one or more commands that can be executed simply by entering the function's name, similar to a built−in command. Here is a review of some of the important rules about using functions.

1. The Korn shell executes built−in commands first, then functions, and then executables. Functions are read into memory once when they are defined, not every time they are referenced.
2. A function must be defined before it is used; therefore, it is best to place function definitions at the beginning of the script.
3. The function runs in the current environment; it shares variables with the script that invoked it, and lets you pass arguments by setting them as positional parameters. The present working directory is that of the calling script. If you change the directory in the function, it will be changed in the calling script.
4. In the Korn shell, you can declare local variables in the function using the typeset command. Ksh functions can be exported to subshells.
5. The return statement returns the exit status of the last command executed within the function or the value of the argument given, and cannot exceed a value of 255.
6. To list functions and definitions, use the preset alias, functions.
7. Traps are local to functions and will be reset to their previous value when the function exits (not so with the Bourne shell).
8. Functions can be recursive, that is, call themselves. Recursion should be handled carefully. The Korn shell will warn you otherwise with the message, recursion too deep.
9. Functions can be autoloaded; they are defined only if referenced. If never referenced, they are not loaded into memory.
10. Versions of the Korn shell that are more recent than 1988 also support discipline functions, passing variables by reference, and compound variables. A built−in command is no longer found before a function of the same name. In older versions it was necessary to use a combination of aliases and functions to write a function that would override a built−in command.[8]

Defining Functions. A function must be defined before it can be invoked. Korn shell functions are defined with the keyword function preceding the function name. The curly braces must have a space on the inside of each brace. (Please see Bourne shell functions for the older−style function definition, still compatible in Korn shell scripts.)

FORMAT

```
function function_name { commands; commands; }
```

Example 10.121

```
function usage { print "Usage $0 [−y] [−g] " ; exit 1; }
```

EXPLANATION

The function name is usage. It is used to print a diagnostic message and exit the script if the script does not receive the proper arguments, either –y or –g.

Listing and Unsetting Functions. To list local function definitions, type: typeset –f. To list exported function definitions, type: typeset –fx. To unset a function, type: unset –f function_name. See the typeset command, Table 10.30.

Local Variables and the Return Value. The typeset command can be used to create local variables. These variables will be known only in the function where they are created. Once out of the function, the local variables are undefined.

The return value of a function is really just the value of the exit status of the last command in the script unless a specific return command is used. If a value is assigned to the return command, that value is stored in the ? variable. It can hold an integer value between 0 and 255. Because the return command is limited to returning only integer values, you can use command substitution to return the output of a function and assign the output to a variable, just as you would if getting the output of a UNIX command.

Example 10.122

```
(The Script)
    #!/bin/ksh
    # Scriptname: do_increment
    # Using the return Command)
1   function increment {
2      typeset sum       # sum is a local variable.
       (( sum = $1 + 1 ))
3      return $sum       # Return the value of sum to the script.
    }

    print -n "The sum is "
4   increment 5          # Call the function increment and pass 5 as a
                         # parameter. 5 becomes $1 for the increment
                         # function.
5   print $?             # The return value is stored in the ? variable
6   print $sum           # The variable "sum" was local to the
                         # function, and is undefined in the main
                         # script. Nothing is printed.

(The Output)
    $ do_increment
5   The sum is 6
    6
```

EXPLANATION

1. The function called increment is defined.
2. The typeset command defines the variable sum to be local to this function.
3. The return built−in command, when given an argument, returns to the main script after the line where the function was invoked and stores its argument in the ? variable. In the script, the increment function is called with an argument.
4. The increment function is called with an argument of 5.
5. The exit status of the function is stored in ? unless an explicit argument is given to the return command. The return command argument specifies a return status for the function, its value is stored in the ? variable, and it must be an integer between 0 and 255.
6. Since sum was defined as a local variable in the function increment, it is not defined in the script that invoked the function. Nothing is printed.

Example 10.123

```
(Using Command Substitution)
(The Script)
    # Scriptname: do_square
    #!/bin/ksh
1   function square {
     (( sq = $1 * $1 ))
       print "Number to be squared is $1."
2      print "The result is $sq "
    }

3   read number?"Give me a number to square. "
4   value_returned=$(square $number)
5   print $value_returned

(The Output)
    $ do_square
5   Number to be squared is 10. The result is 100
```

EXPLANATION

1. The function called square is defined. It will multiply its argument times itself.
2. The result of squaring the number is printed.
3. The user is asked for input.
4. The function square is called with a number (input from the user) as its argument. Command substitution is performed because the function is enclosed in parentheses preceded by a $. The output of the function (both of its print statements) is assigned to the variable value_returned.
5. The command substitution removes the newline between the strings Number to be squared is and The result is 100.

Exported Functions. Function definitions are not inherited by subshells unless you define them in the ENV file with the typeset command, e.g., typeset –fx function_names.

You can export functions with typeset –fx from the current Korn shell to a script, or from one script to another, but not from one invocation of ksh to the next (e.g., a separate invocation means that if you type ksh at the prompt, a brand new shell is started up). Exported function definitions will not be inherited by the new shell.

Example 10.124

```
(The First Script)
    $ cat calling_script
    #!/bin/ksh

1   function sayit { print "How are ya $1?" ; }
2   typeset –fx sayit   # Export sayit to other scripts
3   sayit Tommy
4   print "Going to other script"
5   other_script        # Call other_script
    print "Back in calling script"
****************************************************************
(The Second Script)
    $ cat other_script
           NOTE: This script cannot be invoked with #!/bin/ksh
6   print "In other script "
```

```
7   sayit Dan
8   print "Returning to calling script"

(The Output)
    $ calling_script
3   How are ya Tommy?
4   Going to other script
6   In other script
7   How are ya Dan?
8   Returning to calling script
    Back in calling script
```

EXPLANATION

1. The function sayit is defined. It will accept one argument to be stored in $1.
2. The typeset command with the –fx option allows the function to be exported to any script called from this script.
3. The function sayit is invoked with Tommy as an argument. Tommy will be stored in $1 in the function.
4. After the sayit function terminates, the program resumes here.
5. The script, called other_script, is executed.
6. We are now in the other script. This script is called from the first script, sayit. It cannot start with the line #!/bin/ksh because this line causes a ksh subshell to be started, and exporting functions does not work if a separate Korn shell is invoked.
7. The function sayit is invoked. Dan is passed as an argument, which will be stored in $1 in the function.
8. After this line is printed, other_script terminates and control goes back to the calling script at the line where it left off after the function was invoked.

10.2.11 The typeset Command and Function Options

The typeset command is used to display function attributes.

Table 10.30. typeset and Function Options

Option	What It Does
typeset –f	Displays all functions and their values. Must have a history file, as all function definitions are stored there.
typeset +f	Displays just function names.
typeset –fx	Displays all function definitions that will be exported across shell scripts, but not as a separate invocation of ksh.
typeset –fu func	func is the name of a function that has not yet been defined.

Autoloaded Functions. An autoloaded function is not loaded into your program until you reference it. The autoloaded function can be defined in a file somewhere else and the definition will not appear in your script, allowing you to keep the script small and compact. To use autoload, you need to set the FPATH variable in your ENV file. The FPATH variable contains a search path for directories containing function files. The files in this directory have the same names as the functions defined within them.

The autoload alias for typeset –fu specifies that the function names that have not yet been defined are to be autoloaded functions. After the autoload command is executed with the function as its argument, you must invoke the function to execute the commands contained in it. The primary advantage of autoloading functions is better performance, since the Korn shell does not have to read the function definition if it has never been referenced.[9]

Example 10.125

```
(The Command Line)
1   $ mkdir functionlibrary
2   $ cd functionlibrary
3   $ vi foobar

(In Editor)
4   function foobar { pwd; ls; whoami; }  # function has the same
                                          # name as the file.

(In .profile File)
5   export FPATH=$HOME/functionlibrary    # This path is searched for
                                          # functions.

(In Your Script)
6   autoload foobar
7   foobar
```

EXPLANATION

1. Make a directory in which to store functions.
2. Go to the directory.
3. foobar is a file in functionlibrary. The file foobar contains the definition of function foobar. The filename and function name must match.
4. The function foobar is defined in the file called foobar.
5. In the user's .profile initialization file, the FPATH variable is assigned the path where the functions are stored. This is the path the Korn shell will search when autoloading a function. FPATH is exported.
6. In your script, the function foobar is brought into the program's memory.
7. The function foobar is invoked.

A number of functions can be stored in one file; for example, calculation functions may be contained in a file called math. Since the function must have the same name as the file in which it is stored, you may create hard links to the function file. Each function name will be a link to the file in which the function is defined. For example, if a function in the math file is called square, use the UNIX ln command to give the math file another name, square. Now the math file and square file can be referenced, and in either case you are referencing the file by the corresponding function name. Now the square function can be autoloaded by its own name.

Example 10.126

```
(The Command Line)
1   $ ln math square add divide
2   $ ls −i
    12256 add
    12256 math
    12256 square
    12256 divide
3   $ autoload square; square
```

EXPLANATION

1. The UNIX ln (link) command lets you give a file alternate names. The math file and square are the same file. The link count is incremented by one for each link created.
2. A listing shows that all files have the same inode number, meaning they are all one file but can be accessed with different names.
3. Now, when the square file is autoloaded, the function square has the same name and will be invoked. None of the other functions defined in the file can be referenced until they, in turn, have been specifically autoloaded by name.

10.2.12 Trapping Signals

While your program is running, if you press Control−C or Control−\, the program terminates as soon as the signal arrives. There are times when you would rather not have the program terminate immediately after the signal arrives. You could arrange to ignore the signal and keep running, or perform some sort of cleanup operation before actually exiting the script. The trap command allows you to control the way a program behaves when it receives a signal.

A signal is defined as an asynchronous message that consists of a number that can be sent from one process to another, or by the operating system to a process if certain keys are pressed or if something exceptional happens.[10] The trap command tells the shell to terminate the command currently in execution upon the receipt of a signal. If the trap command is followed by commands within single quotes, those commands will be executed upon receipt of a specified signal. Use the command kill –l to get a list of all signals and the numbers corresponding to them.

FORMAT

```
trap 'command; command' signal
```

Example 10.127

```
trap 'rm tmp*$$; exit 1' 1 2 15
```

EXPLANATION

When any of the signals 1 (hangup), 2 (interrupt), or 15 (software termination) arrives, remove all the tmp files and then exit.

If an interrupt comes in while the script is running, the trap command lets you handle the interrupt signal in several ways. You can let the signal behave normally (default), ignore the signal, or create a handler function to be called when the signal arrives. See Table 10.31 for a list of signal numbers and their corresponding names.

Table 10.31. Signals [a] (Type: kill –1)

1) HUP12) SYS23) POLL2) INT13) PIPE24) XCPU3) QUIT14) ALRM25) XFSZ4) ILL15) TERM26) VTALRM5) TRAP16) URG27) PROF6) IOT17) STOP28) WINCH7) EMT18) TSTP29) LOST8) FPE19) CONT30) USR19) KILL20) CHLD31) USR210) BUS21) TTIN 11) SEGV22) TTOU

[a] The output of this command may differ slightly with the operating system.

Pseudo or Fake Signals. The three fake signals are not real signals, but are generated by the shell to help debug a program. They are treated like real signals by the trap command and defined in the same way. See Table 10.32 for a list of pseudo signals.

Table 10.32. Korn Shell Fake Trap Signals

Signal	What It Does
DEBUG	Executes trap commands after every script command.
ERR	Executes trap commands if any command in the script returns a nonzero exit status.
0 or EXIT	Executes trap commands if the shell exits.

Signal names such as HUP and INT are normally prefixed with SIG, for example, SIGHUP, SIGINT, and so forth. The Korn shell allows you to use symbolic names for the signals, which are the signal names without the SIG prefix, or you can use the numeric value for the signal. See Example 10.128.

Resetting Signals. To reset a signal to its default behavior, the trap command is followed by the signal name or number. Traps set in functions are local to functions; that is, they are not known outside the function where they were set.

Example 10.128

```
trap 2  or  trap INT
```

EXPLANATION

Resets the default action for signal 2, SIGINT. The default action is to kill the process when the interrupt key (Control−C) is pressed.

Ignoring Signals. If the trap command is followed by a pair of empty quotes, the signals listed will be ignored by the process.

Example 10.129

```
trap " " 1 2    or    trap "" HUP INT
```

EXPLANATION

Signals 1 (SIGHUP) and 2 (SIGINT) will be ignored by the shell process.

Listing Traps. To list all traps and the commands assigned to them, type trap.

Example 10.130

```
(The Script)
    #!/bin/ksh
    # Scriptname: trapping
    # Script to illustrate the trap command and signals
    # Can use the signal numbers or ksh abbreviations seen
    # below. Cannot use SIGINT, SIGQUIT, etc.
1   trap 'print "Control–C will not terminate $PROGRAM."' INT
2   trap 'print "Control–\ will not terminate $PROGRAM."' QUIT
3   trap 'print "Control–Z will not terminate $PROGRAM."' TSTP
4   print "Enter any string after the prompt.\
    When you are ready to exit, type \"stop\"."
5   while true
```

```
    do
6      print –n "Go ahead...> "
7      read
8      if [[ $REPLY = [Ss]top ]]
       then
9         break
       fi
10  done

(The Output)
    $ trapping
4   Enter any string after the prompt.
    When you are ready to exit, type "stop".
6   Go ahead...> this is it^C
1   Control–C will not terminate trapping.
6   Go ahead...> this is it again^Z
3   Control–Z will not terminate trapping.
6   Go ahead...> this is never it^\
2   Control–\ will not terminate trapping.
6   Go ahead...> stop
    $
```

EXPLANATION

1. The first trap catches the INT signal, Control−C. If Control−C is pressed while the program is running, the command enclosed in quotes will be executed. Instead of aborting, the program will print Control−C will not terminate trapping and continue to prompt the user for input.
2. The second trap command will be executed when the user presses Control−\, the QUIT signal. The string Control−\ will not terminate trapping will be displayed and the program will continue to run. This signal, SIGQUIT by default, kills the process and produces a core file.
3. The third trap command will be executed when the user presses Control−Z, the TSTP signal. The string Control−Z will not terminate trapping will be displayed, and the program will continue to run. This signal normally causes the program to be suspended in the background if job control is implemented.
4. The user is prompted for input.
5. The while loop is entered.
6. The string Go ahead…> is printed and the program waits for input (see read next line).
7. The read command assigns user input to the built−in REPLY variable.
8. If the value of REPLY matches Stop or stop, the break command causes the loop to exit and the program will terminate. Entering Stop or stop is the only way we will get out of this program unless it is killed with the kill command.
9. The break command causes the body of the loop to be exited.
10. The done keyword marks the end of the loop.

Example 10.131

```
(The Script)
    $ cat trap.err
    #!/bin/ksh
    # This trap checks for any command that exits with a non-zero
    # status and then prints the message.
1   trap 'print "You gave me a non-integer. Try again. "' ERR
2   typeset -i number      # Assignment to number must be integer
3   while true
    do
4       print -n "Enter an integer. "
5       read -r number 2> /dev/null
6       if (( $? == 0 ))       # Was an integer read in?
        then                   # Was the exit status zero?
7           break
        fi
    done
8   trap - ERR              # Unset pseudo trap for ERR
    n=$number
9   if grep ZOMBIE /etc/passwd > /dev/null 2>&1
    then
        :
    else
10      print "\$n is $n. So long"
    fi

(The Output)
    $ trap.err
4   Enter an integer. hello
1   You gave me a non-integer. Try again.
4   Enter an integer. good-bye
1   You gave me a non-integer. Try again.
4   Enter an integer. \\\
1   You gave me a non-integer. Try again.
4   Enter an integer. 5
10  $n is 5. So long.

    $ trap.err
4   Enter an integer. 4.5
10  $n is 4. So long.
```

EXPLANATION

1. The ERR (fake or pseudo) signal will print the message in double quotes any time a command in the program returns a nonzero exit status, that is, fails.
2. The typeset command with the –i option creates an integer variable, number, which can only be assigned integers.
3. The exit status of the true command is always zero; the body of the while loop is entered.
4. The user is asked to type in an integer.
5. The read command reads user input and assigns it to the number variable. The number must be an integer; if not, an error message will be sent to /dev/null. The –r option to the read command allows you to enter a negative number (starting with the minus sign).
6. If the exit status from the read command is zero, a number was entered, and the if statements will be executed.
7. The break command is executed and the loop exits.
8. The trap for the fake Korn shell signal ERR is unset.
9. When grep fails, it returns a nonzero exit status; if we had not unset the ERR trap, the script would have printed You gave me a non−integer. Try again. So long if the grep failed to find ZOMBIE in the /etc/passwd file.

10. This line is printed if the grep failed. Note that if a floating point number such as 4.5 is entered, the number is truncated to an integer.

Traps and Functions. If trap is used in a function, the trap and its commands are local to the function.

Example 10.132

```
(The Script)
    #!/bin/ksh
1   function trapper {
       print "In trapper"
2      trap 'print "Caught in a trap!"' INT
       print "Got here."
       sleep 25
    }
3   while :
    do
       print "In the main script"
4      trapper   # Call the function
5      print "Still in main"
       sleep 5
       print "Bye"
    done
------------------------------------------------------
(The Output)
$ functrap
In the main script
In trapper
Got here.
^CCaught in a trap!
$
```

EXPLANATION

1. The function trapper is defined. It contains the trap command.
2. The trap command will be executed if Control−C is entered. The print command within the trap is executed and the program continues execution. Control−C is entered while the sleep command is running. Normally, the program will continue to run just after the command where it was interrupted (with the exception of the sleep command, which causes the program to abort). The trap has no effect on lines starting after 4.
3. In the main part of the script, a while loop is started. The colon is a do−nothing command that always returns a zero exit status. The loop will go forever.
4. Once in the loop, the function trapper is called.
5. The trap command within the trapper function will have no effect in this part of the program because the trap is local to the function. If the function exits normally (i.e., ^C is not pressed), execution will continue here. The default behavior for ^C will cause the script to abort if the signal is sent here or to any of the lines that follow.

10.2.13 Coprocesses

A coprocess is a special two−way pipeline that allows shell scripts to write to the standard input of another command and to read from its standard output. This provides a way to create a new interface for an existing program. The append operator, |&, is placed at the end of the command to initiate the command as a coprocess. Normal redirection and background processing should not be used on coprocesses. The print and read commands require a –p switch to read from and write to a coprocess. The output must be sent to standard output and have a newline at the end of each message of output. The standard output must be flushed after each message is sent to standard output. You can run multiple coprocesses by using the exec command with the >&p or <&p operator. To open file descriptor 4 as a coprocess, you would enter exec 4>&p.

Example 10.133

```
(The Script)
    #!/bin/ksh
    # Scriptname: mycalculator
    # A simple calculator –– uses the bc command to perform the
    # calculations
    # Since the shell performs operations on integers only,
    # this program allows
    # you to use floating point numbers by writing to and reading
    # from the bcprogram.

1   cat << EOF
    **************************************************
2        WELCOME TO THE CALCULATOR PROGRAM
    *************************************************
3   EOF

4   bc |&                # Open coprocess

5   while true
    do
6       print "Select the letter for one of the operators below "
7       cat <<– EOF
            a) +
            s) –
            m) *
            d) /
            e) ^
        EOF
8       read op
9       case $op in
            a) op="+";;
            s) op="–";;
            m) op="*";;
            d) op="/";;
            e) op="^";;
            *) print "Bad operator"
                   continue;;
        esac
10      print –p scale=3                    # write to the coprocess
11      print "Please enter two numbers:  "  # write to standard out
12      read num1 num2                      # read from standard in
13      print –p "$num1" "$op" "$num2"       # write to the coprocess
14      read –p result                      # read from the coprocess
15      print $result
16      print –n "Continue (y/n)? "
17      read answer
18      case $answer in
        [Nn]* )
19         break;;
        esac
20  done
21  print Good–bye

(The Output)
$ mycalculator
```

```
    ************************************************
1        WELCOME TO THE CALCULATOR PROGRAM
    ***********************************************
6   Select one of the operators below
7        a) +
         s) -
         m) *
         d) /
         e) ^
    e
11  Please enter two numbers:
    2.3 4
    27.984
16  Continue (y/n)? y
6   Select one of the operators below
7        a) +
         s) -
         m) *
         d) /
         e) ^
    d
11  Please enter two numbers:
    2.1 4.6
    0.456
16  Continue (y/n)? y
6   Select one of the operators below
7       a) +
        s) -
        m) *
        d) /
        e) ^
    m
11  Please enter two numbers:
    4 5
    20
16  Continue (y/n)? n
    Good-bye
```

EXPLANATION

1. The here document is used to display a menu.
2. This text is printed as a header to the menu below.
3. EOF is a user−defined terminator, marking the end of the here document.
4. The bc command (desk calculator) is opened as a coprocess. It is executed in the background.
5. A while loop is started. Since the true command always returns a successful exit status of 0, the loop will continue indefinitely until a break or exit is reached.
6. The user is prompted to select an item from a menu to be displayed.
7. Another here document displays a list of math operations the user can choose for the bc program.
8. The read command assigns user input to the variable op.
9. The case command matches for one of the op values and assigns an operator to op.
10. The print command, with the –p option, pipes output, scale=3, to the coprocess, the bc command. The bc command accepts the print output as input and sets the scale to 3. (The scale defines the number of significant digits to the right of the decimal point in a number that will be displayed by bc.)
11. The user is prompted to enter two numbers.

12. The read command assigns user input to the variables num1 and num2.
13. The print –p command sends the arithmetic expression to the bc coprocess.
14. The shell reads from the bc coprocess (read –p) and assigns the input to the variable result.
15. The result of the calculation ($result) is printed.
16. The user is asked about continuing.
17. The user enters input. It is assigned to the variable answer.
18. The case command evaluates the variable answer.
19. If the user had entered No or no or nope, etc., the break command would be executed, and the while loop would be terminated with control sent to line 21.
20. The done keyword marks the end of the while loop.
21. This line is printed when the loop terminates.

10.2.14 Debugging

By turning on the noexec option or using the –n argument to the ksh command, you can check the syntax of your scripts without really executing any of the commands. If there is a syntax error in the script, the shell will report the error. If there are no errors, nothing is displayed.

The most commonly used method for debugging scripts is to turn on the xtrace option or to use the ksh command with the –x option. These options allow an execution trace of your script. Each command from your script is displayed after variable substitution has been performed, and then the command is executed. When a line from your script is displayed, it is preceded with the value of the PS4 prompt, a plus (+) sign. The PS4 prompt can be changed.

With the verbose option turned on, or by invoking the Korn shell with the –v option (ksh –v scriptname), each line of the script will be displayed, just as it was typed in the script, and then executed. See Table 10.33 for debug commands.

Table 10.33. Debug Commands and Options

Command FunctionHow It Worksksh –x scriptnameInvokes ksh with echo option.Displays each line of the script after variable substitution and before execution.ksh –v scriptnameInvokes ksh with verbose option.Displays each line of the script before execution, just as you typed it.ksh –n scriptnameInvokes ksh with noexec option.Interprets but does not execute commands.set –x orTurns on echo option.Traces execution in a script.set –o xtrace set +xTurns off echo.Turns off tracing.typeset –ftTurns on tracing.Traces execution in a function.export PS4='$LINENO 'The PS4 prompt by default is a +.You can reset the prompt. In this example, a line number will be printed for each line.trap 'print $LINENO ' DEBUGPrints value of $LINENO for each line in the script.For each script command, the trap action is performed. See format for trap.trap 'print Bad input' ERR If a nonzero exit status is returned, the trap is executed.trap 'print Exiting from $0' EXIT Prints message when script or function exits.

Example 10.134

```
(The Script)
    #!/bin/ksh
    # Scriptname: todebug
1   name="Joe Blow"
2   if [[ $name = [Jj]* ]] then
        print Hi $name
    fi

    num=1
3   while (( num < 5 ))
```

```
    do
4       (( num=num+1 ))
    done
5   print The grand total is $num

(The Output)
1   $ ksh –x todebug
2   + name=Joe Blow
    + [[ Joe Blow = [Jj]* ]]
    + print Hi Joe Blow
    Hi Joe Blow
    + num=1         The + is the PS4 prompt
    + let num < 5
    + let num=num+1
    + let num < 5
    + let num=num+1
    + let num < 5
    + let num=num+1
    + let num < 5
    + let num=num+1
    + let num < 5
    + print The grand total is 5
    The grand total is 5
```

EXPLANATION

1. The Korn shell is invoked with the –x option. Echoing is turned on. Each line of the script will be displayed on the screen, followed by the result of executing that line. Variable substitution is performed. Alternatively, the –x option can be used in the script instead of at the command line; e.g., #!/bin/ksh –x
2. The lines are preceded by the plus (+) sign, the PS4 prompt.
3. The while loop is entered. It will loop 4 times.
4. The value of num is incremented by by 1.
5. After the while loop exits, this line is printed.

Example 10.135

```
(The Script)
    #!/bin/ksh
    # Scriptname: todebug2
1   trap 'print "num=$num on line $LINENO"' DEBUG
    num=1
    while (( num < 5 ))
    do
        (( num=num+1 ))
    done
    print The grand total is $num

(The Output)
    $ todebug2
2   num=1 on line 3
    num=1 on line 4
    num=2 on line 6
    num=2 on line 4
    num=3 on line 6
    num=3 on line 4
    num=4 on line 6
    num=4 on line 4
    num=5 on line 6
    num=5 on line 4
```

```
The grand total is 5
num=5 on line 8
num=5 on line 8
```

EXPLANATION

1. LINENO is a special Korn shell variable that holds the number of the current script line. The DEBUG signal, used with the trap command, causes the string enclosed in single quotes to be executed every time a command in the script is executed.
2. As the while loop executes, the value of the variable num and the line of the script are displayed.

10.2.15 Processing Command Line Options with getopts

If you are writing scripts that require a number of command line options, positional parameters are not always most efficient. For example, the UNIX ls command takes a number of command line options and arguments. (An option requires a leading dash; an argument does not.) Options can be passed to the program in several ways: ls –laFi, ls –i –a –l –F, ls –ia –F, and so forth. If you have a script that requires arguments, positional parameters might be used to process the arguments individually, such as ls –l –i –F. Each dash option would be stored in $1, $2, and $3, respectively. But, what if the user listed all of the options as one dash option, as in ls –liF? Now the –liF would all be assigned to $1 in the script. The getopts function makes it possible to process command line options and arguments in the same way they are processed by the ls program.[11] The getopts function will allow the runit program to process its arguments using a variety of combinations.

Example 10.136

```
(The Command Line)

1   $ runit –x –n 200 filex

2   $ runit –xn200 filex

3   $ runit –xy

4   $ runit –yx –n 30

5   $ runit –n250 –xy filey

(any other combination of these arguments )
```

EXPLANATION

1. The program runit takes four arguments; x is an option, n is an option requiring a number argument after it, and filex is an argument that stands alone.
2. The program runit combines the options x and n and the number argument 200; filex is also an argument.
3. The program runit combines the x and y options.
4. The program runit combines the y and x options; the n option is passed separately as is the number argument, 30.
5. The program runit combines the n option with the number argument; the x and y options are combined and the filey is separate.

Before getting into all the details of the runit program, we examine the line from the program where getopts is used to see how it processes the arguments. The following is a line from the script called runit:

```
while getopts :xyn: name
```

1. x, y, and n are the options.
2. Options typed at the command line begin with either – or +.
3. Any options that do not contain a + or – tell getopts that the option list is at an end.
4. The colon after an option says that the option requires an argument; that is, the –n option requires an argument.
5. The colon before an option list says that if you type an illegal option, getopts will allow the programmer to handle it. For example, in the command runit –p, where –p is not one of the legal options, getopts will tell you so programmatically. The shell does not print an error message.
6. Each time getopts is called, it places the next option it finds, without the dash, in the variable name. (You can use any variable name here.) If there is a plus sign prepended to the option, then it goes into name with the plus sign. If an illegal argument is given, name is assigned a question mark; if a required argument is missing, name is assigned a colon.
7. OPTIND is a special variable that is initialized to one and is incremented each time getopts completes processing a command line argument to the number of the next argument getopts will process.
8. The OPTARG variable contains the value of a legal argument, or if an illegal option is given, the value of the illegal option is stored in OPTARG.

Sample getopts Scripts. The following sample scripts illustrate how getopts processes arguments.

Example 10.137

```
(The Script)
    #!/bin/ksh
    # Program opts1
    # Using getopts –– First try ––
1   while getopts xy options
    do
2   case $options in
3       x) print "you entered –x as an option";;
        y) print "you entered –y as an option";;
    esac
    done
––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––
(The Command Line)
4   $ opts1 –x
    you entered –x as an option

5   $ opts1 –xy
    you entered –x as an option
    you entered –y as an option

6   $ opts1 –y
    you entered –y as an option

7   $ opts1 –b
    opts1[3]: getopts: b bad option(s)

8   $ opts1 b
```

EXPLANATION

1. The getopts command is used as a condition for the while command. The valid options for this program are listed after the getopts command; they are x and y. Each option is tested

in the body of the loop, one after the other. Each option will be assigned to the variable options, without the leading dash. When there are no longer any arguments to process, getopts will exit with a nonzero status, causing the while loop to terminate.
2. The case command is used to test each of the possible options found in the options variable, either x or y.
3. If x was an option, the string you entered x as an option is displayed.
4. At the command line, the opts1 script is given an x option, a legal option to be processed by getopts.
5. At the command line, the opts1 script is given an xy option, legal options to be processed by getopts.
6. At the command line, the opts1 script is given a y option, a legal option to be processed by getopts.
7. The opts1 script is given a b option, an illegal option. Getopts sends an error message.
8. An option without a – or + prepended to it is not an option and causes getopts to stop processing arguments.

Example 10.138

```
(The Script)
    #!/bin/ksh
    # Program opts2
    # Using getopts –– Second try ––
1   while getopts :xy options
    do
2        case $options in
         x) print "you entered –x as an option";;
         y) print "you entered –y as an option";;
3        \?) print $OPTARG is not a valid option 1>&2;;
         esac
    done
–––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––
(The Command Line)

    $ opts2 –x
    you entered –x as an option

    $ opts2 –y
    you entered –y as an option


    $ opts2 xy
    $ opts2 –xy
    you entered –x as an option
    you entered –y as an option

4   $ opts2 –g
    g is not a valid option

5   $ opts2 –c
    c is not a valid option
```

EXPLANATION

1. The colon preceding the option list prevents the Korn shell from printing an error message for a bad option. However, if the option is a bad option, a question mark will be assigned to the options variable.

2. The case command can be used to test for the question mark, allowing you to print your own error message to standard error.
3. If the options variable is assigned the question mark, this case statement is executed. The question mark is protected with the backslash so that the Korn shell does not see it as a wildcard and try to perform filename substitution.
4. g is not a legal option. The question mark is assigned to the options variable, and OPTARG is assigned the illegal option g.
5. c is not a legal option. The question mark is assigned to the options variable, and OPTARG is assigned the illegal option c.

Example 10.139

```
(The Script)
    #!/bin/ksh
    # Program opts3
    # Using getopts –– Third try ––
1   while getopts :d options
    do
        case $options in
2       d) print –R "–d is the ON switch";;
3       +d) print –R "+d is the OFF switch";;
        \?) print $OPTARG is not a valid option;;
        esac
    done
 # Need the –R option with print or the shell tries to use –d as a
 # print option
–––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––
(The Command Line)
4   $ opts3 –d
    –d is the ON switch

5   $ opts3 +d
    +d is the OFF switch

6   $ opts3 –e
    e is not a valid option

7   $ opts3 e
```

EXPLANATION

1. The while command tests the exit status of getopts; if getopts can successfully process an argument, it returns zero exit status, and the body of the while loop is entered. The colon prepended to the d option tells getopts not to print an error message if the user enters an invalid option.
2. One of the legal options is –d. If –d is entered as an option, the d (without the dash) is stored in the options variable. (The –R option to the print command allows the first character in the print string to be a dash.)
3. One of the legal options is +d. If +d is entered as an option, the d (with the plus sign) is stored in the options variable.
4. The –d option is a legal option to opts3.
5. The +d option is also a legal option to opts3.
6. The –e option is invalid. A question mark is stored in options if the option is illegal. The illegal argument is stored in OPTARG.
7. The option is prepended with neither a dash nor a plus sign. The getopts command will not process it as an option and returns a nonzero exit status. The while loop is terminated.

Example 10.140

```
(The Script)
    #!/bin/ksh
    # Program opts4
    # Using getopts −− Fourth try −−
1   alias USAGE='print "usage: opts4 [−x] filename " >&2'
2   while getopts :x: arguments
    do
    case $arguments in
3        x) print "$OPTARG is the name of the argument ";;
4        :) print "Please enter an argument after the −x option" >&2
           USAGE ;;
5       \?) print "$OPTARG is not a valid option." >&2
           USAGE;;
    esac
6   print "$OPTIND" # The number of the next argument to be processed
    done
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
(The Command Line)
7   $ opts4 −x
    Please enter an argument after the −x option
    usage: opts4 [−x] filename
    2
8   $ opts4 −x filex
    filex is the name of the argument
    3
9   $ opts4 −d
    d is not a valid option.
    usage: opts4 [−x] filename
    1
```

EXPLANATION

1. The alias USAGE is assigned the diagnostic error message that will be printed if getopts fails.
2. The while command tests the exit status of getopts; if getopts can successfully process an argument, it returns zero exit status, and the body of the while loop is entered. The colon prepended to the x option tells getopts not to print an error message if the user enters an invalid option. The colon appended to the x option tells getopts that an argument should follow the x option. If the option takes an argument, the argument is stored in the getopts built−in variable, OPTARG.
3. If the x option was given an argument, the argument is stored in the OPTARG variable and will be printed.
4. If an argument was not provided after the x option, a colon is stored in the variable arguments. The appropriate error message is displayed.
5. If an invalid option is entered, the question mark is stored in the variable arguments and an error message is displayed.
6. The special getopts variable, OPTIND, holds the number of the next option to be processed. Its value is always one more than the actual number of command line arguments.
7. The x option requires an argument. An error message is printed.
8. The name of the argument is filex. The variable OPTARG holds the name of the argument filex.
9. The option d is invalid. The usage message is displayed.

10.2.16 Security

Privileged Scripts. A script is privileged if the Korn shell is invoked with the –p option. When the privileged option is used and the real UID and/or the real GID are not the same as the effective UID or effective GID, the .profile will not be executed and a system file called /etc/suid_profile will be executed instead of the ENV file.

Restricted Shells. When the Korn shell is invoked with the –r option, the shell is restricted. When the shell is restricted, the cd command cannot be used and the SHELL, ENV, and PATH variables cannot be modified or unset; commands cannot be executed if the first character is a backslash; and the redirection operators (>, <, |, >>) are illegal. This option cannot be unset or set with the set command. The command rksh will invoke a restricted shell.

10.2.17 Built−In Commands

The Korn shell has a number of built−in commands, as shown in Table 10.34.

Table 10.34. Built−In Commands and Their Functions

Command Function:Do−nothing command; returns exit status zero..fileThe dot command reads and executes a command from file.breakSee looping.continueSee looping.cdChanges directory.echo [args]Displays arguments.eval commandShell scans the command line twice before execution.exec commandRuns command in place of this shell.exit [n]Exit the shell with status n.export [var]Makes var known to subshells.fc –e [editor] [lnr] first lastUsed to edit commands in the history list. If no editor is specified, the value of FCEDIT is used; if FCEDIT is not set, /bin/ed is used. Usually history is aliased to fc –l. Examples:fc –lLists the last 16 commands on the history list.fc –e emacs grepReads the last grep command into the emacs editor.fc 25 30Reads commands 25 through 30 into the editor specified in FCEDIT, by default the ed editor.fc –e –Reexecutes the last command.fc –e – Tom=Joe 28Replaces Tom with Joe in history command 28.fgBrings the last background job to the foreground.fg %nBrings job number n to the foreground. Type jobs to find the correct job number.jobs [–l]Lists the active jobs by number and with the –l option by PID number. Examples: $ jobs[3] + Runningsleep 50&[1] – Stoppedvi[2] Runningsleep%kill [–signal process]Sends the signal to the PID number or job number of process. See /usr/include/sys/signal.h for a list of signals. Signals:SIGHUP1/* hangup (disconnect) */SIGINT 2/* interrupt */SIGQUIT 3/* quit */SIGILL 4/* illegal instruction (not reset when caught) */SIGTRAP 5/* trace trap (not reset when caught) */SIGIOT 6/* IOT instruction */SIGABRT 6/* used by abort, replace SIGIOT in the future */SIGEMT 7/* EMT instruction */SIGFPE 8/* floating point exception */SIGKILL 9/* kill (cannot be caught or ignored) */SIGBUS 10/* bus error */SIGSEGV 11/* segmentation violation */SIGSYS 12/* bad argument to system call */SIGPIPE 13/* write on a pipe with no one to read it */SIGALRM 14/* alarm clock */SIGTERM 15/* software termination signal from kill */SIGURG 16/* urgent condition on I/O channel */SIGSTOP 17/* sendable stop signal not from tty */SIGTSTP 18/* stop signal from tty */SIGCONT 19/* continue a stopped process */(To use the kill command and a signal name, strip off the SIG prefix and precede the signal name with a dash.) Examples: kill –INT %3 kill –HUP 1256 kill –9 %3 kill %1getoptsUsed in shell scripts to parse command line and check for legal options.hashLists all tracked aliases.login [username] newgrp [arg]Changes your real group ID to the group ID.print –[nrRsup]Replacement for echo. See print.pwdPrint present working directory.read [var]Read line from standard input into variable var.readonly [var]Make variable var readonly. Cannot be reset.return [n]Exit value given to a function. set [–aefhknoptuvx– [–o option] [–A arrayname] [arg]] Examples:setLists all variables and their values.set +Lists all variables without their values.set –oLists all option settings.set a b cResets positional parameters $1, $2, $3.set –sSorts $1, $2, and $3 alphabetically.set –o viSets the vi option.set –xvTurns on the xtrace and verbose options for debugging.set ––Unsets all positional parameters.set – – "$x"Sets $1 to the value of x, even if x is –x.set == $xDoes pathname expansion on each item in x and then sets the positional parameters to each item. set –A name tom dick harryname[0] is set to tom.name[1] is set to dick.name[2] is set to harry. set +A name joename[0] is reset to joe, the rest of the array is left alone.name[1] is dick.name[2] is harry.(To set options, use the –o flag; to unset options, use the +o flag.) Example: set –o ignoreeof Options:allexportAfter setting this, exports any variable defined or changed.bgniceRuns background jobs with a lesser priority; used instead of nice.emacsSets the emacs built−in editor.errexitThe shell exits when a command returns a nonzero exit status.gmacsSets the built−in gmacs editor.ignoreeofIgnores the EOF (Control−D) key from terminating the shell. Must use exit to exit.keywordAdds keyword arguments occurring anywhere on the command line to the environment of the shell.markdirsPuts a trailing backslash on all directory names resulting from filename expansion.monitorSets job control.noclobberPrevents overwriting files using the redirection operator, >. Use >| to force overwrite.noexecSame as ksh –n; reads commands but does not execute them. Used to check for syntax errors in shell scripts.noglobDisables pathname expansion with ksh wildcard metacharacters.nologFunction definitions will not be stored in the history file.nounsetDisplays an error if a variable has not been set.privilegedTurns on privileged mode for setuid programs.trackallKsh causes each command to become a tracked alias; automatically turned on for interactive shells.verboseEchos each line of input to standard error; useful in debugging.viSets the vi built−in editor.virawSpecifies vi character at a time input.xtraceExpands each command and displays it in the PS4 prompt, with variables expanded.shift [n] Shifts positional parameters to the left n times.timesPrints accumulated user and system times for processes run from this shell.trap [arg] [n]When shell receives signal n (0, 1, 2, or 15), arg is executed.type [command]Prints the type of command; e.g., pwd is a built−in shell. In ksh, an alias for whence –v.typeset [options] [var]Sets attributes and values for shell variables and functions. ulimit [options size]Sets maximum limits on processes. Examples: ulimit –aDisplay all limits:Time (seconds) unlimited.File (blocks) unlimited.Data (kbytes) 524280.Stack (kbytes) 8192.Memory (kbytes) unlimited.Coredump (blocks) unlimited. Other Options:–c sizeLimits core dumps to size blocks.–d sizeLimits the data size (of executables) to size blocks.–f sizeLimits the size of files to size blocks (default).–m sizeLimits the size of physical memory to size K bytes.–s sizeLimits the size of the stack area to size K bytes.–t secsLimits process execution time to secs seconds.umask [mask]Without argument, prints out file creation mask for permissions.umask [octal digits]User file creation mode mask for owner, group, and others.unset [name] Unsets value of variable or function.wait [pid#n] Waits for background process with PID number n and report termination status. whence [command]Prints information about the command, like ucb whereis. Examples:whence –v happyhappy is a functionwhence –v addonaddon is an undefined functionwhence –v lsls is a tracked alias for /bin/lswhence ls/bin/ls

10.2.18 Korn Shell Invocation Arguments

When the Korn shell is involved, it can take options to control its behavior. See Table 10.35.

Table 10.35. Arguments to ksh

Command Function–aAutomatically exports all variables.–c cmdExecutes a command string.–eExits when a command returns a nonzero status.–fTurns off globbing, the expansion of filename metacharacters.–hCauses commands to be treated as tracked aliases.–iSets the interactive mode.–kSets the keyword option. All the key arguments to commands will be made part of the environment.–mCauses commands executed in the background to be run in a separate process group, and will continue to run even if Control−C or logout is attempted. Sends a message that the job has terminated when done.–nCan be used for debugging. Commands are scanned, but not executed. Can be used with –x and –v options.–oAllows options to be set by the names listed in the table above with the set command.–pTurns on privileged mode. Used for running setuid programs.–rSets the restricted mode.–sReads command from stdin, the default.–tCauses the shell to exit after executing the first command found in shell input and the –c option is specified.–uAny reference to an unset variable is considered an error.–vEach line of a script or standard input is printed before any parsing, variable substitution, or other processing is performed. Output is written to standard error. Used for debugging.–xEach line of a script or standard input is printed before it is executed. Filename expansion, variable substitution, and command substitution are shown in the output. All output is prepended with the value of the PS4 prompt, a plus sign followed by a space. Lines are written to standard error.

KORN SHELL LAB EXERCISES

Lab 28: Getting Started

1: What shell are you using? How do you know?

2: Do you have a .profile and/or a .kshrc file in your home directory? What is the difference between the .profile and .kshrc? What is the ENV file and how can you invoke it if you make changes in it?

3: What is the default primary prompt? What is the default secondary prompt? Change your primary prompt at the command line so that it contains your login name.

4: What is the purpose of setting each of the following variables?

a. set –o ignoreeof
b. set –o noclobber
c. set –o trackall
d. set –o monitor
e. set –o vi

Why are these variables set in the ENV file? What is the purpose of the PATH? What are the elements of your PATH variable?

5: What is the difference between a local and an environment variable? How do you list all your variables? How do you list only environment variables? To list all your current option settings, type the following:

```
set –o
```

Which set options are turned on?

6: Create a local variable called myname that contains your full name. Now export the variable. Type the following at the prompt:

```
ksh
```

Was the variable name exported? Type exit to get back to the parent shell. Make the variable name readonly. What is a readonly variable?

7: What are positional parameters normally used for? Type the following:

```
set apples pears peaches plums
```

Using the positional parameters, print plums. Print apples peaches. Print apples pears peaches plums. Print the number of parameters. Reset the positional parameters to a list of veggies. Print the whole list of veggies. What happened to the fruit list?

Type the following:

```
set --
print $*
```

What happened?

8: Print the PID of the current shell. Type the following at the prompt:

```
grep $LOGNAME /etc/passwd
echo $?
```

What does the $? tell you. What does the exit status tell you about the execution of a command?

9: Change both the primary and secondary prompt in your .profile. How do you reexecute the .profile file without logging out and logging back in?

Lab 29: History

1: What is your HISTSIZE variable set to? What is your HISTFILE variable set to? Check your .kshrc file to see if set –o vi is there. If it has not been set, set it in the .kshrc file and reexecute the file by typing the following:

```
. .kshrc
```

2: Type the following commands at the command line:

```
ls
date
who
cal 2 1993
date +%T
```

Type history or fc –l. What do these commands do? Print your history list in reverse. Print your history list without numbers. Print the current command and the five preceding it. Print everything from the tenth command to the present. Print everything between the most recent ls command to the most recent cal command.

3: Using the r command, reexecute the last command. Reexecute the last command that started with the letter d. Change the cal command year output to 1897. Change the date command +%T argument to find the current hour.

4: If your history is set, press the Esc key at the command line and use the K key to move up through the history list. Change the ls command to ls –alF and reexecute it.

5: Check to see if the FCEDIT variable has been set by typing the env command. If it has not been set, type the following at the command line:

```
export FCEDIT=vi
```

Now type the following at the command line:

```
fc –1 –4
```

What happened?

6: How do you comment a line from your history list, so that it will be placed on the list without being executed?

7: At the command line, type the following:

```
touch a1 a2 a3 apples bears balloons a4 a45
```

Now using the history Esc sequences shown in Tables 10.2 and 10.3, print all the files beginning with an a.

a. Print the first file beginning with a.
b. Print a list of all files beginning with a.
c. Print the first file beginning with b.
d. Print a command and comment it.

8: At the command line, type the following:

```
print a b c d e
```

9: Using the history Esc underscore command, change the command to the following:

```
print e
```

Using the history Esc underscore command, change the first command to output:

```
print c
```

Lab 30: Aliases and Functions

1: What command lists all the aliases currently set?

2: What command lists all the tracked aliases?

3: Create aliases for the following commands:

```
date +%T
```

```
history –n

ls –alF

rm –i

cp –i

print
```

4: How do you export an alias?

5: Create a function that contains the following commands:

```
ls –F

print –n "The time is"

date +%T

print –n "Your present working
directory is"

pwd
```

6: Execute the function.

7: Now create your own functions, using positional parameters to pass arguments.

8: What command lists the functions and their definitions?

9: Try some of the print options.

Lab 31: Shell Metacharacters

1: Create a directory called meta. Cd to that directory. Use touch to create the following files:

```
abc abc1 abc2 abc2191 Abc1 ab2 ab3 ab345 abc29 abc9 abc91 abc21xyz
abc2121 noone nobody nothing nowhere
```

2: Do the following:

a. List all files that start with a lower case a.
b. List all files starting with upper case A followed by two characters.
c. List all files that end in a number.

d. List all files that match one number after abc.
e. List all files that match nothing or noone.
f. List all files that match one or more numbers after abc.
g. List all files that do not contain the pattern abc.
h. List all files that contain ab followed by a 3 or 4.
i. List all files starting with a or A, followed by b, and ending in one number.
j. What is the error message if there is not a match?

Lab 32: Tilde Expansion, Quotes, and Command Substitution

1: Use the tilde to do the following:

a. Print your home directory.
b. Print your neighbor's home directory.
c. Print your previous working directory.
d. Print your current working directory.

2: What variable holds the value of your present working directory? What variable holds the value of your previous working directory?

3: Use the – to go to your previous working directory.

4: Use the print command to send the following output to the screen. (The word enclosed in < > is a variable name that will be expanded, and words enclosed in [ ] are output of commands that have been executed; i.e., use command substitution.)

```
Hi <LOGNAME> how's your day going?
"No, <LOGNAME> you can't use the car tonight!", she cried.
The time is [ Sun Feb 21 13:19:27 PST 2001 ]
The name of this machine is [ eagle ] and
the time is [ 31:19:27 ]
```

5: Create a file that contains a list of user names. Now create a variable called nlist which contains the list of user names, extracted by using command substitution.

a. Print out the value of the variable. How does command substitution affect the formatting of a list?
b. Test this by setting a variable to the output of the ps –eaf command.
c. What happened to the formatting?

Lab 33: Redirection

1: Go into the editor and create the following two−line text file called ex6:

```
Last time I went to the beach I found a sea shell.
While in Kansas I found a corn shell.
```

2: Now append this line to your ex6 file: The National Enquirer says someone gave birth to a shell, called the born shell.

3: Mail the ex6 file to yourself.

4: Using a pipe, count the number of lines (wc –l) in your ex6 file.

5: To list all set options, type the following:

```
set –o
```

Do you have the noclobber variable set? If not, type the following:

```
set –o noclobber
```

What happened?

6: Type the following at the command line:

```
cat << FINIS
How are you $LOGNAME
The time is 'date'Bye!!
FINIS
```

What printed?

7: Now try this using tabs:

```
cat <<– END
        hello there
        how are you
END
```

What printed?

8: Type the following at the command line:

```
kat file 2> error || print kat failed
```

What happened? Why?

9: Now type the following at the command line:

```
cat zombie 2> errorfile || print cat failed
```

What happened? Why? How does the && operator work? Try your own command to test it.

10: Use the find command to print all files that begin with an a from the root directory down. Put the standard output in a file called foundit and send the errors to /dev/null.

Lab 34: Job Control

1: At the command line type the following:

```
mail <user>Press control-z
```

Now type:

```
jobs
```

What is the number in the square brackets?

2: Now type:

```
sleep 300
jobs
bg
```

What does bg do? What do the + and – signs indicate?

3: Kill the mail job using job control.

4: Go into the editor. Type ^Z to stop the job.

Now bring the stopped vi job back into the foreground. What command did you type?

5: Type the following command:

```
jobs -l
```

What is the output?

6: What is the TMOUT variable used for?

7: How much time was spent by the kernel when executing the following command:

```
(sleep 5 ; ps -eaf )
```

Lab 35: Writing the info Shell Script

1: Write a program called info. Make sure you make the program executable with the chmod command before you try to execute it.

2: The program should contain comments.

3: The program should do the following when executed:

a. Output the number of users logged on.
b. Output the time and date.
c. Output the present working directory.
d. List all directory files in the parent directory.
e. Print out the name of the shell being used.
f. Print a line from the password file containing your login name.
g. Print your user ID.
h. Print the name of this machine.
i. Print your disk usage.
j. Print a calendar for this month.
k. Tell the user good bye and print the hour in nonmilitary time.

Lab 36: Variable Expansion of Substrings

1: Write a script that will do the following:

a. Set a variable called mypath to your home directory.
b. Print the value of mypath.
c. Print just the last element of the path in mypath.
d. Print the first element of the path in mypath.
e. Print all but the last element of the variable mypath.

Lab 37: The lookup Script

1: Create a file called datafile if it has not been provided for you on the CD. It will consist of colon−separated fields:

a. First and last name
b. Phone number
c. Address (street, city, state, and zip)
d. Birth date (04/12/66)
e. Salary

2: Put 10 entries in your file. Write a script called lookup that will do the following:

a. Welcome the user.
b. Print the names and phone numbers for all the users in the datafile.
c. Print the number of lines in the datafile.
d. Tell the user good bye.

Lab 38: Using typeset

1: Write a script that will do the following:

a. Ask the user to type in his or her first and last name.
b. Store the answers in two variables.
c. Use the new ksh read command.

2: Use the typeset command to convert the first and last name variables to all lowercase letters.

3: Test to see if the person's name is tom jones. If it is, print Welcome, Tom Jones; if it is not, print, Are you happy today, FIRSTNAME LASTNAME?. (The user's first and last names are converted to uppercase letters.)

4: Have the user type in an answer to the question and use the new ksh test command to see whether the answer is yes or no. If yes, have your script say something nice to him or her, and if no, tell the user to go home and give the current time of day.

5: Rewrite the lookup script.

a. The script will ask the user if he or she would like to add an entry to the datafile.
b. If the user answers yes or y, ask for the following input:

Name

Phone number

Address

Birth date

Salary

A variable for each item will be assigned the user input.

```
print –n "What is the name of the person you are adding to the file?"
read name The information will be appended to the datafile.
```

Lab 39: The if/else Construct and the let Command

1: Write a script called grades that will ask the user for his or her numeric grade on a test.

a. The script will test that the grade is within the possible grade range, 0 to 100.
b. The script will tell the user if he or she got an A, B, C, D, or F.

2: Write a script called calc that will perform the functions of a simple calculator. The script will provide a simple menu:

[a] Add
[s] Subtract
[m] Multiply
[d] Divide
[r] Remainder

3: The user will choose one of the letters from the menu.

4: The user will then be asked to enter two integers between 0 and 100.

5: If the numbers are out of the range, an error message will be printed and the script will exit.

6: The program will perform the arithmetic on the two integers.

7: The answer will be printed in base 10, 8, and 16.

Lab 40: The case Statement

1: Write a script timegreet that will do the following:

a. Provide a comment section at the top of the script, with your name, the date, and the purpose of this program.
b. Convert the following program using case statements:

```
# The timegreet script by Ellie Quigley
you=$LOGNAME
hour='date | awk '{print substr($4, 1, 2)}''
print "The time is: $(date)"
if (( hour > 0 && $hour < 12 ))
then
   print "Good morning, $you!"
elif (( hour == 12 ))
then
   print "Lunch time!"
elif (( hour > 12 && $hour < 16 ))
then
   print "Good afternoon, $you!"
else
   print "Good night, $you!"
fi
```

2: Rewrite the lookup script, replacing the if/elif construct with the case command. Add one more menu item:

1) Add Entry
2) Delete Entry
3) Update Entry
4) View Entry
5) Exit

Lab 41: The select Loop

1: Write a script that will do the following:

a. Provide a comment section at the top of the script, with your name, the date, and the purpose of this program.
b. Use the select loop to provide a menu of foods. The output will resemble the following:

```
$ foods
1) steak and potatoes
2) fish and chips
3) soup and salad
Please make a selection. 1
Stick to your ribs
Watch your cholesterol
Enjoy your meal.

$ foods
1) steak and potatoes
2) fish and chips
3) soup and salad
Please make a selection. 2
British are coming
Enjoy your meal.

$ foods
1) steak and potatoes
2) fish and chips
3) soup and salad
Please make a selection. 3
Health foods…
Dieting is so boring.
Enjoy your meal.

$ foods
1) steak and potatoes
2) fish and chips
3) soup and salad
Please make a selection. 5
Not on the menu today!
```

2: Rewrite the lookup script using the select command to create a main menu and a sub menu. The menu will resemble the following:

```
1) Add Entry
2) Delete Entry
3) Update Entry
4) View Entry
     a) Name
     b) Phone
     c) Address
     d) Birthday
     e) Salary
5) Exit
```

Lab 42: Autoloading Functions

Steps for autoloading a function:

1: Make a directory called myfunctions.

2: Change directory to myfunctions and use the editor to create a file called goodbye.

3: Insert in the goodbye file a function called goodbye, spelled exactly the same as the filename.

4: The goodbye function contains:

```
function goodbye {
print The current time is $(date)
print "The name of this script is $0"
print See you later $1
print Your machine is 'uname –n'
}
```

5: Write and quit the editor. You now have a file containing a function with the same name.

6: Go to your home directory. Modify the .kshrc file in the editor by typing the following line:

```
FPATH=$HOME/myfunctions
```

7: Exit the editor, and to execute the .kshrc in the current environment, use the dot command.

8: In the timegreet script you have already written, include the following lines:

```
autoload goodbye
goodbye $LOGNAME
```

9: Run the timegreet script. The goodbye function output will appear.

10: Create functions for each of the menu items in the lookup script. Store the functions in a file called lookup_functions in a directory called myfunctions.

11: Autoload the functions in your lookup script and make the function calls for the corresponding cases.

12: Use the trap command so that if the user enters a menu selection other than an integer value, the trap command will print an error to the screen, and cause the script to ask the user to reenter the correct data type.

[1] A built−in command will override a function; therefore, an alias must be defined to the name of the function. (See "Aliases".) In the 1994 version of the Korn shell, the order of processing functions and built−ins was reversed, thus alleviating this problem.

[2] On versions of the Korn shell newer than 1988, the FCEDIT variable has been renamed HISTEDIT, and the fc command has been renamed hist.

[3] Tracked aliases will be undefined if the PATH variable is reset.

[4] Using backquotes for command substitution is an old form still used in the Bourne and C shells. Although still legal syntax, the Korn shell introduces a new method shown in this section.

[5] The POSIX standard defines functions with the Bourne shell syntax, but variables and traps cannot be local in scope, as with the new Korn shell definition.

[6] Bases greater than 36 are available on versions of the Korn shell that are newer than 1988.

[7] If you want the menu to reappear when the loop starts again, set the REPLY variable to null just before the done keyword.

[8] Korn, David G., and Bolsky, Morris I., *The Korn Shell Command and Programming Language* (Englewood Cliffs, NJ: Prentice−Hall, Inc., 1988), p. 77.

[9] Bolsky, Morris, and Korn, David, *The New Kornshell.* (Upper Saddle River, NJ: Prentice Hall, 1995), p. 78.

[10] Bolsky, Morris I., and Korn, David G., *The New KornShell Command and Programming Language* (Englewood Cliffs, NJ: Prentice Hall PTR, 1995), p. 327.

[11] See Section 3 of the UNIX manual for the C library function getopt.

CONTENTS

Chapter 11. The Interactive bash Shell

11.1 Introduction

With an interactive shell, the standard input, output, and error are tied to a terminal. When using the Bourne Again (bash) shell interactively, you type UNIX commands at the bash prompt and wait for a response. Bash provides you with a large assortment of built−in commands and command line shortcuts, such as history, aliases, file and command completion, command line editing, and many more. Some of the features were present in the standard UNIX Bourne shell but the GNU project has expanded the shell to include a number of new features as well adding POSIX compliancy. With the release of bash 2.x, so many features of the UNIX Korn shell and C shell have been included that the bash shell is a fully functional shell at both the interactive and programming level, while upwardly compatible with the standard Bourne shell. For UNIX users, bash offers an alternative to the standard shells, sh, csh, and ksh.[1]

This chapter focuses on how you interact with bash at the command line and how to customize your working environment. You will learn how to take advantage of all shortcuts and built−in features in order to create an efficient and fun working environment. The next chapter takes you a step further. Then you will be ready to write bash shell scripts to further tailor the working environment for yourself by automating everyday tasks and developing sophisticated scripts, and if you are an administrator, doing the same not only for yourself but also for whole groups of users.

11.1.1 Versions of bash

The Bourne Again shell is a Capricorn, born on January 10, 1988, fathered by Brian Fox and later adopted by Chet Ramey, who now officially maintains bash, enhances it, and fixes bugs. The first version of bash was 0.99. The current version (as of this writing) is version 2.04. Major enhancements were completed in version 2.0, but there are a num ber of operating systems that are still using version 1.14.7. All versions are freely available under the GNU public license. To see what version you are using, use the − −version option to bash or print the value of the BASH_VERSION environment variable.

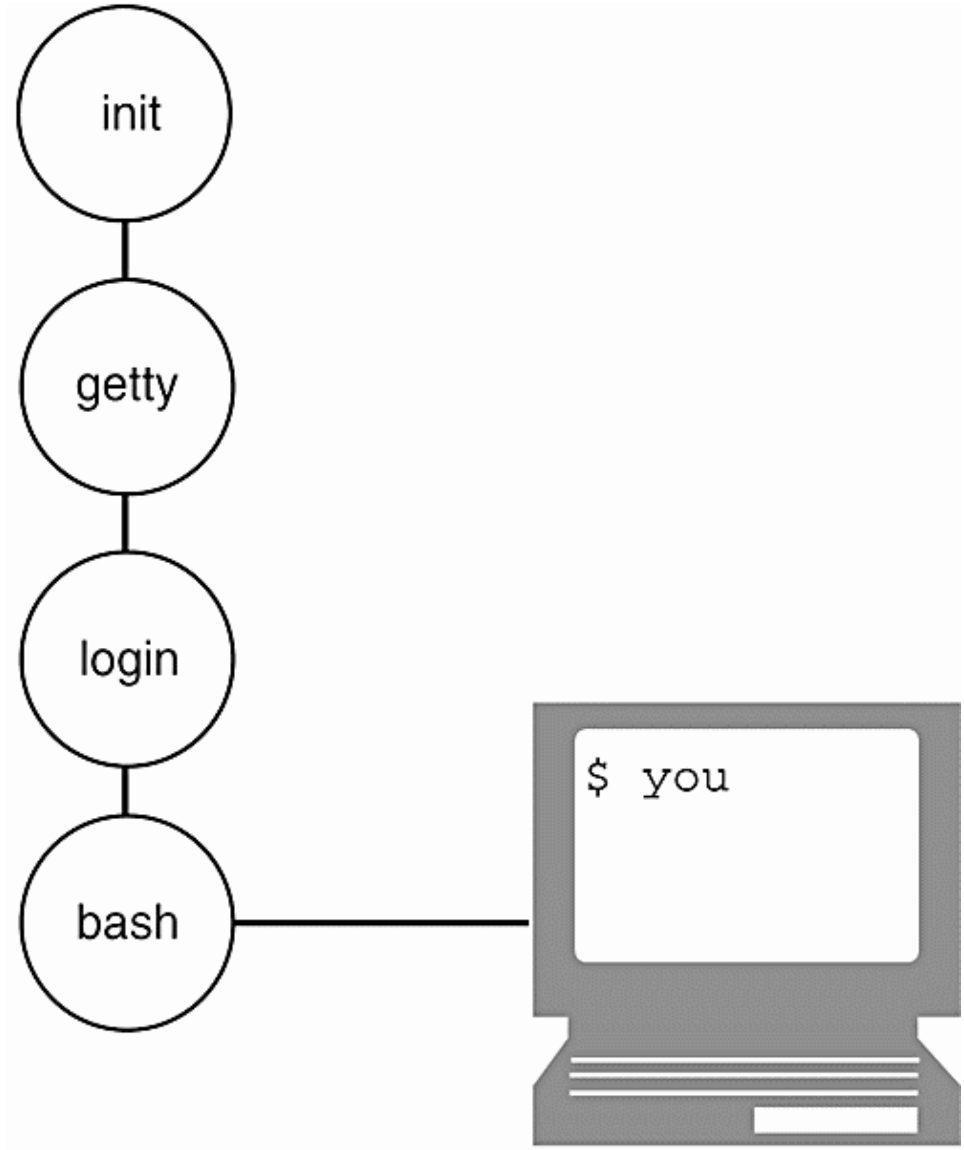
Example 11.1

```
$ bash −−version
GNU bash, version 2.03.0(1)−release (sparc−sun−solaris)
Copyright 1998 Free Software Foundation, Inc.

$ echo $BASH_VERSION
2.03.0(1)−release
```

11.1.2 Startup

If the bash shell is your login shell, it follows a chain of processes before you see a shell prompt.[2]

Figure 11.1. Starting the bash shell.



When the system boots, the first process to run is called init, PID #1. It spawns a getty process. This process opens up the terminal ports, providing a place where standard input comes from and a place where standard output and errors go, and puts a login prompt on your screen. The /bin/login program is then executed. The login program prompts for a password, encrypts and verifies the password, sets up an initial environment, and starts up the login shell, /bin/bash, the last entry in the passwd file. The bash process looks for the system file, /etc/profile, and executes its commands. It then looks in the user's home directory for an initialization file called .bash_profile. After executing commands from bash _profile, [3] it will execute a command from the user's ENV file, usually called .bashrc, and finally the default dollar sign ($) prompt appears on your screen and the shell waits for commands. (For more on initialization files, see "The Environment".)

Changing the Shell at the Command Line. If you want to start another shell from the command line temporarily (without changing the /etc/passwd file), just type the name of the shell. For example, if you are currently using the standard Bourne shell and would rather have bash as your shell, you can change the shell at the command line simply by typing bash.

Example 11.2

```
1   $ ps
    PID   TTY    TIME   CMD
    1574  pts/6  0:00   sh

2   $ bash
    bash−2.03$

3   bash−2.03$ ps
    PID   TTY    TIME    CMD
    1574  pts/6  0:00    sh
    1576  pts/6  0:00    bash
```

EXPLANATION

1. The output of the ps command shows what processes are running. Currently, sh (the Bourne shell) is running.
2. At the Bourne shell prompt, the user enters bash and starts up the Bourne Again shell. A new prompt appears.
3. At the bash prompt, the ps command is executed. The output shows that two shells are running and the current shell is now bash.

11.1.3 The Environment

The environment of a process consists of variables, open files, the current working directory, functions, resource limits, signals, and so forth. It defines those features that are inherited from one shell to the next and the configuration for the working environment. The configuration for the user's shell is defined in the shell initialization files.

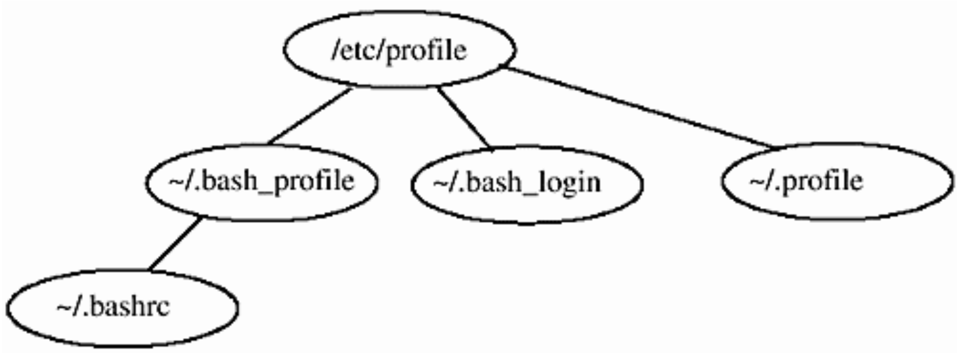
The Initialization Files. The bash shell has a number of startup files that are sourced. Sourcing a file causes all settings in the file to become part of the current shell; i.e., a subshell is not created. (The source command is discussed in "The source or dot Command" on page 621.) The initialization files are sourced depending on the whether the shell is a login shell, an interactive shell (but not the login shell), or a noninteractive shell (a shell script).

When you log on, before the shell prompt appears, the systemwide initialization file, etc/profile, is sourced. Next, if it exists, the .bash_profile in the user's home directory is sourced. It sets the user's aliases and functions and then sets user−specific environment variables and startup scripts.

If the user doesn't have a .bash_profile, but does have a file called .bash_login, that file will be sourced, and if he doesn't have a .bash_login, but does have a .profile, it will be sourced. (The .bash_login file is similar to the C shell's .login file and the .profile is normally sourced by the Bourne shell when it starts up.)

Here is a summary of the order that bash processes its initialization files [4] (see figure 11.2):

Figure 11.2. Order of processing initialization files.




```
if /etc/profile exists, source it,
   if ~/.bash_profile exists, source it,
      if  ~/.bashrc exists, source it,
   else if ~/.bash_login exists, source it,
   else if ~/.profile exists, source it.
```

The /etc/profile File. The /etc/profile file is a systemwide initialization file set up by the system administrator to perform tasks when the user logs on. It is executed when the bash shell starts up. It is also available to all Bourne and Korn shell users on the system and normally performs such tasks as checking the mail spooler for new mail and displaying the message of the day from the /etc/motd file. (The following examples will make more sense after you have completed this chapter.)

Example 11.3

```
(Sample /etc/profile)
# /etc/profile
# Systemwide environment and startup programs
# Functions and aliases go in /etc/bashrc

1  PATH="$PATH:/usr/X11R6/bin"
2  PS1="[\u@\h \W]\\$ "

3  ulimit -c 1000000
4  if [ 'id -gn' = 'id -un' -a 'id -u' -gt 14 ]; then
5    umask 002
   else
     umask 022
   fi

6  USER='id -un'
7  LOGNAME=$USER
8  MAIL="/var/spool/mail/$USER"

9  HOSTNAME='/bin/hostname'
10 HISTSIZE=1000
11 HISTFILESIZE=1000
12 export PATH PS1 HOSTNAME HISTSIZE HISTFILESIZE USER LOGNAME MAIL

13  for i in /etc/profile.d/*.sh ; do
14      if [ -x $i ]; then
15           . $i
        fi
16  done

17  unset i #
```

EXPLANATION

1. The PATH variable is assigned locations where the shell should search for commands.
2. The primary prompt is assigned. It will be displayed in the shell window as the user's name (\u),the @ symbol, the host machine (\W), and a dollar sign.
3. The ulimit command (a shell built−in command) is set to limit the maximum size of core files created to 1,000,000 bytes. Core files are memory dumps of programs that have crashed, and they take up a lot of disk space.
4. This line reads, if the user's group name is equal to the user's name and the user's ID number is greater than 14… (see 5)
5. Then set the umask to 002. When directories are created they will get 775 permissions and files will get 664 permissions. Otherwise, the umask is set to 022, giving 755 to directories and 644 to files.
6. The USER variable is assigned the username (id −un).
7. The LOGNAME variable is set to the value in $USER.
8. The MAIL variable is assigned the path to the mail spooler where the user's mail is saved.
9. The HOSTNAME variable is assigned the name of the user's host machine.
10. The HISTSIZE variable is set to 1000. HISTSIZE controls the number of history items that are remembered (from the history list stored in the shell's memory) and saved in the history file after the shell exits.
11. The HISTFILESIZE is set to limit the number of commands stored in the history file to 1000, i.e., the history file is truncated after it reaches 1,000 lines. (See "History".)
12. These variables are exported so that they will be available in subshells and child processes.
13. For each file (ending in .sh) in the etc/profile.d directory… (see 14)
14. Check to see if the file is executable, and if it is… (see 15)
15. Execute (source) the file with the dot command. The files in the /etc/profile.d directory: lang.sh and mc.sh, respectively, set the character and font sets and create a function called mc that starts up a visual/browser file manager program called Midnight Commander. To see how the file manager works, type mc at the bash prompt.
16. The done keyword marks the end of the for loop.
17. The variable i is unset, i.e., removed from shell's name space. The value of i is whatever was assigned to it while in the for loop, if anything was assigned at all.

The ~/.bash_profile File. If the ~/.bash_profile is found in the user's home directory, it is sourced after the /etc/profile. If ~/.bash_profile doesn't exist, bash will look for another user−defined file, ~./bash_login, and source it, and if ~./bash_login doesn't exist, it will source the ~/.profile, if it exists. Only one of the three files (~/.bash_profile, ~/.bash_login, or ~/.profile) will be sourced. Bash will also check to see if the user has a .bashrc file and then source it.

Example 11.4

```
(Sample .bash_profile)

    # .bash_profile
    # The file is sourced by bash only when the user logs on.

    # Get the aliases and functions
1   if [ −f ~/.bashrc ]; then
2           . ~/.bashrc
    fi

    # User−specific environment and startup programs
```

```
3   PATH=$PATH:$HOME/bin
4   ENV=$HOME/.bashrc     # or BASH_ENV=$HOME/.bashrc
5   USERNAME="root"

6   export USERNAME ENV PATH
7   mesg n
8   if [ $TERM = linux ]
    then
           startx    # Start the X Window system
    fi
```

EXPLANATION

1. If there is a file called .bashrc in the user's home directory… (see 2)
2. Execute (source) the .bashrc file for the login shell.
3. The PATH variable is appended with a path to the user's bin directory, normally the place where shell scripts are stored.
4. The BASH_ENV[a] (ENV) file is set to the pathname for the .bashrc file, an initialization file that will be sourced for interactive bash shells and scripts only if the BASH_ENV (ENV) variable is set. The .bashrc file contains user−defined aliases and functions.
5. The variable USERNAME is set to root.
6. The variables are exported so that they are available to subshells and other processes will know about them.
7. The mesg command is executed with the n option, disallowing others to write to the terminal.
8. If the value of the TERM variable is linux, then startx will start the X window system (the graphical user interface allowing multiple virtual consoles), rather than starting an interactive session in the Linux console window. Because the ~/.bash_profile is only sourced when you log in, the login shell would be the best place to start up your X windows session.

[a] BASH_ENV is used by versions of bash starting at 2.0.

The BASH_ENV (ENV) Variable. Before bash version 2.0, the BASH_ENV file was simply called the ENV file (same as in Korn shell). The BASH_ENV (ENV) variable is set in the ~/.bash_profile. It is assigned the name of a file that will be executed every time an interactive bash shell or bash script is started. The BASH_ENV (ENV) file will contain special bash variables and aliases. The name is conventionally .bashrc, but you can call it anything you want. The BASH_ENV (ENV) file is not processed when the privileged option is on (bash −p or set −o privileged) or the − −norc command line option is used (bash −norc or bash −−norc [bash 2.x +]).

The .bashrc File. The BASH_ENV (ENV) variable is assigned (by convention) the name .bashrc. This file is automatically sourced every time a new or interactive bash shell or bash script starts. It contains settings that pertain only to the bash shell.

Example 11.5

```
(Sample .bashrc)
# If the .bashrc file exists, it is in the user's home directory.
# It contains aliases (nicknames for commands) and user−defined
# functions.

# .bashrc
# User−specific aliases and functions
```

```
1   set −o vi
2   set −o noclobber
3   set −o ignoreeof
4   alias rm='rm −i'
    alias cp='cp −i'
    alias mv='mv −i'
5   stty erase ^h
   # Source global definitions
6  if [ −f /etc/bashrc ]; then
      . /etc/bashrc
   fi
7   case "$−" in
8      *i*) echo This is an interactive bash shell
              ;;
9      *)   echo This shell is noninteractive
              ;;
    esac
10  history_control=ignoredups

11  function cd { builtin cd $1; echo $PWD; }
```

EXPLANATION

1. The set command with the −o switch turns on or off special built−in options. (See "The set −o Options" on page 610.) If the switch is −o, a minus sign, the option is turned on, and if a plus sign, the option is turned off. The vi option allows interactive command line editing. For example, set −o vi turns on interactive command−line editing, whereas set vi +o turns it off. (See Table 11.1.)
2. The noclobber option is turned on, which prevents the user from overwriting files when using redirection; e.g., sort filex > filex. (See "Standard I/O and Redirection".)
3. When exiting a shell, normally you can type ^D (Control−D). With ignoreeof set, you must type exit.
4. The alias for rm, rm −i, causes rm to be interactive (−i), i.e., it will ask the user if it's OK to remove files before actually removing them.The alias for the cp, cp −i, command causes the copy to be interactive.
5. The stty command is used to set the terminal backspace key to erase. ^H represents the Backspace key.
6. If a file called /etc/bashrc exists, source it.
7. If the shell is interactive, the special variable, $−, will contain an i. If not, you are probably running a script. The case command evaluates $−.
8. If the value returned from $− matches *i*, i.e., any string containing an i, then the shell prints This is an interactive shell.
9. Otherwise, the shell prints This shell is noninteractive. If you start up a script, or a new shell at the prompt, you will be able to tell whether or not your shell is interactive. It is only here to let you test your understanding of the terms "interactive" and "noninteractive" shell.
10. The history_control setting is used to control how commands are saved in the history file. This line says, Don't save commands in the history file if they're already there.; i.e., ignore duplicates.
11. This is a user−defined function. When the user changes directories, the present working directory, PWD, is printed. The function is named cd and contains within its definition, the command cd. The special built−in command, called builtin, precedes the cd command

within the function definition to prevent the function from going into an infinite recursion; i.e., from calling itself indefinitely.

The /etc/bashrc File. Systemwide functions and aliases can be set in the /etc/bashrc file. The primary prompt is often set here.

Example 11.6

```
 (Sample /etc/bashrc)

    # Systemwide functions and aliases
    # Environment stuff goes in /etc/profile

    # For some unknown reason bash refuses to inherit
    # PS1 in some circumstances that I can't figure out.
    # Putting PS1 here ensures that it gets loaded every time.

1   PS1="[\u@\h \W]\\$ "

2   alias which="type −path"
```

EXPLANATION

1. Systemwide functions and aliases are set here. The primary bash prompt is set to the name of the user (\u), and @ symbol, the host machine (\h), the basename of the current working directory, and a dollar sign. (See Table 11.2 .) This prompt will appear for all interactive shells.
2. Aliases, nicknames for commands, are usually set in the user's .bashrc file. The alias was preset and is available when bash starts up. You use it when you want to find out where a program resides on disk; i.e., what directory it is found in; e.g., which ls will print /bin/ls.

The ~/.profile File. The .profile file is a user−defined initialization file. It is found in the user's home directory, and sourced once at login if running sh (Bourne shell). If running bash, .profile will be run if bash cannot find any other of the initialization files listed above. It allows a user to customize and modify his shell environment. Environment and terminal settings are normally put here, and if a window application or database application is to be initiated, it is started here.

Example 11.7

```
(Sample .profile)
# A login initialization file sourced when running as sh or the
#.bash_profile or .bash_login are not found.
1  TERM=xterm
2  HOSTNAME='uname −n'
3  EDITOR=/bin/vi
4  PATH=/bin:/usr/ucb:/usr/bin:/usr/local:/etc:/bin:/usr/bin:.
5  PS1="$HOSTNAME $ > "
6  export TERM HOSTNAME EDITOR PATH PS1
7  stty erase ^h
8  go () { cd $1; PS1='pwd'; PS1='basename $PS1'; }
9  trap '$HOME/.logout' EXIT
10 clear
```

EXPLANATION

1. The TERM variable is assigned the value of the terminal type, xterm.
2. Because the uname −n command is enclosed in backquotes, the shell will perform command substitution, i.e., the output of the command (the name of the host machine) will be assigned to the variable HOSTNAME.
3. The EDITOR variable is assigned /bin/vi. Programs such as mail and history will now have this variable available when defining an editor.
4. The PATH variable is assigned the directory entries that the shell searches in order to find a UNIX program. If, for example, you type ls, the shell will search the PATH until it finds that program in one of the listed directories. If it never finds the program, the shell will tell you so.
5. The primary prompt is assigned the value of HOSTNAME, the machine name, and the $ and > symbols.
6. All of the variables listed are exported. They will be known by child processes started from this shell.
7. The stty command sets terminal options. The Erase key is set to ^H, so that when you press the Backspace key, the letter typed preceding the cursor is erased.
8. A function called go is defined. The purpose of this function is to take one argument, a directory name, cd to that directory, and set the primary prompt to the present working directory. The basename command removes all but the last entry of the path. The prompt will show you the current directory.
9. The trap command is a signal handling command. When you exit the shell, that is, log out, the .logout file will be executed. The .logout file is a user−defined file containing commands that will be executed just before logging out, commands that will clean up temp files or log the time of log out, etc.
10. The clear command clears the screen.

The ~/.bash−logout File. When the user logs out (exits the login shell), if a file called ~/.bash_logout exists, it is sourced. This file normally contains commands to clean up temporary files, truncate the history file, record the time of logout, etc.

Options to Prevent Startup Files from Being Executed. If bash is invoked with the − −noprofile option (e.g., bash − −noprofile), then the /etc/profile, ~/.bash_profile, ~/.bash_login, or ~/.profile startup files will not be sourced.

If invoked with the −p option (e.g., bash −p), bash will not read the user's ~/.profile file.

If bash is invoked as sh (Bourne shell), it tries to mimic the behavior of the Bourne shell as closely as possible. For a login shell, it attempts to source only /etc/profile and ~/.profile, in that order. The −noprofile option may still be used to disable this behavior. If the shell is invoked as sh, it does not attempt to source any other startup files.

The .inputrc File. Another default initalization file, .inputrc, is also read when bash starts up. This file, if it exists in the user's home directory, contains variables to customize keystroke behavior and settings that bind strings, macros, and control functions to keys. The names for the key bindings and what they do are found in the Readline library, a library that is used by applications that manipulate text. The bindings are used particularly by the built−in emacs and vi editors, when performing command line editing. (See "Command Line Editing" on page 641 for more on readline.)

11.1.4 Setting bash Options with the Built−In set and shopt Commands

The set −o Options. The set command can take options when the −o switch is used. Options allow you to customize the shell environment. They are either on or off, and are normally set in the BASH_ENV (ENV) file. Many of the options for the set command are set with an abbreviated form. For example, set −o noclobber can also be written, set −C. (See Table 11.1.)

Table 11.1. The Built−In set Command Options

Name of Option Shortcut SwitchWhat It Doesallexport−aAutomatically marks new or modified variables for export from the time the option is set, until unset.braceexpand−BEnables brace expansion, and is a default setting.emacs For command line editing, uses the emacs built−in editor, and is a default setting.errexit−eIf a command returns a nonzero exit status (fails), exits. Not set when reading initialization files.histexpand−HEnables ! and !! when performing history substitution, and is a default setting.history Enables command line history; on by default.ignoreeof Disables EOF (Control−D) from exiting a shell; must type exit. Same as setting shell variable, IGNOREEOF=10.keyword−kPlaces keyword arguments in the environment for a command. interactive−comments For interactive shells, a leading # is used to comment out any text remaining on the line.monitor−mAllows job control.noclobber−CProtects files from being overwritten when redirection is used.noexec−nReads commands, but does not execute them. Used to check the syntax of scripts. Not on when running interactively.noglob−dDisables pathname expansion; i.e., turns off wildcards.notify−bNotifies user when background job finishes.nounset−uDisplays an error when expanding a variable that has not been set.onecmd−tExit after reading and executing one command.physical−PIf set, does not follow symbolic links when typing cd or pwd. The physical directory is used instead.posix Shell behavior is changed if the default operation doesn't match the POSIX standard.privileged−pWhen set, the shell does not read the .profile or ENV file and shell functions are not inherited from the environment; automatically set for setuid scripts.posix Change the default behavior to POSIX 1003.2.verbose−vTurns on the verbose mode for debugging.vi For command line editing, uses the vi built−in editor.xtrace−xTurns on the echo mode for debugging.

FORMAT

```
set −o option  # Turns on the option.
set +o option  # Turns off the option.
set −[a−z]  # Abbreviation for an option; the minus turns it on.
set +[a−z]  # Abbreviation for an option; the plus turns it off.
```

Example 11.8

```
1   set −o allexport
2   set +o allexport
3   set −a
4   set +a
```

EXPLANATION

1. Sets the allexport option. This option causes all variables to be automatically exported to subshells.
2. Unsets the allexport option. All variables will now be local in the current shell.

3. Sets the allexport option. Same as 1. Not every option has an abbreviation. (See Table 11.1.)
4. Unsets the allexport option. Same as 2.

Example 11.9

```
1 $ set −o
  braceexpand    on
  errexit        off
  hashall        on
  histexpand     on
  keyword        off
  monitor        on
  noclobber      off
  noexec         off
  noglob         off
  notify         off
  nounset        off
  onecmd         off
  physical       off
  privileged     off
  verbose        off
  xtrace         off
  history        on
  ignoreeof      off
  interactive−comments on
  posix          off
  emacs          off
  vi             on

2  $ set −o noclobber
3  $ date > outfile
4  $ ls > outfile
   bash: outfile: Cannot clobber existing file.
5  $ set +o noclobber
6  $ ls > outfile
7  $ set −C
```

EXPLANATION

1. With the −o option, the set command lists all the options currently set or not set.
2. To set an option, the −o option is used. The noclobber option is set. It protects you from overwriting files when using redirection. Without noclobber, the file to the right of the > symbol is truncated if it exists, and created if it doesn't exist.
3. The output of the UNIX date command is redirected to a file called outfile.
4. This time, the outfile exists. By attempting to redirect the output of ls to outfile, the shell complains that the file already exists. Without noclobber set, it would be clobbered.
5. With the +o option to the set command, noclobber is turned off.
6. This time, trying to overwrite outfile is fine because noclobber is no longer set.
7. Using the −C switch to the set command is an alternate way of turning on noclobber. +C would turn it off.

The shopt Built−In (Version 2.x+). The shopt (shell options) built−in command is used in newer versions of bash as an alternative to the set command. In many ways shopt duplicates the set built−in command, but it adds more options for configuring the shell. See Table 11.27 for a list of all the shopt options. In the following example, shopt with the −p option prints all the available options settings. The −u switch indicates an unset option and −s indicates one that is currently set.

Example 11.10

```
1   $ shopt −p
    shopt −u cdable_vars
    shopt −u cdspell
    shopt −u checkhash
    shopt −u checkwinsize
    shopt −s cmdhist
    shopt −u dotglob
    shopt −u execfail
    shopt −s expand_aliases
    shopt −u extglob
    shopt −u histreedit
    shopt −u histappend
    shopt −u histverify
    shopt −s hostcomplete
    shopt −u huponexit
    shopt −s interactive_comments
    shopt −u lithist
    shopt −u mailwarn
    shopt −u nocaseglob
    shopt −u nullglob
    shopt −s promptvars
    shopt −u restricted_shell
    shopt −u shift_verbose
    shopt −s sourcepath

2   $ shopt −s cdspell
3   $ shopt −p cdspell
    shopt −s cdspell
4   $ cd /hame
    /home
5   $ pwd
    /home
6   $ cd /ur/lcal/ban
    /usr/local/man
7   $ shopt −u cdspell
8   $ shopt −p cdspell
    shopt −u cdspell
```

EXPLANATION

1. With the −p (print) option, the shopt command lists all settable shell options and their current values, either set (−s) or unset (−u).
2. With the −s option, shopt sets (or turns on) an option. The cdspell option causes the shell to correct minor spelling errors on directory names given as arguments to the cd command. It will correct simple typos, insert missing letters, and even transpose letters if it can.
3. With the −p option and the name of the option, shopt indicates whether the option is set. The option has been set (−s).
4. In this example, the user tries to cd to his home directory, but misspells home. The shell fixes the spelling; i.e., hame becomes home. The directory is changed to /home.
5. The output of the pwd command displays the current working directory, showing that the directory was really changed even though the user spelled it wrong.
6. This time the directory name is missing letters and has a misspelling for the last entry, ban. The shell makes a pretty good attempt to spell out the correct pathname by inserting the missing letters, and correcting ban to man. Because the b in ban is the first misspelled

character, the shell searches in the directory for an entry that might end with a and n. It finds man.

7. With the −u switch[a], shopt unsets (or turns off) the option.
8. With the −p switch and the name of the option, shopt indicates whether the option is set. The cdspell option has been unset (−u).

[a] The words switch or option are interchangeable. They are arguments to a command that contain a leading dash.

11.1.5 The Prompts

When used interactively, the shell prompts you for input. When you see the prompt, you know that you can start typing commands. The bash shell provides four prompts: the primary prompt is a dollar sign ($), and the secondary prompt is a right angle bracket symbol (>). The third and fourth prompts, PS3 and PS4 respectively, will be discussed later. The prompts are displayed when the shell is running interactively. You can change these prompts.

The variable PS1 is set to a string containing the primary prompt. Its value, the dollar sign, appears when you log on and waits for user input, normally a UNIX command. The variable PS2 is the secondary prompt, initially set to the right angle bracket character (>). It appears if you have partially typed a command and then pressed Enter. You can change the primary and secondary prompts.

The Primary Prompt. The dollar sign (or bash $) is the default primary prompt. You can change your prompt. Normally prompts are defined in /etc/bashrc or the user initialization file, .bash_profile, or .profile (Bourne shell).

Example 11.11

```
1   $ PS1="$(uname −n) > "
2   chargers >
```

EXPLANATION

1. The default primary prompt is a dollar sign (bash $). The PS1 prompt is being reset to the name of the machine[a](uname −n) and a > symbol.
2. The new prompt is displayed.

[a] The command, uname −n, is executed because it is enclosed in a set of parentheses preceded by a dollar sign. An alternative would be to enclose the command in backquotes. See "Command Substitution".)

Setting the Prompt with Special Escape Sequences. By inserting special backslash/escape sequences into the prompt string, you can customize the prompts. Table 11.2 lists the special sequences.

Table 11.2. Prompt String Settings

Backslash SequenceWhat It Evaluates To\tThe current time in HH:MM:SS format.\dThe date in "Weekday Month Date" format (e.g., Tue May 26).\nNewline.\sThe name of the shell, the basename of $0 (the portion following the final slash).\wThe current working directory.\WThe basename of the current working directory.\uThe username of the current user.\hThe hostname.\#The command number of this command.\!The history number of this command.\$If the effective UID is 0, a #, otherwise a $.\nnnThe character corresponding to the octal number nnn.\\Backslash.\[Begin a sequence of nonprinting characters; could be used to embed a terminal control sequence into the prompt.\]End a sequence of nonprinting characters. New in bash Version 2.x+:\aThe ASCII bell character.\@The current time in 12−hour AM/PM format.\HThe hostname.\TThe current time in 12−hour format: HH:MM:SS.\eThe ASCII escape character (033).\vThe version of bash, e.g., 2.03.\VThe release and pathlevel of bash; e.g., 2.03.0.

Example 11.12

```
1   $  PS1="[\u@\h \W]\\$ "
    [ellie@homebound ellie]$

2   $  PS1="\W:\d> "
    ellie:Tue May 18>
```

EXPLANATION

1. You customize the primary bash prompt using special backslash/escape sequences. \u evaluates to the user's login name, \h to the host machine, and \W is the basename for the current working directory. There are two backslashes. The first backslash escapes the second backslash, resulting in \$. The dollar sign is protected from shell interpretation and thus printed literally.
2. The primary prompt is assigned \W, the escape sequence evaluating to the basename of the current working directory, and \d, the escape sequence evaluating to today's date.

The Secondary Prompt. The PS2 variable is assigned a string called the secondary prompt. Its value is displayed to standard error, which is the screen by default. This prompt appears when you have not completed a command or more input is expected. The default secondary prompt is >.

Example 11.13

```
1   $ echo "Hello
2   > there"
3   Hello
    there
4   $

5   $ PS2="----> "
6   $ echo 'Hi
7   ------>
    ------>
    ------>there'
     Hi


    there
    $

8 $ PS2="\s:PS2 > "
  $ echo 'Hello
   bash:PS2 > what are
   bash:PS2 > you
   bash:PS2 > trying to do?
   bash:PS2 > '
   Hello
   what are
   you
   trying to do?
```

```
$
```

EXPLANATION

1. The double quotes must be matched after the string "Hello.
2. When a newline is entered, the secondary prompt appears. Until the closing double quotes are entered, the secondary prompt will be displayed.
3. The output of the echo command is displayed.
4. The primary prompt is displayed.
5. The secondary prompt is reset.
6. The single quote must be matched after the string 'Hi.
7. When a newline is entered, the new secondary prompt appears. Until the closing single quote is entered, the secondary prompt will be displayed.
8. The PS2 prompt is set to the name of the shell (\s) followed by a string consisting of a colon, PS2 and >, followed by a space.

The Search Path. Bash uses the PATH variable to locate commands typed at the command line. The path is a colon−separated list of directories used by the shell when searching for commands. The default path is system−dependent, and is set by the administrator who installs bash. The path is searched from left to right. The dot at the end of the path represents the current working directory. If the command is not found in any of the directories listed in the path, the shell sends to standard error the message filename: not found. The path is normally set in the .bash_profile if running the bash shell or .profile file if using sh, the Bourne shell.

If the dot is not included in the path and you are executing a command or script from the current working directory, the name of the script must be preceded with a ./, such as ./program_name, so that shell can find the program.

Example 11.14

```
(Printing the PATH)
1   $ echo $PATH
    /usr/gnu/bin:/usr/local/bin:/usr/ucb:/bin:/usr/bin:.

(Setting the PATH)
2   $ PATH=$HOME:/usr/ucb:/usr:/usr/bin:/usr/local/bin:
3   $ export PATH
4   $ runit
    bash: runit: command not found
5   $ ./runit
    < program starts running here >
```

EXPLANATION

1. By echoing $PATH, the value of the PATH variable is displayed. The path consists of a list of colon−separated elements and is searched from left to right. The dot at the end of the path represents the user's current working directory.
2. To set the path, a list of colon−separated directories are assigned to the PATH variable. Note that in this path, the dot is not at the end of the path, perhaps as a security measure.
3. By exporting the path, child processes will have access to it. It is not necessary to export the PATH on a separate line: It could be written as follows: export PATH=$HOME:/usr/ucb:/bin:., etc., on the same line.
4. Because the dot is not in the search path, when the runit program is executed in the present working directory, bash can't find it.

5. Because the program name is preceded with a dot and a slash (./), the shell will be able to find it, and execute it, if it is the current working directory.

The hash Command. The hash command controls the internal hash table used by the shell to improve efficiency in searching for commands. Instead of searching the path each time a command is entered, the first time you type a command, the shell uses the search path to find the command, and then stores it in a table in the shell's memory. The next time you use the same command, the shell uses the hash table to find it. This makes it much faster to access a command than having to search the complete path. If you know that you will be using a command often, you can add the command to the hash table. You can also remove commands from the table. The output of the hash command displays the number of times the shell has used the table to find a command (hits) and the full pathname of the command. The hash command with the −r option clears the hash table. An argument of − − disables option checking for the rest of the arguments. Hashing is automatically implemented by bash. Although you can turn it off, if there isn't any compelling reason to do so, don't.

Example 11.15

```
(Printing the PATH)

(Command line)
1   hash
    hits   command
    1      /usr/bin/mesg
    4      /usr/bin/man
    2      /bin/ls

2   hash −r
3   hash
    No commands in hash table

4   hash find
    hits    command
    0       /usr/bin/find
```

EXPLANATION

1. The hash command displays the full pathname of commands that have been executed in this login session.(Built−in commands are not listed) The number of hits is the number of times the hash table has been used to find the command.
2. The −r option to the hash command erases all remembered locations in the hash table.
3. After the −r option was used in the last command, the hash command reports that there are no commands currently in the table.
4. If you know you are going to use a command often, you can add it to the hash table by giving it as an argument to the hash command. The find command has been added. The table has zero hits because the command hasn't been used yet.

The source or dot Command. The source command (from the C shell) is a built−in bash shell command. The `dot` command, simply a period, (from the Bourne shell) is another name for source. Both commands take a scriptname as an argument. The script will be executed in the environment of the current shell; that is, a child process will not be started. All variables set in the script will become part of the current shell's environment. Likewise, all variables set in the current shell will become part of the script's environment. The source (or dot) command is normally used to reexecute any of the initialization files, e.g., .bash_profile, .profile, etc, if they have been modified. For example, if one of the settings, such as the EDITOR or TERM variable, has been changed in the .bash_profile since you logged on, you can use the source command to reexecute commands in the .bash_profile without logging out and then logging back on. A file, such as .bash_profile, or for that matter any shell script, does not need execute permissions to be sourced with either the dot or the source commands.

Example 11.16

```
$ source .bash_profile
$ . .bash_profile
```

EXPLANATION

The source or dot command executes the initialization file, .bash_profile, within the context of the current shell. Local and global variables are redefined within this shell. The dot command makes it unnecessary to log out and then log back in again after the file has been modified.[a]

[a] If the .bash_profile were executed directly as a script, a child shell would be started. Then the variables would be set in the child shell, and when the child shell exited, the parent shell would not have any of the settings available to it.

11.1.6 The Command Line

After you log on, the bash shell displays its primary prompt, a dollar sign by default. The shell is your command interpreter. When the shell is running interactively, it reads commands from the terminal and breaks the command line into words. A command line consists of one or more words (or tokens), separated by whitespace (blanks and/or tabs), and terminated with a newline, generated by pressing the Enter key. The first word is the command, and subsequent words are the command's arguments. The command may be a UNIX executable program such as ls or date, a user−defined function, a built−in command such as cd or pwd, or a shell script. The command may contain special characters, called metacharacters, which the shell must interpret while parsing the command line. If a command line is too long, the backslash character, followed by a newline, will allow you to continue typing on the next line. The secondary prompt will appear until the command line is terminated.

The Order of Processing Commands. The first word on the command line is the command to be executed. The command may be a keyword, an alias, a function, a special built−in command or utility, an executable program, or a shell script. The command is executed according to its type in the following order:

1. Aliases
2. Keywords (such as if, function, while, until)
3. Functions
4. Built−in commands
5. Executables and scripts

Special built−in commands and functions are defined within the shell, and therefore are executed from within the context of the current shell, making them much faster in execution. Scripts and executable programs such as ls and date are stored on disk, and the shell, in order to execute them, must first locate them within the directory hierarchy by searching the PATH environment variable; the shell then forks a new shell that executes the script. To find out the type of command you are using—i.e., a built−in command, an alias, a function, or an executable, etc.—use the built−in type command. (See Example 11.17.)

Example 11.17

```
$ type pwd
pwd is a shell builtin
$ type test
test is a shell builtin
$ type clear
clear is /usr/bin/clear
```

```
$ type m
m is aliased to 'more'
$ type bc
bc is /usr/bin/bc
$ type if
if is a shell keyword
$ type −path cal
/usr/bin/cal
$ type which
which is aliased to 'type −path'
$ type greetings
greetings is a function
greetings ()
{
       echo "Welcome to my world!";
}
```

Built−In Commands and the help Command. Built−in commands are commands that are part of the internal source code for the shell. They are built−in and readily available to the shell, whereas commands such as date, cal, and finger are compiled binary programs that reside on the disk. There is less overhead in executing a built−in because it involves no disk operations. Built−in commands are executed by the shell before the programs on disk. Bash has added a new online help system so that you can see all the built−ins, or a description for a particular built−in; help itself is a built−in command. See Table 11.28 for a complete list of built−in commands.

Example 11.18

```
1   $ help help
    help: help [pattern ...]
    Display helpful information about built−in commands. if PATTERN
    is specified, gives detailed help on all commands matching
    PATTERN, otherwise a list of the built−ins is printed.

2   $ help pw
    pwd: pwd
        Print the current working directory.
```

Changing the Order of Command Line Processing. Bash provides three built−in commands that can override the order of command line processing: command, builtin, and enable.

The command built−in eliminates aliases and functions from being looked up in the order of processing. Only built−ins and executables, found in the search path, will be processed.

The builtin command looks up only built−ins, ignoring functions and executables found in the path.

The enable built−in command turns built−ins on and off. By default, built−ins are enabled. Disabling a built−in allows an executable command found on the disk to be to be executed without specifying a full pathname, even if it has the same name as a built−in. (In normal processing, bash searches for built−ins before disk executable commands.) Built−ins become disabled by using the −n switch. For example, a classic confusion for new shell programmers is naming a script test. Because test is a built−in command, the shell will try to execute it rather than the user's script (a built−in is normally executed before any executable program). By typing: enable −n test, the test built−in is disabled, and the user's script will take precedence.

Without options, the enable built−in prints a list of all the built−ins. Each of the following built−ins are described in "Shell Built−In Commands".

Example 11.19

```
1   $ enable
    enable .
    enable :
    enable [
    enable alias
    enable bg
    enable bind
    enable break
    enable builtin
    enable cd
    enable command
    enable continue
    enable declare
    enable dirs
        .....
    enable read
    enable readonly
    enable return
    enable set
    enable shift
    enable shopt
       .....
    enable type
    enable typeset
    enable ulimit
    enable umask
    enable unalias
    enable unset
    enable wait

2   enable −n test

3   function cd { builtin cd; echo $PWD; }
```

EXPLANATION

1. The enable built−in, without any options, displays a complete list of all bash shell built−in commands. This example shows just part of that list.
2. With the −n switch, the test built−in command is disabled. Now, you execute your script named test without worrying about the built−in test being executed instead. It's not good practice to name a script by the same name as an operating system command, because if you try to run the same script in another shell, the disabling of built−ins doesn't exist.
3. The function is called cd. The builtin command causes the cd within the function definition to be called instead of the function cd, which would cause an endless recursive loop.

The Exit Status. After a command or program terminates, it returns an exit status to the parent process. The exit status is a number between 0 and 255. By convention, when a program exits, if the status returned is zero, the command was successful in its execution. When the exit status is nonzero, the command failed in some way. If a command is not found by the shell, the exit status returned is 127. If a fatal signal causes the command to terminate, the exit status is 128 plus the value of the signal that caused it to die.

The shell status variable, ?, is set to the value of the exit status of the last command that was executed. Success or failure of a program is determined by the programmer who wrote the program.

Example 11.20

```
1   $ grep ellie /etc/passwd
    ellie:MrHJEFd2YpkJY:501:501::/home/ellie:/bin/bash
2   $ echo $?
    0

3   $ grep nicky /etc/passwd
4   $ echo $?
    1

5   $ grep ellie /junk
    grep: /junk: No such file or directory
6   $ echo $?
    2

7   $ grip ellie /etc/passwd
    bash: grip: command not found
8   $ echo $?
    127

9   $ find / −name core ^C    User presses Control−C
10  $ echo $?
    130
```

EXPLANATION

1. The grep program searches for the pattern ellie in the /etc/passwd file and is successful. The line from /etc/passwd is displayed.
2. The ? variable is set to the exit value of the grep command. Zero indicates successful status.
3. The grep program cannot find user nicky in the /etc/passwd file.
4. The grep program cannot find the pattern; the ? variable return value is nonzero. An exit status of 1 indicates failure.
5. The grep fails because the /junk file cannot be opened.The grep error message is sent to standard error, the screen.
6. If grep cannot find the file, it returns an exit status of 2.
7. The grip command is not found by the shell.
8. Because the command is not found, the exit status, 127, is returned.
9. The find command is interrupted when the SIGINT signal is sent by pressing Control−C. The signal number for Ctrl−C is 2.
10. The status returned from a process that has been killed is 128 + the number of the signal; i.e., 128 + 2.

Multiple Commands at the Command Line. A command line can consist of multiple commands. Each command is separated by a semicolon, and the command line is terminated with a newline. The exit status is that of the last command in the chain of commands.

Example 11.21

```
$ ls; pwd; date
```

EXPLANATION

The commands are executed from left to right, one after the other, until the newline is reached.

Grouping Commands. Commands may also be grouped so that all of the output is either piped to another command or redirected to a file.

Example 11.22

```
$ ( ls; pwd; date ) > outputfile
```

EXPLANATION

The output of each of the commands is sent to the file called outputfile. The spaces inside the parentheses are necessary.

Conditional Execution of Commands. With conditional execution, two command strings are separated by the special metacharacters, double ampersands (&&) and double vertical bars (||). The command on the right of either of these metacharacters will or will not be executed based on the exit condition of the command on the left.

Example 11.23

```
$ cc prgm1.c –o prgm1 && prgm1
```

EXPLANATION

If the first command is successful (has a zero exit status), the command after the && is executed; i.e., if the cc program can successfully compile prgm1.c, the resulting executable program, prgm1, will be executed.

Example 11.24

```
$ cc prog.c >& err || mail bob < err
```

EXPLANATION

If the first command fails (has a nonzero exit status), the command after the || is executed; i.e., if the cc program cannot compile prog.c, the errors are sent to a file called err, and user bob will be mailed the err file.

Commands in the Background. Normally, when you execute a command, it runs in the foreground, and the prompt does not reappear until the command has completed execution. It is not always convenient to wait for the command to complete. When you place an ampersand (&) at the end of the command line, the shell will return the shell prompt immediately and execute the command in the background concurrently. You do not have to wait to start up another command. The output from a background job will be sent to the screen as it processes. Therefore, if you intend to run a command in the background, the output of that command might be redirected to a file or piped to another device, such as a printer, so that the output does not interfere with what you are doing.

The ! variable contains the PID number of the last job put in the background. (See "Job Control" for more on background processing.)

Example 11.25

```
1   $ man sh | lp&
2   [1] 1557
3   $ kill −9 $!
```

EXPLANATION

1. The output of the man command (the manual pages for the UNIX command) is piped to the printer. The ampersand at the end of the command line puts the job in the background.
2. There are two numbers that appear on the screen: the number in square brackets indicates that this is the first job to be placed in the background; the second number is the PID, or the process identification number of this job.
3. The shell prompt appears immediately. While your program is running in the background, the shell is waiting for another command in the foreground. The ! variable evaluates to the PID of the job most recently put in the background. If you get it in time, you will kill this job before it goes to the print queue.

11.1.7 Job Control

Job control is a powerful feature of the bash shell that allows you to selectivly run programs, called jobs, in the background or foreground. A running program is called a process or a job and each process has a process ID number, called the PID. Normally, a command typed at the command line is running in the foreground and will continue until it has finished unless you send a signal by pressing Ctrl−C or Ctrl−\ to terminate it. With job control you can send a job to the background and let it keep running; you can stop a job by pressing Ctrl−Z, which sends the job to the background and suspends it; you can cause a stopped job to run in the background; you can bring a background job back to the foreground; and you can even kill the jobs you have running in the background or foreground. For a list of job commands, see Table 11.3.

By default, job control is already set (some older versions of UNIX do not support this feature). If disabled, it can be reset by any one of the following commands:

FORMAT

```
set −m             # set job control in the .bashrc file
set −o monitor     # set job control in the .bashrc file
bash −m −i         # set job control when invoking interactive bash
```

Example 11.26

```
1   $ vi
    [1]+  Stopped     vi

2   $ sleep 25&
    [2] 4538

3   $ jobs
    [2]+  Running     sleep 25&
    [1]−  Stopped       vi

4   $ jobs −l
    [2]+ 4538   Running      sleep 25&
    [1]− 4537   Stopped        vi

5   $ jobs %%
```

```
    [2]+ 4538   Running       sleep 25&

6   $ fg %1

7   $ jobs -x echo %1
    4537

8   $ kill %1         # or  kill 4537
    [1]+   Stopped      vi
    Vim: Caught deadly signal TERM
    Vim: Finished.
    [1]+   Exit 1      vi
```

EXPLANATION

1. After the vi editor is invoked, you can press ^Z (Control−Z) to suspend the vi session. The editor will be suspended in the background, and after the message Stopped appears, the shell prompt will appear immediately.
2. The ampersand at the end of the command causes the sleep command, with an argument of 25, to execute in the background. The notation [2] means that this is the second job to be run in the background and the PID of this job is 4538.
3. The jobs command displays the jobs currently in the background.
4. The jobs command with the −l option displays the processes (jobs) running in the background and the PID numbers of those jobs.
5. The %% argument causes jobs to display the most recent command put in the job table.
6. The fg command followed by a percent sign and the job number will bring that numbered job into the foreground. Without a number, fg brings the most recently backgrounded job back into the foreground.
7. The −x option can be used to print just the PID number of the job. %1 refers to the vi session that was stopped in the first example.
8. The kill command sends a TERM signal to the process and kills it. The vi program is killed. You can specify either the job number or the PID number as arguments to the kill command.

Table 11.3. Job Control Commands

Command MeaningjobsLists all the jobs running.^Z (Ctrl−Z)Stops (suspends) the job; the prompt appears on the screen.bgStarts running the stopped job in the background.fgBrings a background job to the foreground.stopSuspends a background job.stty tostopSuspends a background job if it sends output to the terminal.killSends the kill signal to a specified job.wait [n]Waits for a specified job and returns its exit status, where n is a PID or job number.

Argument to jobs command	Represents
%n	Job number n.
%sting	Job name starting with string.
%?string	Job name containing string.
%%	Current job.

%+	Current job.
%−	Previous job, before current job.
−r	Lists all running jobs.
−s	Lists all suspended jobs.

New jobs Options. Two new options were added to the jobs command in bash versions 2.x. They are the −r and −s options. The −r option lists all running jobs, and the −s option lists all stopped jobs.

The disown Built−In. The disown built−in command (bash 2.x) removes a specified job from the job table. After the job has been removed, the shell will no longer recognize it as a viable job process and it can only be referenced by its process ID number.

11.2 Command Line Shortcuts

11.2.1 Command and Filename Completion

To save typing, bash implements command and filename completion, a mechanism that allows you to type part of a command or filename, press the Tab key, and the rest of the word will be completed for you.

If you type the first letters in a command and press the Tab key, bash will attempt to complete the command and execute it. If bash cannot complete the filename or command, because neither exists, the terminal may beep and the cursor will stay at the end of the command. If there is more than one command starting with those characters and you press the Tab key a second time, all commands that start with those characters will be listed.

If there are several files starting with the same letters, bash will complete the shortest name that matches, expand out the filename until the characters differ, and then flash the cursor for you to complete the rest.

Example 11.27

```
1   $ ls
    file1 file2 foo foobarckle fumble

2   $ ls fu[tab]       # Expands to filename to fumble

3   $ ls fx[tab]       # Terminal beeps, nothing happens

4   $ ls fi[tab]       # Expands to file_  (_ is a cursor)

5   $ ls fi[tab][tab]  # Lists all possibilities
    file1 file2

6   $ ls foob[tab]     # Expands to foobarckle

7   $ da[tab]          # Completes the date command
    date
    Tue Feb 28 18:53:40 PST 2001

8   $ ca[tab][tab]      # Lists all commands starting with ca
    cal    captoinfo  case   cat
```

EXPLANATION

1. All files are listed for the current working directory.
2. After fu is typed, the Tab key is pressed, causing the spelling of the filename to be completed to fumble, and listed.
3. Because none of the files start with fx, the terminal beeps and the cursor remains but does nothing. (The terminal may not beep if that feature has been disabled.)
4. There are a number of files starting with fi; the filenames are completed until the letters are no longer the same. If another Tab key is pressed, all files with that spelling are listed.
5. By pressing two Tab keys, a list of all files beginning with file is printed.
6. When the Tab key is pressed, the filename is expanded to foobarckle.
7. When the Tab key is pressed after da, the only command that begins with da is the date command. The command name is expanded and executed.
8. When the Tab key is pressed after ca, nothing happens because more than one command starts with ca. Pressing the Tab key twice lists all commands starting with ca.

11.2.2 History

The history mechanism keeps a history list, a numbered record of the commands that you have typed at the command line. During a login session, the commands you type are stored in the the shell's memory in a history list and then appended to the history file when you exit. You can recall a command from the history list and reexecute it without retyping the command. The history built−in command displays the history list. The default name for the history file is .bash_history, and it is located in your home directory.

When bash starts accessing the history file, the HISTSIZE variable specifies how many commands can be copied from the history file into the history list. The default size is 500. The HISTFILE variable specifies the name of the command history file (~/.bash_history is the default) where commands are stored. If unset, the command history is not saved when an interactive shell exits.

The history file grows from one login session to the next. The HISTFILESIZE variable controls the maximum number of lines contained in the history file. When this variable is assigned a value, the history file is truncated when it surpasses that number of lines. The default size is 500.

The fc −l command can be used to display or edit commands in the history list.

Table 11.4. History Variables

FCEDITThe pathname of the UNIX editor that uses the fc command.HISTCMDThe history number, or index in the history list, of the current command. If HISTCMD is unset, it loses its special properties, even if it is subsequently reset.HISTCONTROLIf set to a value of ignorespace, lines that begin with a space character are not entered on the history list. If set to a value of ignoredups, lines matching the last history line are not entered. A value of ignoreboth combines the two options. If unset, or if set to any other value than those above, all lines read by the parser are saved on the history list.HISTFILESpecifies file in which to store command history. The default value is ~/.bash_history. If unset, the command history is not saved when an interactive shell exits.HISTFILESIZEThe maximum number of lines contained in the history file. When this variable is assigned a value, the history file is truncated, if necessary, to contain no more than that number of lines. The default value is 500.HISTIGNOREA colon−separated list of patterns used to decide which command lines should be saved on the history list. Each pattern is anchored to the beginning of the line and consists of normal shell pattern matching characters. An & can be used in the pattern causing the history command to ignore duplicates; e.g., ty??:& would match for any command line starting with ty followed by two characters, and any duplicates of that command. Those commands would not be placed in the history list.HISTSIZEThe number of commands to remember in the command history. The default value is 500.

11.2.3 Accessing Commands from the History File

The Arrow Keys. To access commands from the history file, you can use the arrow keys on the keyboard to move up and down through the history file, and from left to right. You can edit any of the lines from the history file by using the standard keys for deleting, updating, backspacing, etc. As soon as you have edited the line, pressing the Enter key will cause the command line to be reexecuted.

Table 11.5. The Arrow Keys

↑Up arrow moves up the history list. ↓Down arrow moves down the history list. →Right arrow moves cursor to right on history command. ←Left arrow moves left on history command.

The history Built−In Command. The history built−in command displays the history of commands typed preceded by an event number.

Example 11.28

```
1   $ history
    982  ls
    983  for i in 1 2 3
    984  do
    985  echo $i
    986  done
    987  echo $i
    988  man xterm
    989  adfasdfasdfadfasdfasdfadfasdfasdf
    990  id −gn
    991  id −un
    992  id −u
    993  man id
    994  more /etc/passwd
    995  man ulimit
    996  man bash
    997  man baswh
    998  man bash
    999  history
    1000  history
```

EXPLANATION

1. The built−in history command displays a list of numbered commands from the history list. Any lines listed with an * have been modified.

The fc Command. The fc command, also called the fix command, can be used in two ways: (1) to select commands from the history list, and (2) to edit the commands in either the vi or emacs editor, or for that matter, any editor on your system.

In the first form, fc with the −l option can select specific lines or ranges of lines from the history list. When the −l switch is on, the output goes to the screen. For example, fc −l, the default, prints the last 16 lines from the history list, fc −l 10 selects lines numbered 10 through the end of the list, and fc −l −3 selects the last three lines. The −n switch turns off the numbering of commands in the history list. With this option on, you could select a range of commands and redirect them to a file, which in turn could be executed as a shell script. The −r switch reverses the order of the commands.

The second form of fc is described in "Command Line Editing" on page 641.

Table 11.6. The fc Command

fc Argument	Meaning
−e editor	Puts history list into editor.
−l n−m	Lists commands in range from n to m.
−n	Turns off numbering of history list.
−r	Reverses the order of the history list.
−s string	Accesses command starting with string.

Example 11.29

```
1  $ fc −l
   4       ls
   5       history
   6       exit
   7       history
   8       ls
   9       pwd
  10       clear
  11       cal 2000
  12       history
  13       vi file
  14       history
  15       ls −l
  16       date
  17       more file
  18       echo a b c d
  19       cd
  20       history
2 $ fc −l −3
  19       cd
  20       history
  21       fc −l
3 $  fc −ln
         exit
         history
         ls
         pwd
         clear
         cal 2000
         history
         vi file
         history
         ls −l
         date
         more file
         echo a b c d
         cd
         history
         fc −l
         fc −l −3

4 $ fc −ln −3 > saved

5 $ more saved
         fc −l
         fc −l −3
```

```
         fc −ln
6 $ fc −l 15
  15       ls −l
  16       date
  17       more file
  18       echo a b c d
  19       cd
  20       history
  21       fc −l
  22       fc −l −3
  23       fc −ln
  24       fc −ln −3 > saved
  25       more saved
  26       history
7 $ fc −l 15 20
  15       ls −l
  16       date
  17       more file
  18       echo a b c d
  19       cd
  20       history
```

EXPLANATION

1. fc −l selects the last 16 commands from the history list.
2. fc −l −3 selects the last three commands from the history list.
3. fc with the −ln options prints the history list without line numbers.
4. The last three commands, without line numbers, from the history list are redirected to a file called saved.
5. The contents of the file saved are displayed.
6. Commands from the history list, starting at number 15, are listed.
7. Commands numbered 15 through 20 are displayed.

If fc is given the −s option, a string pattern can be used to reexecute a previous command; e.g., fc −s rm will cause the most previous line containing the pattern rm to be reexecuted. To emulate the Korn shell's redo command, you can create a bash alias called r, e.g., alias r='fc −s' so that if you type r vi at the command line, the last history item containing that pattern will be reexecuted; in this case, the vi editor will be started just as it was the last time it started, including any arguments passed.

Example 11.30

```
1   $ history
    1    ls
    2    pwd
    3    clear
    4    cal 2000
    5    history
    6    ls −l
    7    date
    8    more file
    9    echo a b c d

2   $ fc −s da
    date
    Thu Jul  15 12:33:25 PST 2001

3   $ alias r="fc −s"
4   $ date +%T
```

```
    18:12:32

5   $ r d
    date +%T
    18:13:19
```

EXPLANATION

1. The built−in history command displays the history list.
2. fc with the −s option searches for the last command that began with string da. The date command is found in the history list and is reexecuted.
3. An alias (a user−defined nickname) called r is assigned the command fc −s. This means that any time r is typed at the command line, it will be substituted with fc −s.
4. The date command is executed. It will print the current time.
5. The alias is used as a shortcut to the fs −s command. The last command beginning with a d is reexecuted.

Reexecuting History Commands (bang! bang!). To reexecute a command from the history list, the exclamation point (called bang) is used. If you type two exclamation points (!!) bang, bang, the last command in the history list is reexecuted. If you type an exclamation point, followed by a number, the command listed by that number is reexecuted. If you type an exclamation point and a letter or string, the last command that started with that letter or string is reexecuted. The caret (^) is also used as a shortcut method for editing the previous command. See Table 11.7 for a complete list of history substitution characters.

Table 11.7. Substitution and History

Event Designator	Meaning
!	Indicates the start of history substitution.
!!	Reexecutes the previous command.
!N	Reexecutes the Nth command from the history list.
!−N	Reexecutes the Nth command back from present command.
!string	Reexecutes the last command starting with string.
!?string?	Reexecutes the last command containing string.
!?string?%	Reexecutes the most recent command line argument from the history list containing string.
!$	Uses the last argument from the last history command in the current command line.
!! string	Appends string to the previous command and executes.
!N string	Appends string to Nth command in history list and executes.
!N:s/old/new/	In previous Nth command, substitutes the first occurrence of old string with new string.
!N:gs/old/new/	In previous Nth command, globally substitutes old string with new string.
^old^new^	In last history command, substitutes old string with new string.
command !N:wn	Executes current command appending an argument (wn) from the Nth previous command. Wn is a number starting at 0, 1, 2, … designating the number of the word from the previous command; word 0 is the command itself, and 1 is its first argument, etc. (See Example 11.32.)

Example 11.31

```
1   $ date
    Mon Jul  12 12:27:35 PST 2001

2   $ !!
    date
    Mon Jul  12 12:28:25 PST 2001

3   $ !106
    date
    Mon Jul  12 12:29:26 PST 2001

4   $ !d
    date
```

```
    Mon Jul  12 12:30:09 PST 2001

5   $ dare
    dare: Command not found.

6   $ ^r^t
    date
    Mon Jul  12 12:33:25 PST 2001
```

EXPLANATION

1. The UNIX date command is executed at the command line. The history list is updated. This is the last command on the list.
2. The !! (bang bang) gets the last command from the history list; the command is reexecuted.
3. Command number 106 from the history list is reexecuted.
4. The last command on the history list that started with the letter d is reexecuted.
5. The command is mistyped. It should be date, not dare.
6. The carets are used to substitute letters from the last command on the history list. The first occurrence of an r is replaced with a t; i.e., dare becomes date.

Example 11.32

```
1   $ ls  file1 file2 file3
    file1 file2 file3

    $ vi !:1
    vi file1

2   $ ls file1 file2 file
    file1 file2 file3

    $ ls !:2
    ls file2
    file2

3   $ ls file1 file2 file3
    $ ls  !:3
    ls file3
    file3

4   $ echo a b c
    a b c
    $ echo !$
    echo c
    c

5   $ echo a b c
    a b c
    $ echo !^
    echo a
    a

6   % echo a b c
    a b c
    % echo !*
    echo a b c
    a b c
```

```
7   % !!:p
    echo a b c
```

EXPLANATION

1. The ls command lists file1, file2, and file3. The history list is updated. The command line is broken into words, starting with word number zero. If the word number is preceded by a colon, that word can be extracted from the history list. The !:1 notation means, get the first argument from the last command on the history list and replace it in the command string. The first argument from the last command is file1. (Word 0 is the command itself.)
2. The !:2 is replaced with the second argument of the last command, file2, and given as an argument to ls. file2 is printed. (file2 is the third word.)
3. ls !:3 reads, go to the last command on the history list and get the fourth word (words start at zero) and pass it to the ls command as an argument. (file3 is the fourth word.)
4. The bang (!) with the dollar sign ($) refers to the last argument of the last command on the history list. The last argument is c.
5. The caret (^) represents the first argument after the command. The bang (!) with the ^ refers to the first argument of the last command on the history list. The first argument of the last command is a.
6. The asterisk (*) represents all arguments after the command. The ! with the * refers to all of the arguments of the last command on the history list.
7. The last command from the history list is printed but not executed. The history list is updated. You could now perform caret substitutions on that line.

Command Line Editing. The bash shell provides two built−in editors, emacs and vi, that allow you to interactively edit your history list. When you use the editing features at the command line, whether in vi or emacs mode, the readline functions determine which keys will perform certain functions. For example, if using emacs, Ctrl−P allows you to scroll upward in the command line history, whereas if using vi, the K key moves upward through the history list. Readline also controls the arrow keys, cursor movement, changing, deleting, inserting text, and redoing or undoing corrections. Another feature of readline is the completion feature previously discussed in "Command and Filename Completion". This allows you to type part of a command, filename, or variable, and then, by pressing the Tab key, the rest of the word is completed. There are many more features provided by the Readline library designed to help manipulate text at the command line.

The emacs built−in editor is the default built−in editor and is modeless, whereas the vi built−in editor works in two modes, one to execute commands on lines and the other to enter text. If you use UNIX, you are probably familiar with at least one of these editors. To enable the vi editor, add the set command listed below[5] and put this line in your ~/.bashrc file. To set vi, type what's shown in the following example, at either the prompt or in the ~/.bashrc file.

Example 11.33

```
set −o vi
```

EXPLANATION

Sets the built−in vi editor for command line editing of the history list.

To switch to the emacs editor, type:

Example 11.34

```
set −o emacs
```

EXPLANATION

Sets the built−in emacs editor for command line editing of the history list.

The vi Built−In Editor. To edit the history list, go to the command line and press the Esc key. Then press the K key if you want to scroll upward in the history list, and the J key[6] to move downward, just like standard vi motion keys. When you find the command that you want to edit, use the standard keys that you would use in vi for moving left and right, deleting, inserting, and changing text. (See Table 11.8.) After making the edit, press the Enter key. The command will be executed and added to the bottom of the history list.

Table 11.8. vi Commands

Command Function Moving Through the History File:Esc k or +Move up the history list.Esc j or −Move down the history list.GMove to first line in history file.5GMove to fifth command in history file for string./stringSearch upward through history file.?String search downward through history file. Moving Around on a Line:hMove left on a line.lMove right on a line.bMove backward a word.e or wMove forward a word.^ or 0Move to beginning of first character on the line.$Move to end of line. Editing with vi:a AAppend text.i IInsert text.dd dw xDelete text into a buffer (line, word, or character).cc CChange text.u UUndo.yy YYank (copy a line into buffer).p PPut yanked or deleted line down below or above the line.r RReplace a letter or any amount of text on a line.

The emacs Built−In Editor. If using the emacs built−in editor, like vi, start at the command line. To start moving upward through the history file, press ^P. To move down, press ^N. Use emacs editing commands to change or correct text, then press Enter and the command will be reexecuted. See Table 11.9.

Table 11.9. emacs Commands

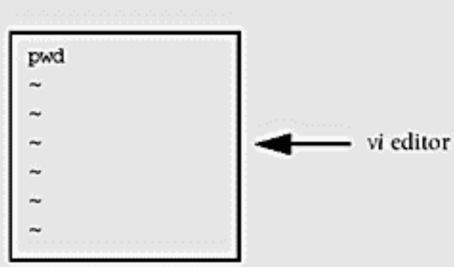
Command Function Ctrl−PMove up history file.Ctrl−NMove down history file.Ctrl−BMove backward one character.Ctrl−RSearch backward for string.Esc BMove backward one word.Ctrl−FMove forward one character.Esc FMove forward one word.Ctrl−AMove to the beginning of the line.Ctrl−EMove to the end of the line.Esc <Move to the first line of the history file.Esc >Move to the last line of the history file. Editing with emacs:Ctrl−UDelete the line.Ctrl−YPut the line back.Ctrl−KDelete from cursor to the end line.Ctrl−DDelete a letter.Esc DDelete one word forward.Esc HDelete one word backward.Esc spaceSet a mark at cursor position.Ctrl−X Ctrl−XExchange cursor and mark.Ctrl−P Ctrl−YPush region from cursor to mark into a buffer (Ctrl−P) and put it down (Ctrl−Y).

FCEDIT and Editing Commands. If the fc command is given the −e option followed by the name of a UNIX editor, that editor is invoked containing history commands selected from the history list; e.g., fc −e vi −1 −3 will invoke the vi editor, create a temporary file in /tmp, with the last three commands from the history list in the vi buffer. The commands can be edited or commented out. (Preceding the command with a # will comment it.) If the user quits the editor, the commands will all be echoed and executed.[7]

If the editor name is not given, the value of the FCEDIT variable is used (typically set in the initialization files, either bash_profile or .profile), and the value of the EDITOR variable is used if FCEDIT is not set. When editing is complete, and you exit the editor, all of the edited commands are echoed and executed.

Example 11.35

```
1   $ FCEDIT=/bin/vi
2   $ pwd
3   $ fc
< Starts up the full screen vi editor with the pwd command on line 1>
```




```
4   $ history
    1 date
    2 ls -l
    3 echo "hello"
    4 pwd

5   $ fc -3 -1        # Start vi, edit, write/quit, and execute
                      # last 3 commands.
```

EXPLANATION

1. The FCEDIT variable can be assigned the pathname for any of the UNIX text editors you have on your system, such as vi, emacs, etc. If not set, the vi editor is the default.
2. The pwd command is typed at the command line. It will be placed in the history file.
3. The fc command caused the editor (set in FCEDIT) to be invoked with the last command typed in the editor window. After the user writes and quits the editor, any commands typed there will be executed.
4. The history command lists recently typed commands.
5. The fc command is used to start up the editor with the last three commands from the history file in the editor's buffer.

11.2.4 Aliases

An alias is a bash user−defined abbreviation for a command. Aliases are useful if a command has a number of options and arguments or the syntax is difficult to remember. Aliases set at the command line are not inherited by subshells. Aliases are normally set in the .bashrc file. Because the .bashrc is executed when a new shell is started, any aliases set there will be reset for the new shell. Aliases may also be passed into shell scripts but will cause potential portability problems unless they are set directly within the script.

Listing Aliases. The alias built−in command lists all set aliases. The alias is printed first, followed by the real command or commands it represents.

Example 11.36

```
$ alias
alias co='compress'
alias cp='cp −i'
```

```
alias mroe='more'
alias mv='mv −i'
alias ls='ls −−colorztty'
alias uc='uncompress'
```

EXPLANATION

The alias command lists the alias (nickname) for the command and the real command the alias represents after the = sign.

Creating Aliases. The alias command is used to create an alias. The first argument is the name of the alias, the nickname for the command. The rest of the line consists of the command or commands that will be executed when the alias is executed. Bash aliases cannot take arguments (see "Defining Functions" on page 693). Multiple commands are separated by a semicolon, and commands containing spaces and metacharacters are surrounded by single quotes.

Example 11.37

```
1   $ alias m=more
2   $ alias mroe=more
3   $ alias lF='ls −alF'
4   $ alias r='fc −s'
```

EXPLANATION

1. The nickname for the more command is set to m.
2. The alias for the more command is set to mroe. This is handy if you can't spell.
3. The alias definition is enclosed in quotes because of the whitespace. The alias lF is a nickname for the command ls −alF.
4. The alias r will be used instead of fc −s to recall commands from the history list by a specified pattern; e.g., r vi will reexecute the last command in the history list containing the pattern vi.

Deleting Aliases. The unalias command is used to delete an alias. To temporarily turn off an alias, precede the alias name by a backslash.

Example 11.38

```
1   $ unalias mroe
2   $ \ls
```

EXPLANATION

1. The unalias command deletes the alias mroe from the list of defined aliases.
2. The alias ls is temporarily turned off for this execution of the command only.

11.2.5 Manipulating the Directory Stack

If you find that as you work, you cd up and down the directory tree into many of the same directories, you can make it easy to access those directories by pushing them onto a directory stack and manipulating the stack. The pushd built−in command pushes directories onto a stack and the popd command removes them. (See Example 11.39.) The stack is a list of directories with the directory at the left being the most recent directory pushed onto the stack. The directories can be listed with the built−in dirs command.

The dirs Built−In Command. The built−in command dirs, with a −l option, displays the directory stack with each of its directories in full pathname format; without an option, dirs uses a tilde to denote the home directory. With a +n option, dirs displays the nth directory entry counting from the left in the directory list, starting at 0. With −n option, it does the same thing, but starts at the right−hand side of the directory list with 0.

The pushd and popd Commands. The pushd command, with a directory as an argument, causes the new directory to be added to the directory stack and, at the same time, changes to that directory. If the argument is a +n where n is a number, pushd rotates the stack so that the nth directory from the stack, starting at the left−hand side, is pushed onto the top of the stack. With a −n option, it does the same thing but starts at the right−hand side. Without arguments, pushd exchanges the top two elements of the directory stack, making it easy to switch back and forth between directories.

The popd command removes a directory from the top of the stack, and changes to that directory. With +n, where n is a number, popd removes the nth entry, starting at the left of the list shown by dirs.

Example 11.39

```
1   $ pwd
    /home/ellie

    $ pushd ..
    /home ~

    $ pwd
    /home

2   $ pushd       # Swap the two top directories on the stack
    ~ /home

    $ pwd
    /home/ellie

3   $ pushd perlclass
    ~/perlclass  ~  /home

4   $ dirs
    ~/perlclass ~ /home

5   $ dirs −l
    /home/ellie/perlclass /home/ellie  /home

6   $ popd
    ~/home

    $ pwd
    /home/ellie

7   $ popd
    /home

    $ pwd
    /home

8   $ popd
    bash: popd: Directory stack empty.
```

EXPLANATION

1. First the pwd command displays the present working directory, /home/ellie. Next the pushd command with .. as its argument, pushes the parent directory (..) onto the directory stack. The output of pushd indicates that /home is at the top of the directory stack (starting at the left−hand side of the displayed list) and the user's home directory, represented by the tilde character (~) is at the bottom of the stack. pushd also changes the directory to the one that was pushed onto the stack; i.e., .. which translates to /home. The new directory is displayed with the second pwd command.
2. Pushd, without arguments, exchanges the two top directory entries on the stack and changes to the swapped directory; in this example, the directory is switched back to the user's home directory, /home/ellie.
3. The pushd command will push its argument, ~/perlclass, onto the stack, and change to that directory.
4. The built−in dirs command displays the directory stack, with the top level starting at left−hand side of the listing. The tilde expands to the user's home directory.
5. With the −l option, dirs list displays the directory stack with full pathnames instead of using tilde expansion.
6. The popd command removes a directory from the top of the stack, and changes to that directory.
7. The popd command removes another directory from the top of the stack, and changes to that directory.
8. The popd command cannot remove any more directory entries because the stack is empty, and issues an error message saying so.

11.2.6 Metacharacters (Wildcards)

Metacharacters are special characters used to represent something other than themselves. Shell metacharacters are called wildcards. Table 11.10 lists metacharacters and what they do.

Table 11.10. Metacharacters

Metacharacter Meaning\Literally interprets the following character.&Processes in the background.;Separates commands.$Substitutes variables.?Matches for a single character.[abc]Matches for one character from a set of characters; e.g., a, b, or c.[!abc]Matches for one character not from the set of characters; e.g., not a, b, or c.*Matches for zero or more characters.(cmds)Executes commands in a subshell.{cmds}Executes commands in current shell.

11.2.7 Filename Substitution (Globbing)

When evaluating the command line, the shell uses metacharacters to abbreviate filenames or pathnames that match a certain set of characters. The filename substitution metacharacters listed in Table 11.11 are expanded into an alphabetically listed set of filenames. The process of expanding the metacharacter into filenames is also called filename substitution, or globbing. If a metacharacter is used and there is no filename that matches it, the shell treats the metacharacter as a literal character.

Table 11.11. Shell Metacharacters and Filename Substitution

Metacharacter Meaning*Matches zero or more characters.?Matches exactly one character.[abc]Matches one character in the set a, b, or c.[!abc]Matches one character not in the set, not a, b, or c.{a,ile,ax}Matches for a character or set of characters.[! a–z]Matches one character not in the range from a to z.\Escapes or disables the metacharacter.

The Asterisk. The asterisk is a wildcard that matches for zero or more of any characters in a filename.

Example 11.40

```
1   $ ls  *
    abc abc1 abc122 abc123 abc2 file1 file1.bak file2 file2.bak none
    nonsense nobody nothing nowhere one
2   $ ls  *.bak
    file1.bak file2.bak
3   $ echo a*
    ab abc1 abc122 abc123 abc2
```

EXPLANATION

1. The asterisk expands to all of the files in the present working directory. All of the files are passed as arguments to ls and displayed.
2. All files starting with zero or more characters and ending with .bak are matched and listed.
3. All files starting with a, followed by zero or more characters, are matched and passed as arguments to the echo command.

The Question Mark. The question mark represents a single character in a filename. When a filename contains one or more question marks, the shell performs filename substitution by replacing the question mark with the character it matches in the filename.

Example 11.41

```
1   $ ls
    abc  abc122  abc2  file1.bak  file2.bak  nonsense  nothing  one
    abc1  abc123  file1  file2  none  noone  nowhere

2   $ ls a?c?
    abc1 abc2

3   $ ls ??
    ls: ??: No such file or directory

4   $ echo  abc???
    abc122 abc123

5   $ echo ??
    ??
```

EXPLANATION

1. The files in the current directory are listed.
2. Filenames starting with a, followed by a single character, followed by c and a single character, are matched and listed.

3. Filenames containing exactly two characters are listed, if found. Because there are not any two−character files, the question marks are treated as a literal filename. Such a file is not found, and the error message is printed.
4. Filenames starting with abc and followed by exactly three characters are expanded and displayed by the echo command.
5. There are no files in the directory that contain exactly two characters. The shell treats the question mark as a literal question mark if it cannot find a match.

The Square Brackets. The brackets are used to match filenames containing one character in a set or range of characters.

Example 11.42

```
1   $ ls
    abc abc122 abc2 file1.bak file2.bak nonsense nothing
    one abc1 abc123 file1 file2 none noone nowhere

2   $ ls abc[123]
    abc1  abc2

3   $ ls abc[1−3]
    abc1  abc2

4   $ ls [a−z][a−z][a−z]
    abc one

5   $ ls [!f−z]???
    abc1  abc2

6   $ ls abc12[23]
    abc122 abc123
```

EXPLANATION

1. All of the files in the present working directory are listed.
2. All filenames containing four characters are matched and listed if the filename starts with abc, followed by 1, 2, or 3. Only one character from the set in the brackets is matched.
3. All filenames containing four characters are matched and listed, if the filename starts with abc and is followed by a number in the range from 1 to 3.
4. All filenames containing three characters are matched and listed, if the filename contains exactly three lowercase alphabetic characters.
5. All filenames containing four characters are listed if the first character is not a letter between f and z ([!f–z], followed by three of any characters, where ? represents a single character.
6. Files are listed if the filenames contain abc12 followed by 2 or 3.

Brace Expansion. The curly braces match for any of a list of comma−separated strings. Normally the strings are filenames. Any characters prepended to the opening curly brace are called the preamble, and any characters appended to the closing curly brace are called the postamble. Both the preamble and postamble are optional. There can be no unquoted whitespace within the braces.

Example 11.43

```
1   $ ls
    a.c b.c abc ab3 ab4 ab5 file1 file2 file3 file4 file5 foo
    faa fumble
```

```
2   $ ls f{oo,aa,umble}
    foo faa fumble

3   $ ls a{.c,c,b[3−5]}
    a.c ab3 ab4 ab5

4   $ mkdir /usr/local/src/bash/{old,new,dist,bugs}

5   $ chown root /usr/{ucb/{ex,edit},lib/{ex?.?*,how_ex}}

6   $ echo fo{o, um}*
    fo{o, um}*

7   $ echo {mam,pap,ba}a
    mama papa baa

8   $ echo post{script,office,ure}
    postscript postoffice posture
```

EXPLANATION

1. All the files in the current directory are listed.
2. Files starting with f and followed by the strings oo, aa, or umble are listed. Spaces inside the curly braces will cause the error message Missing }.
3. Files starting with a followed by .c, c, or b3, b4, or b5 are listed. (The square brackets can be used inside the curly braces.)
4. Four new directories will be made in /usr/local/src/bash: old, new, dist, and bugs.
5. Root ownership will be given to files, ex and edit, in directory /usr /ucb and to files named ex followed by one character, a period, and at least one more character, and a file called how_ex in directory /usr/lib.
6. Brace expansion will not occur if there are any unquoted spaces within the braces.
7. Brace expansion does not necessarily always cause expansion of filenames. In this example the postamble a is added to each of the strings within the curly braces and echoed back after the expansion.
8. The preamble is the string post, followed by a comma−separated list enclosed within braces. Brace expansion is performed and the resulting strings are displayed.

Escaping Metacharacters. To use a metacharacter as a literal character, use the backslash to prevent the metacharacter from being interpreted.

Example 11.44

```
1   $ ls
    abc file1 youx

2   $ echo How are you?
    How are youx

3   $ echo How are you\?
    How are you?

4   $ echo  When does this line \
    > ever end\?
    When does this line ever end?
```

EXPLANATION

1. The files in the present working directory are listed. (Note the file youx.)
2. The shell will perform filename expansion on the ?. Any files in the current directory starting with y−o−u and followed by exactly one character are matched and substituted in the string. The filename youx will be substituted in the string to read How are youx (probably not what you wanted to happen).
3. By preceding the question mark with a backslash, it is escaped, meaning that the shell will not try to interpret it as a wildcard.
4. The newline is escaped by preceding it with a backslash. The secondary prompt is displayed until the string is terminated with a newline. The question mark (?) is escaped to protect it from filename expansion.

Tilde and Hyphen Expansion. The tilde character was adopted by the bash shell (from the C shell) for pathname expansion. The tilde by itself evaluates to the full pathname of the user's home directory.[8] When the tilde is appended with a username, it expands to the full pathname of that user.

When the plus sign follows the tilde, the value of the PWD (present working directory) replaces the tilde. The tilde followed by the hyphen character is replaced with the previous working directory; OLDPWD also refers to the previous working directory.

Example 11.45

```
1   $ echo ~
    /home/jody/ellie

2   $ echo ~joe
    /home/joe

3   $ echo ~+
    /home/jody/ellie/perl

4   $ echo ~−
    /home/jody/ellie/prac

5   $ echo $OLDPWD
   /home/jody/ellie/prac

6   $ cd −
    /home/jody/ellie/prac
```

EXPLANATION

1. The tilde evaluates to the full pathname of the user's home directory.
2. The tilde preceding the username evaluates to the full pathname of joe's home directory.
3. The ~+ notation evaluates to the full pathname of the working directory.
4. The ~− notation evaluates to the previous working directory.
5. The OLDPWD variable contains the previous working directory.
6. The hyphen refers to the previous working directory; cd to go to the previous working directory and display the directory.

Controlling Wildcards (Globbing). If the bash noglob variable is set or if the set command is given a −f option, filename substitution, called globbing, is turned off, meaning that all metacharacters represent themselves; they are not used as wildcards. This can be useful when searching for patterns containing metacharacters in programs like grep, sed, or awk. If globbing is not set, all metacharacters must be escaped with a backslash to turn off wildcard interpretation.

The built−in shopt command (bash versions 2.x) also supports options for controlling globbing.

Example 11.46

```
1   $ set noglob or set −f

2   $ print * ?? [] ~ $LOGNAME
    * ?? [] /home/jody/ellie ellie

3   $ unset noglob or set +f

4   $ shopt −s dotglob   # Only available in bash versions 2.x

5   $ echo *bash*
    .bash_history .bash_logout .bash_profile .bashrc bashnote
    bashtest
```

EXPLANATION

1. The −f option is given as an argument to the set command. It turns off the special meaning of wildcards used for filename expansion.
2. The filename expansion metacharacters are displayed as themselves without any interpretation. Note that the tilde and the dollar sign are still expanded, because they are not used for filename expansion.
3. If either noglob is unset or the +f option is set, filename metacharacters will be expanded.
4. The shopt built−in allows you to set options for the shell. The dotglob option allows filenames to be matched with globbing metacharacters, even if they start with a dot. Normally the files starting with a dot are invisible and not recognized when performing filename expansion.
5. Because the dotglob option was set in line 4, when the wildcard * is used for filename expansion, the filenames starting with a dot are also expanded if the filename contains the pattern bash.

Extended Filename Globbing (bash 2.x). Derived from Korn shell pattern matching, bash 2.x has included this extended functionality, allowing regular expression−type syntax. The regular expression operators are not recognized unless the extglob option to the shopt command is turned on:

```
shopt −s extglob
```

Table 11.12. Extended Pattern Matching

Regular Expression Meaningabc?(2|9)1? matches zero or one occurrences of any pattern in the parentheses. The vertical bar represents an or condition; e.g., either 2 or 9. Matches abc21, abc91, or abc1.abc*([0–9])* matches zero or more occurrences of any pattern in the parentheses. Matches abc followed by zero or more digits; e.g., abc, abc1234, abc3, abc2, etc.abc+([0–9])+ matches one or more occurrences of any pattern in the parentheses. Matches abc followed by one or more digits; e.g., abc3, abc123, etc.no@(one|ne)@ matches exactly one occurrence of any pattern in the parentheses. Matches noone or none. no!(thing|where)! matches all strings except those matched by any of the patterns in the parentheses. Matches no, nobody, or noone, but not nothing or nowhere.

Example 11.47

```
1   $ shopt −s extglob

2   $ ls
    abc      abc122    f1    f3     nonsense   nothing   one
    abc1     abc2      f2    none   noone      nowhere

3   $ ls abc?(1|2)
    abc      abc1      abc2

4   $ ls abc*([1−5])
    abc      abc1      abc122     abc2

5   $ ls abc+([0−5])
    abc1     abc122    abc2

6   $ ls no@(thing|ne)
    none     nothing

7   $ ls no!(thing)
    none     nonsense   noone     nowhere
```

EXPLANATION

1. The shopt built−in is used to set the extglob (extended globbing) option, allowing bash to recognize extended pattern matching characters.
2. All the files in the present working directory are listed.
3. Matches filenames starting with abc and followed by zero characters or one of either of the patterns in parentheses. Matches abc, abc1, or abc2.
4. Matches filenames starting with abc and followed by zero or more numbers between 1 and 5. Matches abc, abc1, abc122, abc123, and abc2.
5. Matches filenames starting with abc and followed by one or more numbers between 0 and 5. Matches abc1, abc122, abc123, and abc2.
6. Matches filenames starting with no and followed by exactly thing or ne. Matches nothing or none.
7. Matches filenames starting with no and followed by anything except thing. Matches none, nonsense, noone, and nowhere. The ! means not.

11.3 Variables

Types of Variables. There are two types of variables: local and environment. Local variables are known only to the shell in which they were created. Environment variables are available to any child processes spawned from the shell from which they were created. Some variables are created by the user and others are special shell variables.

Naming Conventions. Variable names must begin with an alphabetic or underscore character. The remaining characters can be alphabetic, decimal digits (0 to 9), or an underscore character. Any other characters mark the termination of the variable name. Names are case−sensitive. When assigning a value to a variable, do not include any whitespace surrounding the equal sign. To set the variable to null, follow the equal sign with a newline. The simplest format for creating a local variable is to assign a value to a variable in the following format.

FORMAT

```
variable=value
```

Example 11.48

```
name=Tommy
```

The declare Built−In. There are two built−in commands, declare and typeset, used to create variables, with options to control the way the variable is set. The typeset command (from Korn shell) is exactly the same as the declare command (bash). The bash documentation says, "The typeset command is supplied for compatibility with the Korn shell; however, it has been deprecated in favor of the declare built−in command."[9] So from this point on we'll use the declare built−in (even though we could just as easily have chosen to use typeset).

Without arguments, declare lists all set variables. Normally read−only variables cannot be reassigned or unset. If read−only variables are created with declare, they cannot be unset, but they can be reassigned. Integer−type variables can also be assigned with declare.

FORMAT

```
declare variable=value
```

Example 11.49

```
declare name=Tommy
```

Table 11.13. declare Options

Option	Meaning
−f	Lists functions names and definitions.
−r	Makes variables read−only.
−x	Exports variable names to subshells.
−i	Makes variables integer types.
−a[a]	Treats variable as an array; i.e., assigns elements.
−F[a]	Lists just function names.

[a] a and −F are implemented only on versions of bash 2.x.

11.3.1 Local Variables and Scope

The scope of a variable refers to where the variable is visible within a program. For the shell, the scope of local variables is confined to the shell in which the variable is created.

When assigning a value, there can be no whitespace surrounding the equal sign. To set the variable to null, the equal sign is followed by a newline.[10]

A dollar sign is used in front of a variable to extract the value stored there.

The local function can be used to create local variables, but this is only used within functions. (See "Defining Functions" on page 693.)

Setting Local Variables. Local variables can be set by simply assigning a value to a variable name, or by using the declare built−in function as shown in Example 11.50.

Example 11.50

```
1   $ round=world or declare round=world
    $ echo $round
    world

2   $ name="Peter Piper"
    $ echo $name
    Peter Piper

3   $ x=
    $ echo $x

4   $ file.bak="$HOME/junk"
    bash: file.bak=/home/jody/ellie/junk: not found
```

EXPLANATION

1. The local variable round is assigned the value world. When the shell encounters the dollar sign preceding a variable name, it performs variable substitution. The value of the variable is displayed. (Don't confuse the prompt ($) with the $ used to perform variable substitution.)
2. The local variable name is assigned the value "Peter Piper". The quotes are needed to hide the whitespace so that the shell will not split the string into separate words when it parses the command line. The value of the variable is displayed.
3. The local variable x is not assigned a value. It will be assigned null. The null value, an empty string, is displayed.
4. The period in the variable name is illegal. The only characters allowed in a variable name are numbers, letters, and the underscore. The shell tries to execute the string as a command.

Example 11.51

```
1   $ echo $$
    1313
2   $ round=world
    $ echo $round
    world
3   $ bash                # Start a subshell

4   $ echo $$
    1326
5   $ echo $round
6   $ exit                # Exits this shell, returns to parent shell

7   $ echo $$
    1313
8   $ echo $round
    world
```

EXPLANATION

1. The value of the double dollar sign variable evaluates to the PID of the current shell. The PID of this shell is 1313.
2. The local variable round is assigned the string value world, and the value of the variable is displayed.

3. A new bash shell is started. This is called a subshell, or child shell.
4. The PID of this shell is 1326. The parent shell's PID is 1313.
5. The local variable round is not defined in this shell. A blank line is printed.
6. The exit command terminates this shell and returns to the parent shell. (Control−D will also exit this shell.)
7. The parent shell returns. Its PID is displayed.
8. The value of the variable round is displayed. It is local to this shell.

Setting Read−Only Variables. A read−only variable is a special variable that cannot be redefined or unset. If, however, the declare function is used, a read−only variable can be redefined, but not unset.

Example 11.52

```
1   $ name=Tom
2   $ readonly name
    $ echo $name
    Tom

3   $ unset name
    bash: unset: name: cannot unset: readonly variable
4   $ name=Joe
    bash: name: readonly variable

5   $ declare −r city='Santa Clara'
6   $ unset city
    bash: unset: city: cannot unset: readonly variable

7   $ declare city='San Francisco'    # What happened here?
    $ echo $city
    San Francisco
```

EXPLANATION

1. The local variable name is assigned the value Tom.
2. The variable is made read−only.
3. A read−only variable cannot be unset.
4. A read−only variable cannot be redefined.
5. The declare built−in command assigns a read−only variable, city, the value Santa Clara. Quotes are necessary when assigning a string containing whitespace.
6. Since it is read−only, the variable cannot be unset.
7. When a read−only variable is created with the declare command, it cannot be unset, but it can be reassigned.

11.3.2 Environment Variables

Environment variables are available to the shell in which they are created and any subshells or processes spawned from that shell. They are often called global variables to differentiate them from local variables. By convention, environment variables are capitalized. Environment variables are variables that have been exported with the export built−in command.

The shell in which a variable is created is called the parent shell. If a new shell is started from the parent shell, it is called the child shell. Environment variables are passed to any child process started from the shell where the environment variables were created. They are passed from parent to child to grandchild, etc., but not the other direction; i.e., a child process can create an environment variable, but cannot pass it back to its parent, only to its children.[11] Some of the environment variables, such as HOME, LOGNAME, PATH, and SHELL, are set before you log on by the /bin/login program. Normally, environment variables are defined and stored in the .bash_profile file in the user's home directory. See Table 11.15 for a list of environment variables.

Setting Environment Variables. To set environment variables, the export command is used either after assigning a value or when the variable is set. The declare built−in, given the −x option, will do the same. (Do not use the $ on a variable when exporting it.)

FORMAT

```
export variable=value
variable=value; export variable
declare −x variable=value
```

Example 11.53

```
export NAME=john
PS1= '\d:\W:$USER> ' ; export PS1
declare −x TERM=sun
```

Table 11.14. The export Command and Its Options

Option Value− −Marks the end of option processing; the remaining parameters are arguments.−fName−value pairs are treated as functions, not variables.−nConverts a global (exported) variable to a local variable. The variable will not be exported to child processes.−pDisplays all the global variables.

Example 11.54

```
1   $ export TERM=sun    # or declare −x TERM=sun

2   $ NAME="John Smith"
    $ export NAME
    $ echo $NAME
    John Smith

3   $ echo $$
    319             # pid number for parent shell

4   $ bash          # Start a subshell

5   $ echo $$
    340             # pid number for new shell

6   $ echo $NAME
    John Smith

7   $ declare −x NAME="April Jenner"
    $ echo $NAME
    April Jenner

8   $ exit
                    # Exit the subshell and go back to parent shell
9   $ echo $$
    319             # pid number for parent shell
10  $ echo $NAME
    John Smith
```

EXPLANATION

1. The TERM variable is assigned sun. The variable is exported at the same time. Now, processes started from this shell will inherit the variable. You can use declare −x to do the same thing.
2. The variable NAME is defined and exported to make it available to subshells started from the shell.
3. The value of this shell's PID is printed.
4. A new bash shell is started. The new shell is called the child. The original shell is its parent.
5. The PID of the new bash shell is stored in the $$ variable and its value is echoed.
6. The variable, set in the parent shell, was exported to this new shell and is displayed.
7. The built−in declare function is another way to set a variable. With the −x switch, declare marks the variable for export. The variable is reset to April Jenner. It is exported to all subshells, but will not affect the parent shell. Exported values are not propagated upward to the parent shell.
8. This bash child shell is exited.
9. The PID of the parent is displayed again.
10. The variable NAME contains its original value. Variables retain their values when exported from parent to child shell. The child cannot change the value of a variable for its parent.

Table 11.15. Bash Environment Variables

Variable Name Meaning_ (underscore)The last argument to the previous command.BASHExpands to the full pathname used to invoke this instance of bash.BASH_ENVSame as ENV but set only in bash versions 2.0 or above.[a] BASH_VERSINFOVersion information about this version of bash if the version is 2.0 or above.[a]BASH_VERSIONExpands to the version number of this instance of bash.CDPATHThe search path for the cd command. This is a colon−separated list of directories in which the shell looks for destination directories specified by the cd command. A sample value is .:~:/usr.COLUMNSIf set, defines the width of the edit window for shell edit modes and the select command.DIRSTACKThe current contents of the directory stack if the bash version is 2.0 or above.[a]EDITORPathname for a built−in editor: emacs, gmacs, or vi.ENVThe environment file that is executed every time a new bash shell is started, including a script. Normally the filename assigned to this variable is .bashrc. The value of ENV is subjected to parameter expansion, command substitution, and arithmetic expansion before being interpreted as a pathname.EUIDExpands to the effective user ID of the current user, initialized at shell startup.FCEDITDefault editor name for the fc command.FIGNOREA colon−separated list of suffixes to ignore when performing filename completion. A filename whose suffix matches one of the entries in FIGNORE is excluded from the list of matched filenames. A sample value is .o:~.FORMATUsed to format the output of the time reserved word on a command pipeline.GLOBIGNOREA list of files that will be ignored during filename expansion (called globbing).[a]GROUPSAn array of groups to which the current user belongs.[a]HISTCMDThe history number, or index in the history list, of the current command. If HISTCMD is unset, it loses its special properties, even if it is subsequently reset.HISTCONTROLIf set to a value of ignorespace, lines that begin with a space character are not entered on the history list. If set to a value of ignoredups, lines matching the last history line are not entered. A value of ignoreboth combines the two options. If unset, or if set to any other value than those above, all lines read by the parser are saved on the history list.HISTFILESpecifies file in which to store command history. The default value is ~/.bash_history. If unset, the command history is not saved when an interactive shell exits.HISTFILESIZEThe maximum number of lines contained in the history file. When this variable is assigned a value, the history file is truncated, if necessary, to contain no more than that number of lines. The default value is 500.HISTSIZEThe number of commands to remember in the command history. The default value is 500.HOMEHome directory; used by cd when no directory is specified.HOSTFILEContains the name of a file in the same format as in /etc/hosts that should be read when the shell needs to complete a hostname. The file may be changed interactively; the next time hostname completion is attempted, bash adds the contents of the new file to the already existing database.HOSTTYPEAutomatically set to the type of machine on which bash is executing. The default is system−dependent.IFSInternal field separators, normally SPACE, TAB, and NEWLINE, used for field splitting of words resulting from command substitution, lists in loop constructs, and reading input.IGNOREEOFControls the action of the shell on receipt of an EOF character as the sole input. If set, the value is the number of consecutive EOF characters typed as the first characters on an input line before bash exits. If the variable exists but does not have a numeric value, or has no value, the default value is 10. If it does not exist, EOF signifies the end of input to the shell. This is only in effect for interactive shells.INPUTRCThe filename for the readline startup file, overriding the default of ~./inputrc.LANGUsed to determine the locale category for any category not specifically selected with a variable starting with LC_.[a]LC_ALLOverrides the value of LANG and any other LC_ variable.[a]LC_COLLATEDetermines the collation order used when sorting the results of pathname expansion and the behavior of range expressions, equivalence classes, and collating sequences when matching pathnames and patterns.[a]LC_MESSAGESDetermines the locale used to translate double−quoted strings preceded by a $.[a]LINENOEach time this parameter is referenced, the shell substitutes a decimal number representing the current sequential line number (starting with 1) within a script or function.MACHTYPEContains a string describing the system on which bash is executing.[a]MAILIf this parameter is set to the name of a mail file and the MAILPATH parameter is not set, the shell informs the user of the arrival of mail in the specified file.MAIL_WARNINGIf set, and a file that bash is checking for mail has been accessed since the last time it was checked, the message The mail in [filename where mail is stored] has been read is printed.MAILCHECKThis parameter specifies how often (in seconds) the shell will check for the arrival of mail in the files specified by the MAILPATH or MAIL parameters. The default value is 600 seconds (10 minutes). If set to zero, the shell will check before issuing each primary prompt.MAILPATHA colon−separated list of filenames. If this parameter is set, the shell informs the user of the arrival of mail in any of the specified files. Each filename can be followed by a % and a message that will be printed when the modification time changes. The default message is You have mail.OLDPWDLast working directory.OPTARGThe value of the last option argument processed by the getopts built−in command.OPTERRIf set to 1, displays error messages from the getopts built−in.OPTINDThe index of the next argument to be processed by the getopts built−in command.OSTYPEAutomatically set to a string that describes the operating system on which bash is executing. The default is system−dependent.PATHThe search path for commands. It is a colon−separated list of directories in which the shell looks for commands. The default path is system−dependent, and is set by the administrator who installs bash. A common value is /usr/gnu/bin:/usr/local/bin:/usr/ucb:/bin:/usr/bin:.PIPESTATUSAn array containing a list of exit status values from processes in the most recently executed foreground jobs in a pipeline.PPIDProcess ID of the parent process. PROMPT_COMMANDThe command assigned to this variable is executed before the primary prompt is displayed.PS1Primary prompt string, by default $.PS2Secondary prompt string, by default >.PS3Selection prompt string used with the select command, by default #?.PS4Debug prompt string used when tracing is turned on, by default +. Tracing can be turned on with set −x.PWDPresent working directory; set by cd.RANDOMEach time this parameter is referenced, a random integer is generated. The sequence of random numbers may be initialized by assigning a value to RANDOM. If RANDOM is unset, it loses its special properties, even if it is subsequently reset.REPLYSet when read is not supplied arguments.SECONDSEach time SECONDS is referenced, the number of seconds since shell invocation is returned. If a value is assigned to SECONDS, the value returned upon subsequent references is the number of seconds since the assignment plus the value assigned. If SECONDS is unset, it loses its special properties, even if it is subsequently reset.SHELLWhen the shell is invoked, it scans the environment for this name. The shell gives default values to PATH, PS1, PS2, MAILCHECK, and IFS. HOME and MAIL are set by login(1).SHELLOPTSContains a list of enabled shell options, such as braceexpand, hashall, monitor, etc.SHLVLIncremented by one each time an instance of bash is started.TMOUTSpecifies number of seconds to wait for input before exiting.UIDExpands to the user ID of the current user, initialized at shell startup.

[a] Not available in bash versions prior to 2.x.

Unsetting Variables. Both local and environment variables can be unset by using the unset command, unless the variables are set as read−only.

Example 11.55

```
unset name; unset TERM
```

EXPLANATION

The unset command removes the variable from the shell's memory.

Printing the Values of Variables: The echo Command. The built−in echo command prints its arguments to standard output. Echo, with the −e option, allows the use of numerous escape sequences that control the appearance of the output. Table 11.16 lists the echo options and escape sequences.

Table 11.16. echo Options and Escape Sequences

Option Meaning−eAllows interpretation of the escape sequences shown below.−nSuppresses newline at the end of a line of output.−E[a]Disables the interpretation of these escape characters, even on systems where they are interpreted by default (bash 2.x). Escape Sequence\a[a]Alert (bell).\bBackspace.\cPrints the line without a newline.\fForm feed.\nNewline.\rReturn.\tTab.\vVertical tab.\\Backslash.\nnnThe character whose ASCII code is nnn (octal).

[a] Not available in bash versions prior to 2.x.

When using the escape sequences, don't forget to use the −e switch!

Example 11.56

```
1   $ echo The username is $LOGNAME.
    The username is ellie.

2   $ echo −e "\t\tHello there\c"
                Hello there$

3   $ echo −n "Hello there"
    Hello there$
```

EXPLANATION

1. The echo command prints its arguments to the screen. Variable substitution is performed by the shell before the echo command is executed.
2. The echo command, with the −e option, supports escape sequences similar to those of the C programming language. The $ is the shell prompt.
3. When the −n option is on, the line is printed without the newline. The escape sequences

are not supported by this version of echo.

The printf Command. The GNU version of printf[12] can be used to format printed output. It prints the formatted string in the same way as the C printf function. The format consists of a string that may contain formatting instructions to describe how the printed output will look. The formatting instructions are designated with a % followed by specifiers (diouxXfeEgGcs) where %f would represent a floating point number and %d would represent a whole (decimal) number.

To see a complete listing of printf specifiers and how to use them, type at the command line prompt: printf −−help. To see what version of printf you are using, type: printf − −version. If you are using bash 2.x, the built−in printf command uses the same format as the executable version in /usr/bin.

FORMAT

```
printf format [argument...]
```

Example 11.57

```
printf "%10.2f%5d\n" 10.5  25
```

Table 11.17. Format Specifiers for the printf Command

Format Specifier Value\"Double quote.\0NNNAn octal character where NNN represents 0 to 3 digits.\\Backslash.\aAlert or beep.\bBackspace.\cProduce no further output.\fForm feed.\nNewline.\rReturn.\tHorizontal tab.\vVertical tab.\xNNNHexadecimal character, where NNN is 1 to 3 digits.%%A single %.%bArgument as a string with \ escapes interpreted.

Example 11.58

```
1   $ printf −−version
    printf (GNU sh−utils) 1.16

2   $ type printf
    printf is a shell builtin

3   $ printf "The number is %.2f\n" 100
    The number is 100.00

4   $ printf "%−20s%−15s%10.2f\n" "Jody" "Savage" 28
    Jody                Savage              28.00

5   $ printf "|%−20s|%−15s|%10.2f|\n" "Jody" "Savage" 28
    Jody                |Savage         |     28.00|

6   $ printf "%s's average was %.1f%%.\n" "Jody" $(( (80+70+90)/3 ))
    Jody's average was 80.0%.
```

EXPLANATION

1. The GNU version of the printf command is printed.
2. If using bash2.x, printf is a built−in command.
3. The argument 100 is printed as a floating point number with only 2 places to the right of the decimal point as designated by the specification %.2f in the format string. Unlike C, there are no commas separating the arguments.

4. The format string specifies that three conversions will take place: the first one is %−20s (a left−justified, 20−character string), next is %−15s (a left−justified, 15−character string, and last %10.2f (a right−justified, 10−character floating point number, one of whose characters is the period and the last two characters are the two numbers to the right of the decimal point). Each argument is formatted in the order of the corresponding % signs, so that string Jody corresponds to first %, string Savage corresponds to the second %, and the number 28 to the last % sign.
5. This line is the same as line 4 except vertical bars have been added to demonstrate left− and right−justification of the strings.
6. The printf command formats the string Jody and formats the result of the arithmetic expansion. (See "Arithmetic Expansion".) Two percent (%%) signs are needed to print one percent sign (%).

Variable Expansion Modifiers (Parameter Expansion). Variables can be tested and modified by using special modifiers. The modifier provides a shortcut conditional test to check if a variable has been set, and then assigns a value to the variable based on the outcome of the test. See Table 11.18 for a list of variable modifiers.

Table 11.18. Variable Modifiers

Modifier	Value
${variable:−word}	If variable is set and is non−null, substitute its value; otherwise, substitute word.
${variable:=word}	If variable is set or is non−null, substitute its value; otherwise, set it to word. The value of variable is substituted permanently. Positional parameters may not be assigned in this way.
${variable:+word}	If variable is set and is non−null, substitute word; otherwise, substitute nothing.
${variable:?word}	If variable is set and is non−null, substitute its value; otherwise, print word and exit from the shell. If word is omitted, the message parameter null or not set is printed.
${variable:offset}	Gets the substring of the value in variable starting at offset, where offset starts at 0 to the end of the string.[a]
${variable:offset:length}	Gets the substring of the value in variable starting at offset, length characters over.

[a] Not available on bash versions prior to 2.0.

Using the colon with any of the modifiers (−, =, +, ?) checks whether the variable is not set or is null; without the colon, a variable set to null is considered to be set.

Example 11.59

```
(Substitute Temporary Default Values)
1  $ fruit=peach
2  $ echo ${fruit:−plum}
   peach

3  $ echo ${newfruit:−apple}
   apple
4  $ echo $newfruit

5  $ echo $EDITOR       # More realistic example

6  $ echo ${EDITOR:−/bin/vi}
   /bin/vi
7  $ echo $EDITOR

8  $ name=
   $ echo ${name−Joe}
```

```
9  $ echo ${name:−Joe}
   Joe
```

EXPLANATION

1. The variable fruit is assigned the value peach.
2. The special modifier will check to see if the variable fruit has been set. If it has, the value is printed; if not, plum is substituted for fruit and its value is printed.
3. The variable newfruit has not been set. The value apple will be temporarily substituted for newfruit.
4. The setting was only temporary. The variable newfruit is not set.
5. The environment variable EDITOR has not been set.
6. The :− modifier substitutes EDITOR with /bin/vi.
7. The EDITOR was never set. Nothing prints.
8. The variable name is set to null. By not prefixing the modifier with a colon, the variable is considered to be set, even if to null, and the new value Joe is not assigned to name.
9. The colon causes the modifier to check that a variable is either not set or is set to null. In either case, the value Joe will be substituted for name.

Example 11.60

```
(Substitute Permanent Default Values)

1  $ name=

2  $ echo  ${name:=Peter}
   Peter

3  $ echo $name
   Peter

4  $ echo ${EDITOR:=/bin/vi}
   /bin/vi

5  $ echo $EDITOR
   /bin/vi
```

EXPLANATION

1. The variable name is assigned the null value.
2. The special modifier := will check to see if the variable name has been set. If it has been set, it will not be changed; if it is either null or not set, it will be assigned the value to the right of the equal sign. Peter is assigned to name since the variable is set to null. The setting is permanent.
3. The variable name still contains the value Peter.
4. The value of the variable EDITOR is set to /bin/vi.
5. The value of the variable EDITOR is displayed.

Example 11.61

```
(Substitute Temporary Alternate Value)

1  $ foo=grapes

2  $ echo ${foo:+pears}
   pears
```

```
3  $ echo $foo
   grapes
   $
```

EXPLANATION

1. The variable foo has been assigned the value grapes.
2. The special modifier :+ will check to see if the variable has been set. If it has been set, pears will temporarily be substituted for foo; if not, null is returned.
3. The variable foo now has its original value.

Example 11.62

```
(Creating Error Messages Based On Default Values)

1  $ echo ${namex:?"namex is undefined"}
   namex: namex is undefined

2  $ echo ${y?}
   y: parameter null or not set
```

EXPLANATION

1. The :? modifier will check to see if the variable has been set. If not, the string to the right of the ? is printed to standard error, after the name of the variable. If in a script, the script exits.
2. If a message is not provided after the ?, the shell sends a default message to standard error.

Example 11.63

```
(Creating Substring[a])

1  $ var=notebook

2  $ echo ${var:0:4}
   note

3  $ echo ${var:4:4}
   book

4  $ echo ${var:0:2}
   no
```

[a] Not available in versions of bash prior to 2.x.

EXPLANATION

1. The variable is assigned the value, notebook.
2. The substring of var starts at offset 0, the n in notebook, and has a length of 4 characters, ending at the e.
3. The substring of var starts at offset 4, the b in notebook, and has a length of 4 characters, ending at the k.
4. The substring of var starts at offset 0, the n in notebook, and has a length of 2 characters, ending at the o.

Variable Expansion of Substrings. Pattern−matching arguments are used to strip off certain portions of a string from either the front or end of the string. The most common use for these operators is stripping off pathname elements from the head or tail of the path. See Table 11.19.

Table 11.19. Variable Expansion Substrings[a]

Expression Function${variable%pattern}Matches the smallest trailing portion of the value of variable to pattern and removes it.${variable%%pattern}Matches the largest trailing portion of the value of variable to pattern and removes it. ${variable#pattern}Matches the smallest leading portion of the value of variable to pattern and removes it. ${variable##pattern}Matches the largest leading portion of the value of variable to pattern and removes it.${#variable}Substitutes the number of characters in the variable. If * or @, the length is the number of positional parameters.

[a] Not available on versions of bash prior to 2.x.

Example 11.64

```
1   $ pathname="/usr/bin/local/bin"
2   $ echo ${pathname%/bin*}
    /usr/bin/local
```

EXPLANATION

1. The local variable pathname is assigned /usr/bin/local/bin.
2. The % removes the smallest trailing portion of pathname containing the pattern /bin, followed by zero or more characters; that is, it strips off /bin.

Example 11.65

```
1   $ pathname="usr/bin/local/bin"
2   $ echo ${pathname%%/bin*}
    /usr
```

EXPLANATION

1. The local variable pathname is assigned /usr/bin/local/bin.
2. The %% removes the largest trailing portion of pathname containing the pattern /bin, followed by zero or more characters; that is, it strips off /bin/local/bin

Example 11.66

```
1   $ pathname=/home/lilliput/jake/.bashrc
2   $ echo ${pathname#/home}
    /lilliput/jake/.bashrc
```

EXPLANATION

1. The local variable pathname is assigned /home/liliput/jake/.bashrc.
2. The # removes the smallest leading portion of pathname containing the pattern /home; that is, /home is stripped from the beginning of the path variable.

Example 11.67

```
1   $ pathname=/home/liliput/jake/.bashrc
2   $ echo ${pathname##*/}
    .bashrc
```

EXPLANATION

1. The local variable pathname is assigned /home/liliput/jake/.bashrc.
2. The ## removes the largest leading portion of pathname containing zero or more characters up to and including the last slash; that is, it strips off /home/lilliput/jake from the path variable.

Example 11.68

```
1   $ name="Ebenezer Scrooge"
2   $ echo  ${#name}
    16
```

EXPLANATION

1. The variable name is assigned the string Ebenezer Scrooge.
2. The ${#variable} syntax displays the number of characters in the string assigned to the variable name. There are 16 characters in Ebenezer Scrooge.

Positional Parameters. Normally, the special built−in variables, often called positional parameters, are used in shell scripts when passing arguments from the command line, or used in functions to hold the value of arguments passed to the function. The variables are called positional parameters because they are referenced by numbers 1, 2, 3, and so on, representing their respective positions in the parameter list. See Table 11.20.

The name of the shell script is stored in the $0 variable. The positional parameters can be set, reset, and unset with the set command.

Table 11.20. Positional Parameters

Expression	Function
$0	References the name of the current shell script.
$1–$9	Positional parameters 1–9.
${10}	Positional parameter 10.
$#	Evaluates to the number of positional parameters.
$*	Evaluates to all the positional parameters.
$@	Same as $*, except when double quoted.
"$*"	Evaluates to "$1 $2 $3", etc.
"$@"	Evaluates to "$1" "$2" "$3", etc.

Example 11.69

```
1   $ set punky tommy bert jody
    $ echo $*              # Prints all the positional parameters
    punky tommy bert jody

2   $ echo $1              # Prints the first position
    punky

3   $ echo $2 $3           # Prints the second and third position
    tommy bert

4   $ echo $#              # Prints the total number of positional
    4                      # parameters
```

```
5   $ set a b c d e f g h i j k l m
    $ print $10          # Prints the first positional parameter
    a0                   # followed by a 0.

    $ echo ${10} ${11}   # Prints the 10th and 11th positions
    j k

6   $ echo $#
    13

7   $ echo $*
    a b c d e f g h i j k l m

8   $ set file1 file2 file3
    $ echo \$$#
    $3

9   $ eval echo \$$#
    file3

10  $ set --            # Unsets all positional parameters
```

EXPLANATION

1. The set command assigns values to positional parameters. The $* special variable contains all of the parameters set.
2. The value of the first positional parameter, punky, is displayed.
3. The value of the second and third parameters, tommy and bert, are displayed.
4. The $# special variable contains the number of positional parameters currently set.
5. The set command resets all of the positional parameters. The original parameter list is cleared. To print any positional parameters beyond 9, use the curly braces to keep the two digits together. Otherwise, the value of the first positional parameter is printed, followed by the number appended to it.
6. The number of positional parameters is now 13.
7. The values of all the positional parameters are printed.
8. The dollar sign is escaped; $# is the number of arguments. The echo command displays $3, a literal dollar sign followed by the number of positional parameters.
9. The eval command parses the command line a second time before executing the command. The first time parsed by the shell, the print would display $3; the second time, after eval, the print displays the value of $3, file3.
10. The set command with the − − option clears or unsets all positional parameters.

Other Special Variables. The shell has special variables consisting of a single character.The dollar sign preceding the character allows you to access the value stored in the variable. See Table 11.21.

Table 11.21. Special Variables

Variable Meaning$The PID of the shell.−The sh options currently set.?The exit value of last executed command.!The PID of the last job put in the background.

Example 11.70

```
1   $ echo The pid of this shell is $$
    The pid of this shell is 4725
```

```
2   $ echo The options for this shell are $−
    The options for this shell are imh

3   $ grep dodo /etc/passwd
    $ echo $?
    1

4   $ sleep 25&
    4736
    $ echo $!
    4736
```

EXPLANATION

1. The $ variable holds the value of the PID for this process.
2. The − variable lists all options for this interactive bash shell.
3. The grep command searches for the string dodo in the /etc/passwd file. The ? variable holds the exit status of the last command executed. Since the value returned from grep is 1, grep is assumed to have failed in its search. An exit status of zero indicates a successful exit.
4. The ! variable holds the PID number of the last command placed in the background. The & appended to the sleep command sends the command to the background.

11.3.3 Quoting

Quoting is used to protect special metacharacters from interpretation and prevent parameter expansion. There are three methods of quoting: the backslash, single quotes, and double quotes. The characters listed in Table 11.22 are special to the shell and must be quoted.

Table 11.22. Special Metacharacters Requiring Quotes

Metacharacter Meaning;Command separator.&Background processing.( )Command grouping; creates a subshell.{ }Command grouping; does not create a subshell.|Pipe.<Input redirection.>Output redirection.newlineCommand termination.space/tabWord delimiter.$Variable substitution character.* [ ] ?Shell metacharacters for filename expansion.

Single and double quotes must be matched. Single quotes protect special metacharacters, such as $, *, ?, |, >, and <, from interpretation. Double quotes also protect special metacharacters from being interpreted, but allow variable and command substitution characters (the dollar sign and backquotes) to be processed. Single quotes will protect double quotes and double quotes will protect single quotes.

Unlike the Bourne shell, bash tries to let you know if you have mismatched quotes. If running interactively, a secondary prompt appears when quotes are not matched; if in a shell script, the file is scanned and if the quote is not matched, the shell will attempt to match it with the next available quote. If the shell cannot match it with the next available quote, the program aborts and the message bash:unexpected EOF while looking for `'"'` appears on the terminal. Quoting can be a real hassle for even the best of shell programmers! See Appendix C for shell quoting rules.

The Backslash. The backslash is used to quote (or escape) a single character from interpretation. The backslash is not interpreted if placed in single quotes. The backslash will protect the dollar sign ($), backquotes (`' '`), and the backslash from interpretation if enclosed in double quotes.

Example 11.71

```
1   $ echo Where are you going\?
    Where are you going?

2   $ echo Start on this line and \
    >  go to the next line.
    Start on this line and go to the next line.

3   $ echo \\
    \

4   $ echo '\\'
    \\

5   $ echo '\$5.00'
    \$5.00

6   $ echo  "\$5.00"
    $5.00

7   $ echo 'Don\'t you need $5.00?'
    >
    >'

    Don\t you need .00?
```

EXPLANATION

1. The backslash prevents the shell from performing filename substitution on the question mark.
2. The backslash escapes the newline, allowing the next line to become part of this line.
3. Because the backslash itself is a special character, it prevents the backslash following it from interpretation.
4. The backslash is not interpreted when enclosed in single quotes.
5. All characters in single quotes are treated literally. The backslash does not serve any purpose here.
6. When enclosed in double quotes, the backslash prevents the dollar sign from being interpreted for variable substitution.
7. The backslash is not interpreted when inside single quotes; therefore, the shell sees three single quotes (the one at the end of the string is not matched). A secondary prompt appears, waiting for a closing single quote. When the shell finally gets the closing quote, it strips out all of the quotes and passes the string on to the echo command. Because the first two quotes were matched, the rest of the string t you need $5.00? was not enclosed within any quotes. The shell tried to evaluate $5; it was empty and .00 printed.

Single Quotes. Single quotes must be matched. They protect all metacharacters from interpretation. To print a single quote, it must be enclosed in double quotes or escaped with a backslash.

Example 11.72

```
1   $ echo 'hi there
    > how are you?
    > When will this end?
    > When the quote is matched
    > oh'
    hi there
```

```
    how are you?
    When will this end?
    When the quote is matched
    oh

2   $ echo Don\'t you need '$5.00?'
    Don't you need $5.00?

3   $ echo 'Mother yelled, "Time to eat!"'
    Mother yelled, "Time to eat!"
```

EXPLANATION

1. The single quote is not matched on the line. The Bourne shell produces a secondary prompt. It is waiting for the quote to be matched.
2. The single quotes protect all metacharacters from interpretation. The apostrophe in Don't is escaped with a backslash (the backslash protects a single character, rather than a string). Otherwise, it would match the single quote before the $. Then the single quote at the end of the string would not have a mate. The $ and the ? are enclosed in a pair of single quotes, protecting them from shell interpretation; i.e., treating them as literals.
3. The single quotes protect the double quotes in this string.

Double Quotes. Double quotes must be matched, will allow variable and command substitution, and protect any other special metacharacters from being interpreted by the shell.

Example 11.73

```
1   $ name=Jody

2   $ echo "Hi $name, I'm glad to meet you!"
    Hi Jody, I'm glad to meet you!

3   $ echo "Hey $name, the time is $(date)"
    Hey Jody, the time is Wed Jul 14 14:04:11 PST 2001
```

EXPLANATION

1. The variable name is assigned the string Jody.
2. The double quotes surrounding the string will protect all special metacharacters from interpretation, with the exception of $ in $name. Variable substitution is performed within double quotes.
3. Variable substitution and command substitution are both performed when enclosed within double quotes. The variable name is expanded, and the command in parentheses, date, is executed. (See "Command Substitution" below.)

11.3.4 Command Substitution

Command substitution is used when assigning the output of a command to a variable or when substituting the output of a command within a string. All shells use backquotes to perform command substitution.[13] Bash allows two forms: the older form, where the command(s) is placed within backquotes, and the new Korn−style form, where the command(s) is placed within a set of parentheses preceded by a dollar sign.

Bash performs the expansion by executing the command and returning the standard output of the command, with any trailing newlines deleted. When the old−style backquote form of substitution is used, the backslash retains its literal meaning except when followed by $, ', or \. When using the $(command) form, all characters between the parentheses make up the command; none are treated specially.

Command substitutions may be nested. To nest when using the old form, the inner backquotes must be escaped with backslashes.

FORMAT

```
'UNIX command'    # Old method with backquotes

$(UNIX command)   # New method
```

Example 11.74

```
(The Old Way)
1   $ echo "The hour is 'date +%H'"
    The hour is 09

2   $ name='awk -F: '{print $1}' database'
    $ echo $name
    Ebenezer Scrooge

3   $ ls 'ls /etc'
    shutdown

4   $ set 'date'
5   $ echo $*
    Wed Jul 14 09:35:21 PDT 2001
6   $ echo $2 $6
    Jul 2001

7   $ echo 'basename \'pwd\''
    ellie
```

EXPLANATION

1. The output of the date command is substituted into the string.
2. The output of the awk command is assigned to the variable name and displayed.
3. The output of the ls command, enclosed in backquotes, is a list of files from the /etc directory. The filenames will be arguments to the first ls command. All files with the same name in /etc in the current directory are listed. (The files that are not matches in this directory will cause an error message, such as ls: termcap: No such file or directory.)
4. The set command assigns the output of the date command to positional parameters. Whitespace separates the list of words into its respective parameters.
5. The $* variable holds all of the parameters. The output of the date command was stored in the $* variable. Each parameter is separated by whitespace.
6. The second and sixth parameters are printed.
7. To set the variable dirname to the name (only) of the present working directory, command substitution is nested. The pwd command is executed first, passing the full pathname of the present working directory as an argument to the UNIX command basename. The basename command strips off all but the last element of a pathname. When nesting commands within backquotes, the backquotes for the inner command must be escaped with a backslash.

The bash alternate for using backquotes in command substitution is presented below in Example 11.75.

Example 11.75

```
(The New Way)
1  $ d=$(date)
   $ echo $d
    Wed Jul 14 09:35:21 PDT 2001

2  $ lines = $(cat filex)

3  $ echo The time is $(date +%H)
   The time is 09

4  $ machine=$(uname −n)
   $ echo $machine
   jody

5  $ pwd
   /usr/local/bin
   $ dirname="$(basename $(pwd)) "   # Nesting commands
   $ echo $dirname
   bin

6  $ echo $(cal)                           # Newlines are lost
   July 2001 S M Tu W Th F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
   16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

7  $ echo "$(cal)"
        July 2001
    S  M  Tu  W  Th F  S
                 1  2  3
    4  5  6  7   8  9 10
   11 12 13 14  15 16 17
   18 19 20 21  22 23 24
   25 26 27 28  29 30 31
```

EXPLANATION

1. The date command is enclosed within parentheses. The output of the command is substituted into the expression, then assigned to the variable d, and displayed.
2. The output from the cat command is assigned to the variable lines.
3. Again the date command is enclosed in parentheses. The output of date +%H, the current hour, is substituted for the expression and echoed to the screen.
4. The variable machine is assigned the output of uname −n, the name of the host machine. The value of the machine variable is echoed to the screen.
5. The output of the pwd command (present working directory) is /usr/local/bin.The variable dirname is assigned the output resulting from command substitution where the command substitutions are nested. $(pwd) is the first command substitution to be be performed. The output of the pwd command is substituted in the expression, then the basename program will use the results of that substitution, /usr/local/bin, as its argument, resulting in basename /usr/local/bin.
6. The output of the cal (the current month) command is echoed. The trailing newlines are deleted when command substitution is performed.
7. When you put the whole command substitution expression in double quotes, the trailing newlines are preserved, and calendar looks like it should.

11.3.5 Arithmetic Expansion

The shell performs arithmetic expansion by evaluating an arithmetic expression and substituting the result. The expression is treated as if it were in double quotes and the expressions may be nested. For a complete discussion of arithmetic operations, and arithmetic evaluations, see "The let Command" on page 732.

There are two formats for evaluating arithmetic expressions:

FORMAT

```
$[ expression ]
$(( expression ))
```

Example 11.76

```
echo $[ 5 + 4 − 2 ]
7
echo $[ 5 + 3 * 2]
11
echo $[(5 + 3) * 2]
16
echo $(( 5 + 4 ))
9
echo $(( 5 / 0 ))
bash: 5/0: division by 0 ( error token is "0")
```

11.3.6 Order of Expansion

When you are performing the expansion of variables, commands, arithmetic expressions, and pathnames, the shell is programmed to follow a specific order when scanning the command line. Assuming that the variables are not quoted, the processing is performed in the following order:

1. Brace expansion
2. Tilde expansion
3. Parameter expansion
4. Variable substitution
5. Command substitution
6. Arithmetic expansion
7. Word splitting
8. Pathname expansion

11.3.7 Arrays (Versions 2.x)

Versions of bash 2.x, provide for creation of one−dimensional arrays. Arrays allow you to collect a list of words into one variable name, such as a list of numbers, a list of names, or a list of files. Arrays are created with the built−in function declare −a, or can be created on the fly by giving a subscript to a variable name, such as x[0]=5. The index value is an integer starting at 0. There is no maximum size limit on the array, and indices do not have to be ordered numbers, i.e., x[0], x[1], x[2].... To extract an element of an array, the syntax is ${arrayname[index]}. If declare is given the −a and −r options, a read−only array is created.

FORMAT

```
declare −a variable_name
variable = ( item1 item2 item3 ... )
```

Example 11.77

```
declare −a nums=(45 33 100 65)
declare −ar names   (array is readonly)
names=( Tom  Dick  Harry)
states=( ME  [3]=CA  CT )
x[0]=55
n[4]=100
```

When assigning values to an array, they are automatically started at index 0 and incremented by 1 for each additional element added. You do not have to provide indices in an assignment, and if you do, they do not have to be in order. To unset an array, use the unset command followed by the array name, and to unset one element of the array, use unset and the arrayname[subscript] syntax.

The declare, local, and read−only built−ins also can take the −a option to declare an array. The read command with the −a option is used to read in a list of words from standard input into array elements.

Example 11.78

```
1   $ declare −a friends

2   $ friends=(Sheryl Peter Louise)

3   $ echo ${friends[0]}
    Sheryl

4   $ echo ${friends[1]}
    Peter

5   $ echo ${friends[2]}
    Louise

6   $ echo "All the friends are ${friends[*]}"
    All the friends are Sheryl Peter Louise

7   $ echo "The number of elements in the array is ${#friends[*]}"
    The number of elements in the array is 3

8   $ unset friends  or unset ${friends[*]}
```

EXPLANATION

1. The declare built−in command is used to explicitly declare an array, but it is not necessary. Any variable that uses a subscript, such as variable[0], when being assigned a value, will automatically be treated as an array.
2. The array friends is assigned a list of values: Sheryl, Peter, and Louise.
3. The first element of the friends array is accessed by enclosing the array name and its subscript in curly braces, with an index of 0 used as the value of the subscript. Sheryl is printed.
4. The second element of the friends array is accessed by using the index value of 1.

5. The third element of the friends array is accessed by using the index value of 2.
6. When you place the asterisk within the subscript, all of the elements of the array can be accessed. This line displays all the elements in the friends array.
7. The syntax ${#friends[*]} produces the size of the array; i.e., the number of elements in the array. On the other hand, ${#friends[0]} produces the number of characters in the value of the first element of the array. There are six characters in Sheryl.
8. The unset built−in command deletes the whole array. Just one element of the array can be removed by typing: unset friends[1]; this would remove Sheryl.

Example 11.79

```
1   $ x[3]=100
    $ echo ${x[*]}
    100

2   $ echo ${x[0]}

3   $ echo ${x[3]}
    100

4   $ states=(ME  [3]=CA  [2]=CT)
    $ echo ${states[*]}
    ME CA CT

5   $ echo ${states[0]}
    ME

6   $ echo ${states[1]}

7   $ echo ${states[2]}
    CT

8   $ echo ${states[3]}
    CA
```

EXPLANATION

1. The third element of the array, x, is being assigned 100. It doesn't matter if the index number is 3, but because the first two elements do not exist yet, the size of the array is only 1. ${x[*]} displays the one element of the array, x.
2. x[1] has no value, and neither do x[1] and x[2].
3. x[3] has a value of 100.
4. The states array is being assigned ME at index 0, CA at index 3, and CT at index 2. In this example, you can see that bash doesn't care at what index you store values, and that the index numbers do not have to be contiguous.
5. The first element of the states array is printed.
6. There is nothing stored in states[1].
7. The third element of the states array, states[2], was assigned CT.
8. The fourth element of the states array, states[3], was assigned CA.

11.3.8 An Introduction to Functions

Bash functions are used to execute a group of commands with a name within the context of the current shell (a child process is not forked). They are like scripts, only more efficient. Once defined, functions become part of the shell's memory so that when the function is called, the shell does not have to read it in from the disk as it does with a file. Often functions are used to improve the modularity of a script. Once defined, functions can be used again and again. Although functions can be defined at the prompt when running interactively, they are often defined in the user's initialization file, .bash_profile. They must be defined before they are invoked.

Defining Functions. There are two ways to declare a bash function. One way, the old Bourne shell way, is to give the function name followed by a set of empty parentheses, followed by the function definition. The new way (Korn shell way) is to use the function keyword followed by the function name and then the function definition. If using the new way, the parentheses are optional. The function definition is enclosed in curly braces. It consists of commands separated by semicolons. The last command is terminated with a semicolon. Spaces around the curly braces are required. Any arguments passed to the function are treated as positional parameters within the function. The positional parameters in a function are local to the function. The local built−in function allows local variables to be created within the function definition. Functions may also be recursive, i.e., call themselves an unlimited number of times.

FORMAT

```
function_name () { commands ; commands; }
function function_name { commands ; commands; }
function function_name () { commands ; commands; }
```

Example 11.80

```
1   $ function greet { echo "Hello $LOGNAME, today is $(date)"; }
2   $ greet
    Hello ellie, today is Wed Jul 14 14:56:31 PDT  2001

3   $ greet () { echo "Hello $LOGNAME, today is $(date)"; }
4   $ greet
    Hello ellie, today is Wed Jul 14 15:16:22 PDT  2001

5   $ declare −f
    declare −f greet()
    {
       echo "Hello $LOGNAME, today is $(date)"
    }


6   $ declare −F[a]
    declare −f greet

7   $ export −f greet

8   $ bash                 Start subshell
9   $ greet
    Hello ellie, today is Wed Jul 14 17:59:24 PDT  2001
```

[a] Only on bash version 2.x.

EXPLANATION

1. The keyword function is followed by the name of the function, greet. The function definition is surrounded by curly braces. There must be a space after the opening curly brace. Statements on the same line are terminated with a semicolon.
2. When the greet function is invoked, the command(s) enclosed within the curly braces are executed in the context of the current shell.

3. The greet function is defined again using the Bourne shell syntax, the name of the function, followed by an empty set of parentheses, and the function definition.
4. The greet function is invoked again.
5. The declare command with the −f switch lists all functions defined in this shell and their definitions.
6. The declare command with the −F switch lists only function names.
7. The export command with the −f switch makes the function global, i.e., available to subshells.
8. A new bash shell is started.
9. The function is defined for this child shell because it was exported.

Example 11.81

```
1   $ function fun {
         echo "The current working directory is $PWD."
         echo "Here is a list of your files: "
         ls
         echo "Today is $(date +%A).";
   }
2   $ fun
    The current working directory is /home.
    Here is a list of your files:
    abc      abc123   file1.bak   none       nothing   tmp
    abc1     abc2     file2       nonsense   nowhere   touch
    abc122   file1    file2.bak   noone      one
    Today is Wednesday.

3    $ function welcome { echo "Hi $1 and $2"; }
4    $ welcome tom joe
     Hi tom and joe

5   $ set jane anna lizzy
6   $ echo $*
    jane anna lizzy

7   $ welcome johan joe
    hi johan and joe

8   $ echo  $1 $2
    johan joe

9   $ unset −f welcome     # unsets the function
```

EXPLANATION

1. The function fun is named and defined. The keyword function is followed by the function's name and a list of commands enclosed in curly braces. Commands are listed on separate line; if they are listed on the same line, they must be separated by semicolons. A space is required after the first curly brace or you will get a syntax error. A function must be defined before it can be used.
2. The function behaves just like a script when invoked. Each of the commands in the function definition are executed in turn.
3. There are two positional parameters used in the function welcome. When arguments are given to the function, the positional parameters are assigned those values.
4. The arguments to the function, tom and joe, are assigned to $1 and $2, respectively. The positional parameters in a function are private to the function and will not interfere with

any used outside the function.

5. The positional parameters are set at the command line. These variables have nothing to do with the ones set in the function.
6. $* displays the values of the currently set positional parameters.
7. The function welcome is called. Johan and joe are the values assigned to the positional parameters.
8. The positional variables assigned at the command line are unaffected by those set in the function.
9. The unset built−in command with the −f switch unsets the function. It is no longer defined.

Listing and Unsetting Functions. To list functions and their definitions, use the declare command. In bash versions 2.x and above, declare −F lists just function names. The function and its definition will appear in the output, along with the exported and local variables. Functions and their definitions are unset with the unset −f command.

11.3.9 Standard I/O and Redirection

When the shell starts up, it inherits three files: stdin, stdout, and stderr. Standard input normally comes from the keyboard. Standard output and standard error normally go to the screen. There are times when you want to read input from a file or send output or errors to a file. This can be accomplished by using I/O redirection. See Table 11.23 for a list of redirection operators.

Table 11.23. Redirection

Redirection Operator	What It Does
<	Redirects input.
>	Redirects output.
>>	Appends output.
2>	Redirects error.
&>	Redirects output and error.
>&	Redirects output and error (preferred way).
2>&1	Redirects error to where output is going.
1>&2	Redirects output to where error is going.
>|	Overrides noclobber when redirecting output.
<> filename	Uses file as both standard input and output if a device file (from /dev).

Example 11.82

```
1   $ tr '[A−Z]'  '[a−z]' < myfile   # Redirect  input

2   $ ls > lsfile                    # Redirect output
    $ cat lsfile
    dir1
    dir2
    file1
    file2
    file3

3   $ date >> lsfile                 # Redirect and append otuput
    $ cat lsfile
    dir1
    dir2
    file1
    file2
    file3
    Sun Sept 17 12:57:22 PDT 2001


4   $ cc prog.c 2> errfile           # Redirect error

5   $ find . −name \*.c −print > foundit 2> /dev/null
```

```
    # Redirect output to foundit and errors to /dev/null,
    # respectively.

6   $ find . −name \*.c −print >& foundit
    # Redirect both output and errors to foundit.

7   $ find . −name \*.c −print > foundit 2>&1
    # Redirect output to foundit and send errors to where output
    # is going; i.e. foundit

8   $ echo "File needs an argument" 1>&2
    # Send standard output to error
```

EXPLANATION

1. Instead of getting input from the keyboard, standard input is redirected from the file myfile to the UNIX tr command. All uppercase letters are converted to lowercase.
2. Instead of sending output to the screen, the ls command redirects its output to the file lsfile.
3. The output of the date command is redirected and appended to lsfile.
4. The C program source file prog.c is compiled. If the compile fails, the standard error is redirected to the file errfile. Now you can take your error file to the local guru for an explanation (of sorts)!
5. The find command starts searching in the current working directory for filenames ending in .c, and prints the filenames to a file named foundit. Errors from the find command are sent to /dev/null.
6. The find command starts searching in the current working directory for filenames ending in .c, and prints the filenames to a file named foundit. The errors are also sent to foundit.
7. Same as 6.
8. The echo command sends its message to standard error. Its standard output is merged with standard error.

The exec Command and Redirection. The exec command can be used to replace the current program with a new one without starting a new process. Standard output or input can be changed with the exec command without creating a subshell. (See Table 11.24.) If a file is opened with exec, subsequent read commands will move the file pointer down the file a line at a time until the end of the file. The file must be closed to start reading from the beginning again. However, if using UNIX utilities such as cat and sort, the operating system closes the file after each command has completed.

Table 11.24. The exec Command

exec Command **What It Does** exec ls ls executes in place of the shell. When ls is finished, the shell in which it was started does not return. exec < filea Opens filea for reading standard input. exec > filex Opens filex for writing standard output. exec 3< datfile Opens datfile as file descriptor 3 for reading input. sort <&3 Datfile is sorted. exec 4>newfile Opens newfile as file descriptor (fd) 4 for writing. ls >&4 Output of ls is redirected to newfile. exec 5<&4 Makes fd 5 a copy of fd 4. exec 3<&− Closes fd 3.

Example 11.83

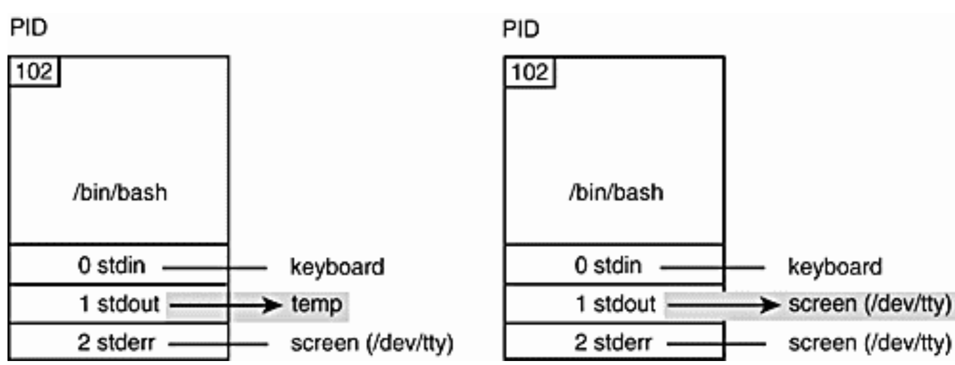
```
1   $ exec date
    Thu Oct 14 10:07:34  PDT 2001
     <Login prompt appears if you are in your login shell >

2   $ exec > temp
```

```
    $ ls
    $ pwd
    $ echo Hello
3   $ exec > /dev/tty
4   $ echo Hello
    Hello
```

EXPLANATION

1. The exec command executes the date command in the current shell (does not fork a child shell). Because the date command is executed in place of the current shell, when the date command exits, the shell terminates. If a bash shell had been started from the TC shell, the bash shell would exit and the TC shell prompt would appear. If you are in your login shell when you try this, you will be logged out. If you are working interactively in a shell window, the window exits.
2. The exec command opens standard output for the current shell to the temp file. Output from ls, pwd, and echo will no longer go to the screen, but to temp. (See Figure 11.3.)

Figure 11.3. The exec command and file descriptors.



3. The exec command reopens standard output to the terminal. Now, output will go to the screen as shown in line 4.
4. Standard output has been directed back to the terminal (/dev/tty).

Example 11.84

```
1   > bash
2   $ cat doit
    pwd
    echo hello
    date
3   $ exec < doit
    /home/homebound/ellie/shell
    hello
    Thu Oct 14 10:07:34  PDT 2001
4   >
```

EXPLANATION

1. From a TC shell prompt, bash is started up. (This is done so that when the exec command exits, the user will not be logged out.)
2. The contents of a file called doit are displayed.
3. The exec command opens standard input to the file called doit. Input is read from the file instead of from the keyboard. The commands from the file doit are executed in place of

the current shell. When the last command exits, so does the shell.

4. The bash shell exited when the exec command completed. The TC shell prompt appeared. It was the parent shell. If you had been in your login shell when the exec finished, you would be logged out; if in a window, the window would have disappeared.

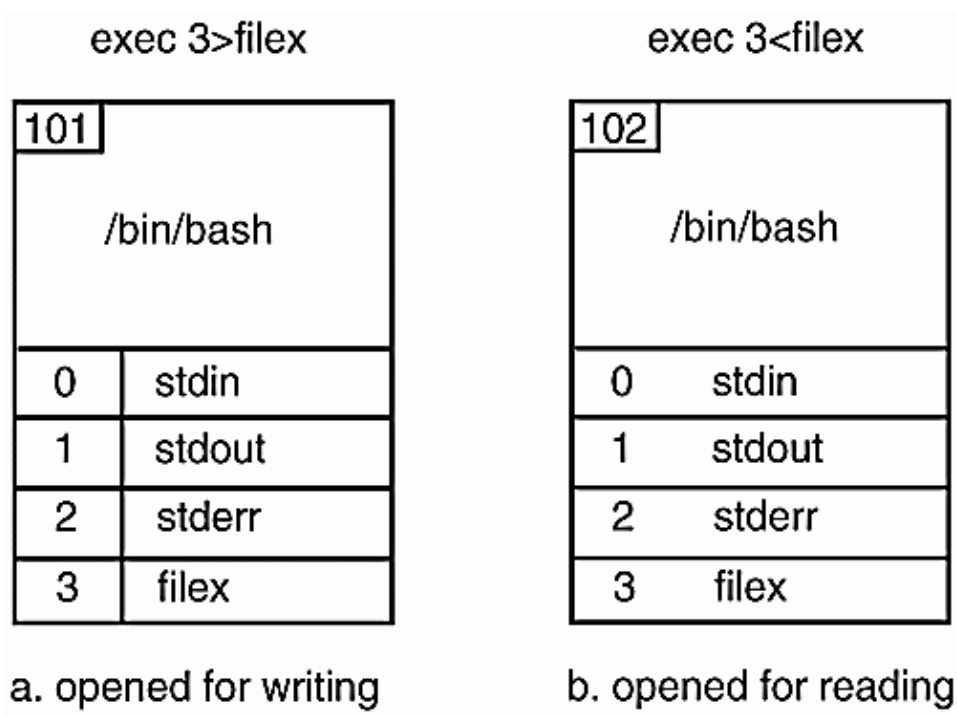
Example 11.85

```
1   $ exec 3> filex
2   $ who >& 3
3   $ date >& 3
4   $ exec 3>&-
5   $ exec 3<filex
6   $ cat <&3
    ellie  tty    Jul 21 09:50
    ellie  ttyp1  Jul 21 11:16  (:0.0)
    ellie  ttyp0  Jul 21 16:49  (:0.0)
    Wed Jul 21 17:15:18 PDT 2001
7   $ exec 3<&-
8   $ date >& 3
    date: write error: Bad file descriptor
```

EXPLANATION

1. File descriptor 3 (fd 3) is assigned to filex and opened for redirection of output. See Figure 11.4(a).

Figure 11.4. exec and file descriptors.



2. The output of the who command is sent to fd 3, filex.
3. The output of the date command is sent to fd 3; filex is already opened, so the output is appended to filex.
4. Fd 3 is closed.
5. The exec command opens fd 3 for reading input. Input will be redirected from filex. See

Figure 11.4(b).
6. The cat program reads from fd 3, assigned to filex.
7. The exec command closes fd 3. (Actually, the operating system will close the file once end of file is reached.)
8. When attempting to send the output of the date command to fd 3, bash reports an error condition, because fd 3 was previously closed.

11.3.10 Pipes

A pipe takes the output from the command on the left−hand side of the pipe symbol and sends it to the input of the command on the right−hand side of the pipe symbol. A pipeline can consist of more than one pipe.

The purpose of the commands in Example 11.86 is to count the number of people logged on (who), save the output of the command in a file (tmp), use the wc −l to count the number of lines in the tmp file (wc −l), and then remove the tmp file (i.e., find the number of people logged on).

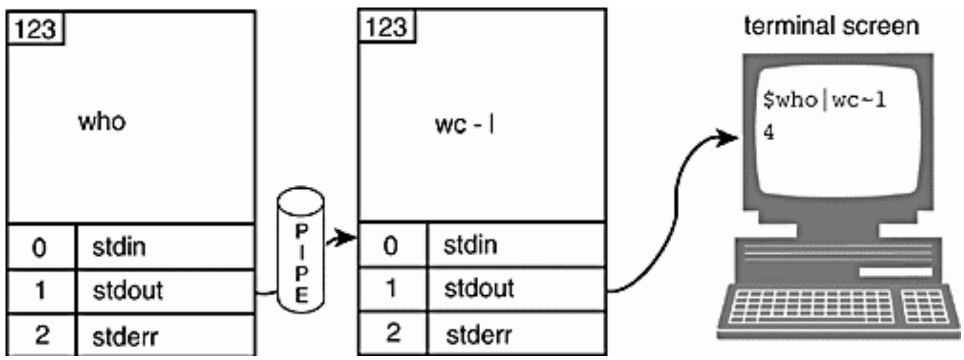
Example 11.86

```
1  $ who > tmp
2  $ wc −l tmp
   4 tmp
3  $ rm tmp

# Using a pipe saves disk space and time.

4  $ who | wc −l
   4

5  $ du .. | sort −n | sed −n '$p'
   1980

6  $ ( du / | sort −n | sed −n '$p' ) 2> /dev/null
   1057747  /
```

EXPLANATION

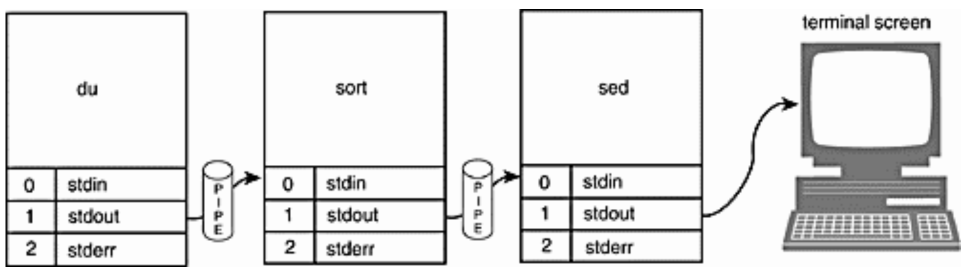
1. The output of the who command is redirected to the tmp file.
2. The wc −l command displays the number of lines in tmp.
3. The tmp file is removed.
4. With the pipe facility, you can perform all three of the preceding steps in one step. The output of the who command is sent to an anonymous kernel buffer; the wc _l command reads from the buffer and sends its output to the screen. See Figure 11.5.

Figure 11.5. The pipe.



5. The output of the du command, the number of disk blocks used per directory, starting in the parent directory (..), is piped to the sort command and sorted numerically. It is then piped to the sed command, which prints the last line of the output it receives. See Figure 11.6.

Figure 11.6. Multiple pipes (filter).



6. The du command (starting in the root directory) will send error messages to stderr (the screen) if it is unable to get into a directory because the permissions have been turned off. When you put the whole command line in a set of parentheses, all the output is sent to the screen, and all the errors are directed to the UNIX bit bucket, /dev/null.

11.3.11 The here document and Redirecting Input

The here document is a special form of quoting. It accepts inline text for a program expecting input, such as mail, sort, or cat, until a user−defined terminator is reached. It is often used in shell scripts for creating menus. The command receiving the input is appended with a << symbol, followed by a user−defined word or symbol, and a newline. The next lines of text will be the lines of input to be sent to the command. The input is terminated when the user−defined word or symbol is then placed on a line by itself in the leftmost column (it cannot have spaces surrounding it). The word is used in place of Control−D to stop the program from reading input.

If the terminator is preceded by the <<− operator, leading tabs, and only tabs, may precede the final terminator. The user−defined terminating word or symbol must match exactly from "here" to "here." The following examples illustrate the use of the here document at the command line to demonstrate the syntax. It is much more practical to use them in scripts.

Example 11.87

```
1   $ cat << FINISH                    # FINISH is a user-defined
2   > Hello there $LOGNAME             # terminator
3   > The time is $(date +%T).
    > I can't wait to see you!!!
4   > FINISH                           # terminator matches first

5   Hello there ellie                  # FINISH on line 1.
    The time is 19:42:12.
    I can't wait to see you!!!
6   $
```

EXPLANATION

1. The UNIX cat program will accept input until the word FINISH appears on a line by itself.
2. A secondary prompt appears. The following text is input for the cat command. Variable substitution is performed within the here document.
3. Command substitution, $(date +%T), is performed within the here document. Could have also used the older form of command substitution: `'date +T'`.
4. The user−defined terminator FINISH marks the end of input for the cat program. It cannot have any spaces before or after it and is on a line by itself.
5. The output from the cat program is displayed.
6. The shell prompt reappears.

Example 11.88

```
1   $ cat <<− DONE
    >  Hello there
    >     What's up?
    >Bye now The time is 'date'.
2   >   DONE
      Hello there
           What's up?
    Bye now The time is Sun Feb 819:48:23 PST 2001.
    $
```

EXPLANATION

1. The cat program accepts input until DONE appears on a line by itself. The <<− operator allows the input and final terminator to be preceded by one or more tabs. Typing this example at the command line may cause problems with the Tab key; the example will work fine, if run from a script.
2. The final matching terminator, DONE, is preceded by a tab. The output of the cat program is displayed on the screen.

11.3.12 Shell Invocation Options

When the shell is started using the bash command, it can take options to modify its behavior. There are two types of options: single−character options and multicharacter options. The single−character options consist of a single leading dash followed by a single character. The multicharacter options consist of two leading dashes and any number of characters. Multicharacter options must appear before single−character options. An interactive login shell normally starts up with −i (starts an interactive shell) , −s (reads from standard input), and −m (enables job control). See Table 11.25.

Table 11.25. Bash 2.x Shell Invocation Options

Option Meaning−c stringCommands are read from string. Any arguments after string are assigned to positional parameters, starting at $0.−DA list of double quoted strings, preceded by a $, are printed to standard output. These strings are subject to language translation when the current locale is not C or POSIX.The −n option is implied; no commands will be executed.−iShell is in the interactive mode. TERM, QUIT, and INTERRUPT are ignored.−sCommands are read from standard input and allows the setting of positional parameters.−rStarts a restricted shell.− −Signals the end of options and disables further option processing. Any arguments after − − or − are treated as filenames and arguments.− −dump−stringsSame as −D.− −helpDisplays a usage message for a built−in command and exits.− −loginCauses bash to be invoked as a login shell.− −noeditingWhen bash is running interactively, does not use the Readline library.− −noprofileWhen starting up, bash does not read the initialization files: /etc/profile, ~/.bash_profile, ~/.bash_login, or ~/.profile.− −norcFor interactive shells, bash will not read the ~/.bashrc file. Turned on by default, if running shell as sh.− −posixChanges the behavior of bash to match the POSIX 1003.2 standard, if otherwise it wouldn't.− −quietDisplays no information at shell startup, the default.− −rcfile fileIf bash is interactive, uses this intialization file instead of ~/.bashrc.− −restrictedStarts a restricted shell.− −verboseTurns on verbose; same as −v.− −versionDisplays version information about this bash shell and exits.

11.3.13 The set Command and Options

The set command can be used to turn shell options on and off, as well as for handling command line arguments. To turn an option on, the dash (–) is prepended to the option; to turn an option off, the plus sign (+) is prepended to the option. See Table 11.26 for a list of set options.

Example 11.89

```
1   $ set −f

2   $ echo *
    *

3   $ echo ??
    ??

4   $ set +f
```

EXPLANATION

1. The f option is turned on, disabling filename expansion.
2. The asterisk is not expanded.
3. The question marks are not expanded.
4. The f is turned off; filename expansion is enabled.

Table 11.26. The Built−In set Command Options

Name of Option Shortcut SwitchWhat It Doesallexport−aAutomatically marks new or modified variables for export from the time the option is set, until unset.braceexpand−BEnables brace expansion, and is a default setting.emacs For command line editing, uses the emacs built−in editor, and is a default setting.errexit−eIf a command returns a nonzero exit status (fails), exits. Not set when reading initialization files.histexpand−HEnables ! and !! when performing history substitution, and is a default setting.history Enables command line history; on by default.ignoreeof Disables EOF (Control−D) from exiting a shell; must type exit. Same as setting shell variable, IGNOREEOF=10.keyword−kPlaces keyword arguments in the environment for a command. interactive_comments For interactive shells, a leading # is used to comment out any text remaining on the line.monitor−mAllows job control.noclobber−CProtects files from being overwritten when redirection is used.noexec−nReads commands, but does not execute them. Used to check the syntax of scripts. Not on when running interactively.noglob−dDisables pathname expansion; i.e., turns off wildcards.notify−bNotifies user when background job finishes.nounset−uDisplays an error when expanding a variable that has not been set.onecmd−tExits after reading and executing one command.physical−PIf set, does not follow symbolic links when typing cd or pwd. The physical directory is used instead.posix Shell behavior is changed if the default operation doesn't match the POSIX standard.privileged−pWhen set, the shell does not read the .profile or ENV file and shell functions are not inherited from the environment; automatically set for setuid scripts.verbose−vTurns on the verbose mode for debugging.vi For command line editing, uses the vi built−in editor.xtrace−xTurns on the echo mode for debugging.

11.3.14 The shopt Command and Options

The shopt (bash 2.x) command can also be used to turn shell options on and off.

Table 11.27. The shopt Command Options

Option Meaningcdable_varsIf an argument to the cd built−in command is not a directory, it is assumed to be the name of a variable whose value is the directory to change to.cdspellCorrects minor errors in the spelling of a directory name in a cd command. The errors checked for are transposed characters, a missing character, and a character too many. If a correction is found, the corrected path is printed, and the command proceeds. Only used by interactive shells.checkhashBash checks that a command found in the hash table exists before trying to execute it. If a hashed command no longer exists, a normal path search is performed.checkwinsizeBash checks the window size after each command and, if necessary, updates the values of LINES and COLUMNS.cmdhistBash attempts to save all lines of a multiple−line command in the same history entry. This allows easy re−editing of multiline commands.dotglobBash includes filenames beginning with a dot (.) in the results of filename expansion.execfailA noninteractive shell will not exit if it cannot execute the file specified as an argument to the exec built−in command. An interactive shell does not exit if exec fails. expand_aliasesAliases are expanded. Enabled by default.extglobThe extended pattern matching features (regular expression metacharacters derived from Korn shell for filename expansion) are enabled.histappendThe history list is appended to the file named by the value of the HISTFILE variable when the shell exits, rather than overwriting the file.histreeditIf readline is being used, a user is given the opportunity to re−edit a failed history substitution.histverifyIf set, and readline is being used, the results of history substitution are not immediately passed to the shell parser. Instead, the resulting line is loaded into the readline editing buffer, allowing further modification.hostcompleteIf set, and readline is being used, bash will attempt to perform hostname completion when a word containing @ is being completed. Enabled by default.huponexitIf set, bash will send SIGHUP (hangup signal) to all jobs when an interactive login shell exits. interactive_commentsAllows a word beginning with # to cause that word and all remaining characters on that line to be ignored in an interactive shell. Enabled by default.lithistIf enabled, and the cmdhist option is enabled, multiline commands are saved to the history with embedded newlines rather than using semicolon separators where possible.mailwarnIf set, and a file that bash is checking for mail has been accessed since the last time it was checked, the message The mail in mailfile has been read is displayed.nocaseglobIf set, bash matches filenames in a case−insensitive fashion when performing filename expansion.nullglobIf set, bash allows filename patterns that match no files to expand to a null string, rather than themselves.promptvarsIf set, prompt strings undergo variable and parameter expansion after being expanded. Enabled by default.

restricted_shellThe shell sets this option if it is started in restricted mode. The value may not be changed. This is not reset when the startup files are executed, allowing the startup files to discover whether or not a shell is restricted. shift_verboseIf this is set, the shift built−in prints an error message when the shift count exceeds the number of positional parameters.sourcepathIf set, the source built−in uses the value of PATH to find the directory containing the file supplied as an argument. Enabled by default.sourceA synonym for dot (.).

11.3.15 Shell Built−In Commands

The shell has a number of commands that are built−in to its source code. Because the commands are built−in, the shell doesn't have to locate them on disk, making execution much faster. The help feature provided with bash gives you online help for any built−in command. The built−in commands are listed in Table 11.28.

Table 11.28. Built−In Commands

CommandWhat It Does:Do−nothing command; returns exit status zero.. fileThe dot command reads and executes command from file.break [n]See "Loop Control"..Executes program in context of current process; same as source.aliasLists and creates "nicknames" for existing commands.bgPuts a job in the background.bindDisplay current key and function bindings, or binds keys to a readline function or macro.breakBreaks out of the innermost loop.builtin [sh−builtin [args]]Runs a shell built−in, passing it args and returning 0 exit status. Useful if a function and built−in have the same name.cd [arg]Changes the directory to home if no arg or to value of arg.command command [arg]Runs a command even if a function has the same name; i.e., bypasses function lookup.continue [n]See "Loop Control".declare [var]Displays all variables or declares variables with optional attributes.dirsDisplays a list of currently remembered directories resulting from pushd.disownRemoves an active job from the job table.echo [args]Displays args terminated with a newline.enableEnables and disables shell built−in commands.eval [args]Reads args as input to the shell and executes the resulting command(s).exec commandRuns command in place of this shell.exit [n]Exits the shell with status n.export [var]Makes var known to subshells.fcHistory's fix command for editing history commands.fgPuts background job into foreground.getoptsParses and processes command line options.hashControls the internal hash table for quicker searches for commands.help [command]Displays helpful info about built−in commands and, if command is specified, detailed help about that built−in command.historyDisplays the history list with line numbers.jobsLists jobs put in the background.kill [−signal process]Sends the signal to the PID number or job number of the process. Type at the prompt: kill −l.getoptsUsed in shell scripts to parse command line and check for legal options.letUsed for evaluating arithmetic expressions and assigning results of arithmetic calculations to variables.localUsed in functions to restrict the scope of variables to the function.logoutExits the login shell.popdRemoves entries from the directory stack.pushdAdds entries to the directory stack.pwdPrints present working directory.read [var]Reads line from standard input into variable var.readonly [var]Makes variable var read−only. Cannot be reset.return [n]Returns from a function where n is the exit value given to the return.setSets options and positional parameters. See "The set Command and Positional Parameters".shift [n]Shifts positional parameters to the left n times.stop pidHalts execution of the process number PID.suspendStops execution of the current shell (but not if a login shell).testChecks file types and evaluates conditional expressions.timesPrints accumulated user and system times for processes run from this shell.trap [arg] [n]When shell receives signal n (0, 1, 2, or 15), executes arg.type [command]Prints the type of command; e.g., pwd is a built−in shell command.typesetSame as declare. Sets variables and gives them attributes.ulimitDiplays and sets process resource limits.umask [octal digits]Sets user file creation mode mask for owner, group, and others.unaliasUnsets aliases.unset [name]Unset value of variable or function.wait [pid#n]Waits for background process with PID number n and reports termination status.

BASH SHELL LAB EXERCISES

Lab 43: Getting Started

1: What process puts the login prompt on your screen?

2: What process assigns values to HOME, LOGNAME, and PATH?

3: How do you know what shell you are using?

4: What command will allow you to change your login shell?

5: Where is your login shell assigned? (What file?)

6: Explain the difference between the /etc/profile and ~/.bash_profile file.

7: Which one is executed first?

8: Edit your .bash_profile file as follows:

a. Welcome the user.
b. Add your home directory to the path if it is not there.
c. Set erase to the Backspace key using stty.
d. Type source.bash_profile. What is the function of the source command?

9: What is the BASH_ENV file? When is it executed?

10: What is the default primary prompt?

a. Change the prompt to include the time of day and your home directory.
b. What is the default secondary prompt? What is its function?

11: Explain the function of each of the following settings:

a. set −o ignoreeof
b. set −o noclobber
c. set −o emacs
d. set−o vi

12: In what file are the settings in the previous example stored? Why are they stored there?

13: What does shopt −p do? Why use shopt instead of set?

14: What is a built−in command? How can you tell if a command is a built−in or an executable? What is the purpose of the builtin command? The enable command?

15: What would cause the shell to return an exit status of 127?

Lab 44: Job Control

1: What is the difference between a program and a process? What is a job?

2: What is the PID of your shell?

3: How do you stop a job?

4: What command brings a background job into the foreground?

5: How do you list all running jobs? All stopped jobs?

6: What is the purpose of the kill command?

7: What does jobs −l display? What does kill −l display?

Lab 45: Command Completion, History, and Aliases

1: What is filename completion?

2: What is the name of the file that stores a history of commands entered at the command line?

3: What does the HISTSIZE variable control? What does HISTFILESIZE control?

4: What does bang, bang mean?

5: How would you reexecute the last command that started with a v?

6: How would you reexecute the 125th command? How would you print the history list in reverse?

7: How do you set interactive editing to use the vi editor? In what initialization file would you put this setting?

8: What is the fc command?

9:

What is the purpose of the Readline library? From what initialization file does it read instructions?

10: What is key binding? How do you find out what keys are bound?

11: What is the universal argument?

12: Create an alias for the following commands:

a. clear
b. fc −s
c. ls − −color=tty
d. kill −l

Lab 46: Shell Metacharacters

1: Make a directory called wildcards. Cd to that directory and type at the prompt:

```
touch ab abc a1 a2 a3 all a12 ba ba.1 ba.2 filex filey AbC ABC ABc2 abc
```

2: Write and test the command that will do the following:

a. List all files starting with a.
b. List all files ending in at least one digit.
c. List all files starting with a or A.
d. List all files ending in a period, followed by a digit.
e. List all files containing just two alphabetic characters.
f. List three character files where all letters are uppercase.
g. List files ending in 10, 11, or 12.
h. List files ending in x or y.
i. List all files ending in a digit, an uppercase letter, or a lowercase letter.
j. List all files not starting with a b or B.
k. Remove two character files starting with a or A.

Lab 47: Redirection

1: What are the names of the three file streams associated with your terminal?

2: What is a file descriptor?

3: What command would you use to do the following:

a. Redirect the output of the ls command to a file called lsfile?
b. Redirect and append the output of the date command to lsfile?
c. Redirect the output of the who command to lsfile? What happened?

4: What happens when you type cp all by itself?

5: How do you save the error message from the above example to a file?

6: Use the find command to find all files, starting from the parent directory, of type directory. Save the standard output in a file called found and any errors in a file called found.errs.

7: Take the output of three commands and redirect the output to a file called gottem_all?

8: Use a pipe(s) with the ps and wc commands to find out how many processes you are currently running.

Lab 48: Variables

1: What is a positional parameter? Type at the command line:

```
set dogs cats birds fish
```

a. How do you list all of the positional parameters?
b. Which positional parameter is assigned birds?
c. How do you print the number of positional parameters?
d. How do you remove all the positional parameters from the shell's memory?

2: What is an environment variable? What is the command used to list them? Create an environment variable called CITY and assign it the value of your home town. How do you export it?

3: What is a local variable? Set a local variable to your name. Print its value. Unset it.

4: What is the function of declare −i?

5: What does the $$ variable display? What does the $! display?

[1] Although bash is traditionally the default shell for Linux platforms, it now comes bundled with Solaris 8.

[2] To get the latest version of bash, visit http://www.delorie.com/gnu/.

[3] There are a number of different initialization files used by bash; they are discussed on the next pages.

[4] If the shell is invoked with the −noprofile option, none of the initialization files are read.

[5] If the set −o (editor) has not been set, but the EDITOR variable has been set to either emacs or vi, then bash will use that definition.

[6] vi is case−sensitive; an uppercase J and a lowercase j are different commands.

[7] Whether the user saves and quits the editor, or simply quits the editor, the commands will all be executed, unless they are commented or deleted.

[8] The tilde character will not be expanded if enclosed in either double or single quotes.

[9] Bash Reference Manual: http://www.delorie.com/gnu/docs/bash/bashref_56.html.

[10] A variable set to a value or to null will be displayed by using the set command, but an unset variable will not.

[11] Like DNA, inheritance goes one direction only, from parent to child.

[12] On bash versions 2.x, printf is a built−in command.

[13] The bash shell allows backquotes for command substitution for upward−compatibility, but provides an alternate method as well.

CONTENTS

CONTENTS

Chapter 12. Programming with the bash Shell

12.1 Introduction

When commands are executed from within a file, instead of from the command line, the file is called a shell script and the shell is running noninteractively. When the bash shell starts running noninteractively, it looks for the environment variable, BASH_ENV (ENV) and starts up the file (normally .bashrc) assigned as its value. After the BASH_ENV file has been read, the shell will start executing commands in the script.[1]

12.1.1 The Steps in Creating a Shell Script

A shell script is normally written in an editor and consists of commands interspersed with comments. Comments are preceded by a pound sign and consist of text used to document what is going on.

The First Line. The first line at the top left corner of the script will indicate the program that will be executing the lines in the script. This line, commonly called the shbang line, is written as

```
#!/bin/bash
```

The #! is called a magic number and is used by the kernel to identify the program that should be interpreting the lines in the script. This line must be the top line of your script. The bash program can also accept arguments to modify its behavior. See Table 12.8 for a list of bash options.

Comments. Comments are lines preceded by a pound sign (#) and can be on a line by themselves or on a line following a script command. They are used to document your script. It is sometimes difficult to understand what the script is supposed to do if it is not commented. Although comments are important, they are often too sparse or not used at all. Try to get used to commenting what you are doing not only for someone else, but also for yourself. Two days from now you may not recall exactly what you were trying to do.

Executable Statements and bash Shell Constructs. A bash shell program consists of a combination of UNIX commands, bash shell commands, programming constructs, and comments.

Making the Script Executable. When you create a file, it is not given the execute permission. You need this permission to run your script. Use the chmod command to turn on the execute permission.

Example 12.1

```
1   $ chmod +x myscript
2   $ ls -lF  myscript
    -rwxr-xr-x    1  ellie   0 Jul  13:00 myscript*
```

EXPLANATION

1. The chmod command is used to turn on the execute permission for the user, group, and others.
2. The output of the ls command indicates that all users have execute permission on the myscript file. The asterisk at the end of the filename also indicates that this is an executable program.

A Scripting Session. In the following example, the user will create a script in the editor. After the user saves the file, the execute permissions are turned on, and the script is executed. If there are errors in the program, the shell will respond immediately.

Example 12.2

```
(The Script)
1   #!/bin/bash
2   # This is the first Bash shell program of the day.
    # Scriptname: greetings
    # Written by:  Barbara Bashful
3   echo "Hello $LOGNAME, it's nice talking to you."
4   echo "Your present working directory is 'pwd'."
    echo "You are working on a machine called 'uname -n'."
```

```
    echo "Here is a list of your files."
5   ls    # List files in the present working directory
6   echo  "Bye for now $LOGNAME. The time is 'date +%T'!"

(The Command Line)
    $ greetings     # Don't forget to turn turn on x permission!
    bash: ./greetings: Permission denied.

    $ chmod +x greetings
    $ greetings  or  ./greetings
3   Hello barbara, it's nice talking to you.
4   Your present working directory is /home/lion/barbara/prog
    You are working on a machine called lion.
    Here is a list of your files.

5   Afile        cplus    letter     prac
    Answerbook   cprog    library    prac1
    bourne       joke     notes      perl5
6   Bye for now barbara. The time is 18:05:07!
```

EXPLANATION

1. The first line of the script, #!/bin/bash, lets the kernel know what interpreter will execute the lines in this program, in this case the bash (Bourne Again shell) interpreter.
2. The comments are nonexecutable lines preceded by a pound sign. They can be on a line by themselves or appended to a line after a command.
3. After variable substitution is performed by the shell, the echo command displays the line on the screen.
4. After command substitution is performed by the shell, the echo command displays the line on the screen.
5. The ls command is executed. The comment will be ignored by the shell.
6. The echo command displays the string enclosed within double quotes. Variables and command substitution (backquotes) are expanded when placed within double quotes. In this case, the quotes were really not necessary.

12.2 Reading User Input

12.2.1 Variables (Review)

In the last chapter we talked about declaring and unsetting variables. Variables are set local to the current shell or as environment variables. Unless your shell script will invoke another script, variables are normally set as local variables within a script. (See "Variables".)

To extract the value from a variable, precede the variable with a dollar sign. You can enclose the variable within double quotes and the dollar sign will be interpreted by the shell for variable expansion. Variable expansion is not performed if the variable is enclosed in single quotes.

Example 12.3

```
1   name="John Doe" or declare name="John Doe"   # local variable
2   export NAME="John Doe"    # global variable
3   echo "$name" "$NAME"      # extract the value
```

12.2.2 The read Command

The read command is a built−in command used to read input from the terminal or from a file (see Table 12.1). The read command takes a line of input until a newline is reached. The newline at the end of a line will be translated into a null byte when read. If no names are supplied, the line read is assigned to the special built−in variable, REPLY. You can also use the read command to cause a program to stop until the user hits Enter. To see how the read command is most effectively used for reading lines of input from a file, see "Looping Commands". The –r option to read causes the backslash/newline pair to be ignored; the backslash is treated as part of the line. The read command has four options to control its behavior: –a, –e, –p, and –r.[2]

Table 12.1. The read Command

Format	**Meaning**
read answer	Reads a line from standard input and assigns it to the variable answer.
read first last	Reads a line from standard input to the first whitespace or newline, putting the first word typed into the variable first and the rest of the line into the variable last.
read	Reads a line from standard input and assigns it to the built−in variable, REPLY.
read –a arrayname	Reads a list of words into an array called arrayname.[a]
read –e	Used in interactive shells with command line editing in effect; e.g., if editor is vi, vi commands can be used on the input line.[a]
read –p prompt	Prints a prompt, waits for input, and stores input in REPLY variable.[a]
read –r line	Allows the input to contain a backslash.[a]

[a] Not implemented on versions of bash prior to 2.0.

Example 12.4

```
(The Script)
    #!/bin/bash
    # Scriptname: nosy
    echo −e "Are you happy? \c"
1   read answer
    echo "$answer is the right response."
    echo −e "What is your full name? \c"
2   read first middle last
    echo "Hello  $first"

    echo –n "Where do you work? "
3   read
4   echo I guess $REPLY keeps you busy!
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−[a]
5   read −p "Enter your job title: "
6   echo "I thought you might be an $REPLY."

7   echo −n "Who are your best friends? "
8   read −a friends
9   echo "Say hi to ${friends[2]}."
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
(The Output)
    $ nosy
    Are you happy? Yes
1   Yes is the right response.
2   What is your full name? Jon Jake Jones
    Hello Jon
3   Where do you work? the Chico Nut Factory
4   I guess the Chico Nut Factory keeps you busy!
5   Enter your job title: Accountant
6   I thought you might be an Accountant.
7,8 Who are your best friends?  Melvin Tim Ernesto
```

```
9   Say hi to Ernesto.
```

[a] The commands listed below this line are not implemented on versions of bash prior to 2.x.

EXPLANATION

1. The read command accepts a line of user input and assigns the input to the variable answer.
2. The read command accepts input from the user and assigns the first word of input to the variable first, the second word of input to the variable middle, and all the rest of the words up to the end of the line to the variable last.
3. A line is read from standard input and stored in the built−in REPLY variable.
4. The value of the REPLY variable is printed.
5. With the –p option, the read command produces a prompt, Enter your job title: and stores the line of input in the special built−in REPLY variable.
6. The value of the REPLY variable is displayed in the string.
7. The user is asked to enter input.
8. With the –a option, the read command takes input as an array of words. The array is called friends. The elements read into the array are Melvin, Tim, and Ernesto.
9. The third element of the friends array, Ernesto, is printed. Array indices start at 0.

Example 12.5

```
(The Script)
    #!/bin/bash
    # Scriptname: printer_check
    # Script to clear a hung−up printer
1   if [ $LOGNAME != root ]
    then
       echo "Must have root privileges to run this program"
       exit 1
    fi
2   cat << EOF
    Warning: All jobs in the printer queue will be removed.
    Please turn off the printer now. Press return when you
    are ready to continue. Otherwise press Control C.
    EOF
3   read JUNK      # Wait until the user turns off the printer
    echo
4   /etc/rc.d/init.d/lpd stop       # Stop the printer
5   echo −e "\nPlease turn the printer on now."
6   echo "Press Enter to continue"
7   read JUNK                 # Stall until the user turns the printer
                              # back on
    echo                      # A blank line is printed
8   /etc/rc.d/init.d/lpd start     # Start the printer
```

EXPLANATION

1. Checks to see if user is root. If not, sends an error and exits.
2. Creates a here document. Warning message is displayed on the screen.
3. The read command waits for user input. When the user presses Enter, the variable JUNK accepts whatever is typed. The variable is not used for anything. The read in this case is used to wait until the user turns off the printer, comes back, and presses Enter.
4. The lpd program stops the printer daemon.

5. Now it's time to turn the printer back on!
6. The user is asked to press Enter when ready.
7. Whatever the user types is read into the variable JUNK, and when Enter is pressed, the program will resume execution.
8. The lpd program starts the print daemons.

12.3 Arithmetic

12.3.1 Integers (declare and let Commands)

The declare Command. Variables can be declared as integers with the declare –i command. If you attempt to assign any string value, bash assigns 0 to the variable. Arithmetic can be performed on variables that have been declared as integers. (If the variable has not been declared as an integer, the built−in let command allows arithmetic operations. See "The let Command" on page 732.) If you attempt to assign a floating point number, bash reports a syntax error. Numbers can also be represented in different bases such as binary, octal, and hex.

Example 12.6

```
1   $ declare –i num

2   $ num=hello
    $ echo $num
    0

3   $ num=5 + 5
    bash: +: command not found

4   $ num=5+5
    $ echo $num
    10

5   $ num=4*6
    $ echo $num
    24

6   $ num="4 * 6"
    $ echo $num
    24

7   $ num=6.5
    bash: num: 6.5: sytax error in expression (remainder of
     expression is ".5")
```

EXPLANATION

1. The declare command with the –i option creates an integer variable num.
2. Trying to assign the string hello to the integer variable num causes the string to be stored as zero.
3. The whitespace must be quoted or removed unless the let command is used.
4. The whitespace is removed and arithmetic is performed.
5. Multiplication is performed and the result assigned to num.
6. The whitespace is quoted so that the multiplication can be performed and to keep the shell from expanding the wildcard (*).
7. Because the variable is set to integer, adding a fractional part causes a bash syntax error.

Listing Integers. The declare command with only the –i argument will list all preset integers and their values, as shown in the following display.

```
$ declare –i
declare –ir EUID="15"          # effective user id
declare –ir PPID="235"         # parent process id
declare –ir UID="15"           # user id
```

Representing and Using Different Bases. Numbers can be represented in decimal (base 10, the default), octal (base 8), hexadecimal (base 16), and a range from base 2 to 36.

FORMAT

```
variable=base#number–in–that–base
```

Example 12.7

```
n=2#101   Base is 2; number 101 is in base 2
```

Example 12.8

```
(The Command Line)
1  $ declare –i x=017
   $ echo $x
   15
2  $ x=2#101
   $ echo $x
   5
3  $ x=8#17
   $ echo $x
   15
4  $ x=16#b
   $ echo $x
   11
```

EXPLANATION

1. The declare function is used to assign an integer variable x the octal value 017. Octal numbers must start with a leading zero. 15, the decimal value of 017, is printed.
2. The variable, x, is assigned the value of 101 (binary). 2 represents the base, separated by a #, and the number in that base, 101. The value of x is printed as decimal, 5.
3. The variable x is assigned the value of 17 (octal). The value of x is printed as decimal, 15.
4. The variable x is assigned the value of b (hexadecimal). The value of x is decimal 11.

The let Command. The let command is a bash shell built−in command that is used to perform integer arithmetic and numeric expression testing. To see what let operators your version of bash supports, type at the prompt:

```
help let
```

A list of the operators is also found in Table 12.4.

Example 12.9

```
1   $ i=5  or let i=5

2   $ let i=i+1
    $ echo $i
    6

3   $ let "i = i + 2"
    $ echo $i
    8

4   $ let "i+=1"
    $ echo $i
    9

5   $ i=3

6   $ (( i+=4))
    $ echo $i
    7

7   $ (( i=i−2 ))
    $ echo $i
    5
```

EXPLANATION

1. The variable i is assigned the value 5.
2. The let command will add 1 to the value of i. The $ (dollar sign) is not required for variable substitution when performing arithmetic.
3. The quotes are needed if the arguments contain whitespace.
4. The shortcut operator, +=, is used to add 1 to the value of i.
5. The variable i is assigned the value 5.
6. The double parentheses can be used to replace let.[a]

   4 is added and assigned to i.
7. 2 is subtracted from i. We could have also written i–=2

[a] Double parentheses (( )) are used to replace let on versions of bash 2.x.

12.3.2 Floating Point Arithmetic

Bash supports only integer arithmetic, but the bc, awk, and nawk utilities are useful if you need to perform more complex calculations.

Example 12.10

```
(The Command Line)
1   $ n='echo "scale=3; 13 / 2" | bc'
    $ echo $n
    6.500

2   product='gawk −v x=2.45 −v y=3.123 'BEGIN{printf "%.2f\n",x*y}''
    $ echo $product
    7.65
```

EXPLANATION

1. The output of the echo command is piped to the bc program. The scale is set to 3, which is the number of significant digits to the right of the decimal point that will be printed. The calculation is to divide 13 by 2. The entire pipeline is enclosed in backquotes. Command substitution will be performed and the output assigned to the variable n.
2. The gawk program gets its values from the argument list passed in at the command line, x=2.45 y=3.123. After the numbers are multiplied, the printf function formats and prints the result with a precision of two places to the right of the decimal point. The output is assigned to the variable product.

12.4 Positional Parameters and Command Line Arguments

12.4.1 Positional Parameters

Information can be passed into a script via the command line. Each word (separated by whitespace) following the scriptname is called an argument.

Command line arguments can be referenced in scripts with positional parameters; for example, $1 for the first argument, $2 for the second argument, $3 for the third argument, and so on. After $9, curly braces are used to keep the number as one number. For example, positional parameter 10 is referenced as ${10}. The $# variable is used to test for the number of parameters, and $* is used to display all of them. Positional parameters can be set or reset with the set command. When the set command is used, any positional parameters previously set are cleared out. See Table 12.2.

Table 12.2. Positional Parameters

Positional Parameter	**What It References**
$0	References the name of the script.
$#	Holds the value of the number of positional parameters.
$*	Lists all of the positional parameters.
$@	Means the same as $*, except when enclosed in double quotes.
"$*"	Expands to a single argument (e.g., "$1 $2 $3").
"$@"	Expands to separate arguments (e.g., "$1" "$2" "$3").
$1 … ${10}	References individual positional parameters.

Example 12.11

```
(The Script)
    #!/bin/bash
    # Scriptname: greetings2
    echo "This script is called $0."
1   echo  "$0  $1 and $2"
    echo "The number of positional parameters is $#"
    -----------------------------------------------------------
(The Command Line)
    $ chmod +x greetings2
2   $ greetings2
    This script is called  greetings2.
    greetings  and
    The number of positional paramters is

3   $ greetings2 Tommy
    This script is called greetings2.
    greetings Tommy and
    The number of positional parameters is 1

4   $ greetings2 Tommy Kimberly
```

```
This script is called greetings2.
greetings Tommy and Kimberly
The number of positional parameters is 2
```

EXPLANATION

1. In the script greetings2, positional parameter $0 references the scriptname, $1 the first command line agreement, and $2 the second command line agreement.
2. The greetings2 script is executed without any arguments passed. The output illustrates that the script is called greetings2 ($0 in the script) and that $1 and $2 were never assigned anything; therefore, their values are null and nothing is printed.
3. This time, one argument is passed, Tommy. Tommy is assigned to positional parameter 1.
4. Two arguments are entered, Tommy and Kimberly. Tommy is assigned to $1 and Kimberly is assigned to $2.

12.4.2 The set Command and Positional Parameters

The set command with arguments resets the positional parameters.[3] Once reset, the old parameter list is lost. To unset all of the positional parameters, use set – –. $0 is always the name of the script.

Example 12.12

```
(The Script)
    #!/bin/bash
    # Scriptname: args
    # Script to test command line arguments
1   echo The name of this script is $0.
2   echo The arguments are $*.
3   echo The first argument is $1.
4   echo The second argument is $2.
5   echo The number of arguments is $#.
6   oldargs=$*
7   set Jake Nicky Scott    # Reset the positional parameters
8   echo All the positional parameters are $*.
9   echo The number of postional parameters is $#.
10  echo "Good–bye for now, $1."
11  set $(date)             # Reset the positional parameters
12  echo The date is $2 $3, $6.
13  echo "The value of \$oldargs is $oldargs."
14  set $oldargs
15  echo $1 $2 $3

(The Output)
    $ args a b c d
1   The name of this script is args.
2   The arguments are a b c d.
3   The first argument is a.
4   The second argument is b.
5   The number of arguments is 4.
8   All the positional parameters are Jake Nicky Scott.
9   The number of positional parameters is 3.
10  Good–bye for now, Jake.
12  The date is Mar 25, 2001.
13  The value of $oldargs is a b c d.
15  Wed Mar 25
```

EXPLANATION

1. The name of the script is stored in the $0 variable.
2. $* represents all of the positional parameters.
3. $1 represents the first positional parameter (command line argument).
4. $2 represents the second positional parameter.
5. $# is the total number of positional parameters (command line arguments).
6. All positional parameters are saved in a variable called oldargs.
7. The set command allows you to reset the positional parameters, clearing out the old list. Now, $1 is Jake, $2 is Nicky, and $3 is Scott.
8. $* represents all of the parameters, Jake, Nicky, and Scott.
9. $# represents the number of parameters, 3.
10. $1 is Jake.
11. After command substitution is performed, i.e., date is executed, the positional parameters are reset to the output of the date command.
12. The new values of $2, $3, and $6 are displayed.
13. The values saved in oldargs are printed.
14. The set command creates positional parameters from the values stored in oldargs.
15. The first three positional parameters are displayed.

Example 12.13

```
(The Script)
    #!/bin/bash
    # Scriptname: checker
    # Script to demonstrate the use of special variable
    # modifiers and arguments
1   name=${1:?"requires an argument" }
    echo Hello $name

(The Command Line)
2   $ checker
    checker: 1: requires an argument
3   $ checker Sue
    Hello Sue
```

EXPLANATION

1. The special variable modifier :? will check whether $1 has a value. If not, the script exits and the message is printed.
2. The program is executed without an argument. $1 is not assigned a value; an error is displayed.
3. The checker program is given a command line argument, Sue. In the script, $1 is assigned Sue. The program continues.

How $* and $@ Differ. The $* and $@ differ only when enclosed in double quotes. When $* is enclosed within double quotes, the parameter list becomes a single string. When $@ is enclosed within double quotes, each of the parameters is quoted; that is, each word is treated as a separate string.

Example 12.14

```
1   $ set 'apple pie' pears peaches
2   $ for i in $*
    > do
    > echo $i
```

```
    > done
    apple
    pie
    pears
    peaches

3   $ set 'apple pie' pears peaches
4   $ for i in "$*"
    > do
    > echo $i
    > done
    apple pie pears peaches

5   $ set 'apple pie' pears peaches
6   $ for i in $@
    > do
    > echo $i
    > done
    apple
    pie
    pears
    peaches

7   $ set 'apple pie' pears peaches
8   $ for i in "$@"         # At last!!
    > do
    > echo $i
    > done
    apple pie
    pears
    peaches
```

EXPLANATION

1. The positional parameters are set.
2. When $* is expanded, the quotes surrounding apple pie are stripped; apple and pie become two separate words. The for loop assigns each of the words, in turn, to the variable i, and then prints the value of i. Each time through the loop, the word on the left is shifted off, and the next word is assigned to the variable i.
3. The positional parameters are set.
4. By enclosing $* in double quotes, the entire parameter list becomes one string, apple pie pears peaches. The entire list is assigned to i as a single word. The loop makes one iteration.
5. The positional parameters are set.
6. Unquoted, $@ and $* behave the same way (see entry 2 of this explanation).
7. The positional parameters are set.
8. By surrounding $@ with double quotes, each of the positional parameters is treated as a quoted string. The list would be apple pie, pears, and peaches. The desired result is finally achieved.

12.5 Conditional Constructs and Flow Control

12.5.1 Exit Status

Conditional commands allow you to perform some task(s) based on whether a condition succeeds or fails. The if command is the simplest form of decision−making; the if/else commands allow a two−way decision; and the if/elif/else commands allow a multiway decision.

Bash allows you to test two types of conditions: the success or failure of commands or whether an expression is true or false. In either case, the exit status is always used. An exit status of zero indicates success or true, and an exit status that is nonzero indicates failure or false. The ? status variable contains a numeric value representing the exit status. To refresh your memory on how exit status works, look at Example 12.15.

Example 12.15

```
    (At the Command Line)

1   $ name=Tom
2   $ grep "$name"  /etc/passwd
    Tom:8ZKX2F:5102:40:Tom Savage:/home/tom:/bin/sh
3   $ echo $?
    0             # Success!
4   $ name=Fred
5   $ grep "$name" /etc/passwd
    $ echo $?
    1              # Failure
```

EXPLANATION

1. The variable name is assigned the string Tom.
2. The grep command will search for string Tom in the passwd file.
3. The ? variable contains the exit status of the last command executed; in this case, the exit status of grep. If grep is successful in finding the string Tom, it will return an exit status of zero. The grep command was successful.
4. The variable name is assigned Fred.
5. The grep command searches for Fred in the passwd file and is unable to find him. The ? variable has a value of 1, indicating that grep failed.

12.5.2 The Built−In test Command

To evaluate an expression, the built−in test command is commonly used. This command is also linked to the bracket symbol. Either the test command itself can be used, or the expression can be enclosed in set of single brackets. Shell metacharacter expansion is not performed on expressions evaluated with the simple test command or when square brackets are used. Since word splitting is performed on variables, strings containing whitespace must be quoted. (See Example 12.16.)

On versions of bash 2.x, double brackets [[ ]] (the built−in compound test command) can be used to evaluate expressions. Word splitting is not performed on variables and pattern matching is done, allowing the expansion of metacharacters. A literal string containing whitespace must be quoted and if a string (with or without whitespace) is to be evaluated as an exact string, rather than part of a pattern, it too must be enclosed in quotes. The logical operators && (and) and || (or) replace the –a and –o operators used with the simple test command. (See Example 12.17.)

Although the test command can evaluate arithmetic expressions, you may prefer to use the let command with its rich set of C−like operators (bash 2.x). The let command can be represented alternatively by enclosing its expression in a set of double parentheses. (See Example 12.18.)

Whether you are using the test command, compound command, or let command, the result of an expression is tested, with zero status indicating success and nonzero status indicating failure. (See Table 11.10.)

The following examples illustrate how the exit status is tested with the built−in test command and the alternate form of test, a set of single brackets [ ]; the compound command, a set of double brackets [[ ]]; and the let command, a set of double parentheses (( )).

Example 12.16

```
    (The test Command)
    (At the Command Line)

1   $ name=Tom
2   $ grep "$name" /etc/passwd
3   $ echo $?
4   $ test $name != Tom
5   $ echo $?
    1             # Failure
6   $ [ $name = Tom ]
        # Brackets replace the test command
7   $ echo $?
    0
8   $ [ $name = [Tt]?? ]
    $ echo $?
    1
9   $ x=5
    $ y=20
10  $ [ $x −gt $y ]
    $ echo $?
    1
11  $ [ $x −le $y ]
    $ echo $?
    0
```

EXPLANATION

1. The variable name is assigned the string Tom.
2. The grep command will search for string Tom in the passwd file.
3. The ? variable contains the exit status of the last command executed, in this case, the exit status of grep. If grep is successful in finding the string Tom, it will return an exit status of zero. The grep command was successful.
4. The test command is used to evaluate strings, numbers, and perform file testing. Like all commands, it returns an exit status. If the exit status is zero, the expression is true; if the exit status is one, the expression evaluates to false. There must be spaces surrounding the equal sign. The value of name is tested to see if it is not equal to Tom.
5. The test fails and returns an exit status of one.
6. The brackets are an alternate notation for the test command. There must be spaces after the first bracket. The expression is tested to see if name evaluates to the string Tom. Bash allows either a single or double equal sign to be used to test for equality of strings.
7. The exit status of the test is 0. The test was successful because $name is equal to Tom.
8. The test command does not allow wildcard expansion. Because the question mark is treated as a literal character, the test fails. Tom and [Tt]?? are not equal. The exit status is 1, indicating that the text in line 8 failed.
9. x and y are given numeric values.
10. The test command uses numeric relational operators to test its operands; in this example it tests if $x is greater than (–gt) $y, and returns 0 exit status if true, 1 if false. (See Table 12.3.)

11. Tests if $x less than or equal to (–le) $y, returning 0 exit status if true,1 if false.

Example 12.17

```
(The compound test command)(bash 2.x)
    $ name=Tom; friend=Joseph
1   $ [[ $name == [Tt]om ]]      # Wildcards allowed
    $ echo $?
    0
2   $ [[ $name == [Tt]om && $friend == "Jose" ]]
    $ echo $?
    1
3   $ shopt −s extglob           # Turns on extended pattern matching
4   $ name=Tommy
5   $ [[ $name == [Tt]o+(m)y ]]
    $ echo $?
    0
```

EXPLANATION

1. If using the compound test command, shell metacharacters can be used in string tests. In this example, the expression is tested for string equality where name can match either Tom or tom or tommy, etc. If the expression is true, the exit status (?) is 0.
2. The logical operators && (and) and || (or) can be used with the compound test. If && is used, both expressions must be true, and if the first expression evaluates as false, no further checking is done. With the || logical operator, only one of the expressions must be true. If the first expression evaluates true, no further checking is done. Note that "Jose" is quoted. If not quoted, the friend variable would be checked to see if it contained the pattern Jose. Jose would match, and so would Joseph. The expression evaluates to false because the second condition is not true. The exit status is 1.
3. Extended pattern matching is turned on with the built−in shopt command.
4. The variable is assigned the value Tommy.
5. In this test, the expression is tested for string equality using the new pattern−matching metacharacters. It tests if name matches a string starting with T or t, followed by an o, one or more m characters, and a y.

Example 12.18

```
    (The let Command) (bash 2.x)
    (At the Command Line)
1   $ x=2
    $ y=3

2   (( x > 2 ))
    echo $?
    1

3   (( x < 2 ))
    echo $?
    0

4   (( x == 2 && y == 3 ))
    echo $?
    0

5   (( x > 2 || y < 3 ))
    echo $?
    1
```

EXPLANATION

1. x and y are assigned numeric values.
2. The double parentheses replace the let command to evaluate the numeric expression. If x is greater than y, the exit status is 0. Because the condition is not true, the exit status is 1. The ? variable holds the exit status of the last command executed; i.e., the (( )) command. Note: To evaluate a variable, the dollar sign is not necessary when the variable is enclosed in (( )).
3. The double parentheses evaluate the expression. If x is less than 2, and exit status of 0 is returned; otherwise, 1 is returned.
4. The compound expression is evaluated. The expression is tested as follows: if x is equal to 2 and y is equal to 3 (i.e., both expressions are true), then an exit status of 0 is returned; otherwise, 1 is returned.
5. The compound expression is evaluated. The expression is tested as follows: if x is greater than 2 or y is less than 3 (i.e., one of the expressions is true), then an exit status of 0 is returned; otherwise, 1 is returned.

Table 12.3. The test Command Operators

Test Operator Tests True If String Test [string1 = string2]String1 is equal to String2 (space surrounding = required).[string1==string2](Can be used instead of the single = sign on bash versions 2.x.)[string1 != string2]String1 is not equal to String2 (space surrounding != required).[string]String is not null.[–z string]Length of string is zero.[–n string]Length of string is nonzero.[–l string]Length of string (number of characters).Examples:test –n $word or [–n $word] test tom = sue or [tom = sue]Logical Test [string1 –a string1]Both string1 and string2 are true.[string1 –o string2]Either string1 or string2 is true.[! string1]Not a string1 match.Logical Test (Compound Test)[a] [[pattern1 && pattern2]]Both pattern1 and pattern2 are true.[[pattern1 || pattern2]]Either pattern1 or pattern2 is true.[[! pattern]]Not a pattern match.Integer Test [int1 –eq int2]Int1 is equal to int2.[int1 –ne int2]Int1 is not equal to int2.[int1 –gt int2]Int1 is greater than int2.[int1 –ge int2]Int1 is greater than or equal to int2.[int1 –lt int2]Int1 is less than int2.[int1 –le int2]Int1 is less than or equal to int2.Binary Operators for File Testing [file1 –nt file2]True if file1 is newer than file2 (according to modification date).[file1 –ot file2]True if file1 is older than file2.[file1 –ef file2]True if file1and file2 have the same device or inode numbers.

[a] With the compound test, pattern can contain pattern matching metacharacters; for exact string testing, pattern2 must be enclosed in quotes.

Table 12.4. The let Command Operators

Operator Meaning– +Unary minus and plus.! ~Logical and bitwise not (negation).* / %Multiply, divide, remainder.+ –Add, subtract. let Operators Not Implemented Prior to bash 2.x<< >>Bitwise left shift, right shift.<= >= < >Comparison operators.== !=Equal to and not equal to.&Bitwise and.^Bitwise exclusive or.|Bitwise or.&&Logical and.||Logical or.= *= /= %= += –= <<= >>= &= ^= |=Assignment and shortcut assignment.

12.5.3 The if Command

The simplest form of conditional is the if command. The command (a bash built−in or executable) following the if construct is executed and its exit status is returned. The exit status is usually determined by the programmer who wrote the utility. If the exit status is zero, the command succeeded and the statement(s) after the then keyword are executed. In the C shell, the expression following the if command is a Boolean−type expression as in C. But in the Bash, Bourne, and Korn shells, the statement following the if is a command or group of commands. If the exit status of the command being evaluated is zero, the block of statements after the then is executed until fi is reached. The fi terminates the if block. If the exit status is nonzero, meaning that the command failed in some way, the statement(s) after the then keyword are ignored and control goes to the line directly after the fi statement.

It is important that you know the exit status of the commands being tested. For example, the exit status of grep is reliable in letting you know whether grep found the pattern it was searching for in a file. If grep is successful in its search, it returns a zero exit status; if not, it returns one. The sed and gawk programs also search for patterns, but they will report a successful exit status regardless of whether they find the pattern. The criterion for success with sed and gawk is correct syntax, not functionality.

FORMAT

```
    if command
    then
        command
        command
    fi
------------------------------------

(Using test for numbers and strings -- old format)

    if test expression
    then
        command
    fi
              or

    if [ string/numeric expression ] then
           command
    fi
-------------------------------------

(Using test for strings -- new formst)

    if [[ string expression ]] then
           command
    fi

(Using let for numbers -- new format)

    if (( numeric expression ))

--------------------------------------
```

Example 12.19

```
1   if grep "$name" /etc/passwd > /dev/null 2>&1
2   then
         echo Found $name!
3   fi
```

EXPLANATION

1. The grep command searches for its argument, name, in the /etc/passwd database. Standard output and standard error are redirected to /dev/null, the UNIX bit bucket.
2. If the exit status of the grep command is zero, the program goes to the then statement and executes commands until fi is reached. Indentation of commands between the then and fi keywords is a convention used to make the program more readable, and hence, easier to debug.
3. The fi terminates the list of commands following the then statement.

Example 12.20

```
1   echo  "Are you o.k. (y/n) ?"
    read answer
2   if [ "$answer" = Y −o "$answer" = y ]
    then
        echo  "Glad to hear it."
3   fi

4   if [ $answer = Y −o "$answer" = y ]
    [: too many arguments

    −−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
5   if [[ $answer == [Yy]* || $answer == Maybe ]][a]
    then
        echo  "Glad to hear it."
    fi

6   shopt −s extglob

7   answer="not really"

8   if [[ $answer = [Nn]o?( way|t really) ]]
    then
        echo "So sorry. "
    fi
```

[a] Lines 5 through 8 are only implemented on versions of bash 2.x.

EXPLANATION

1. The user is asked the question and told to respond. The read command waits for a response.
2. The test command, represented by square brackets, is used to test expressions. It returns an exit status of zero if the expression is true and nonzero if the expression is false. If the variable answer evaluates to Y or y, the commands after the then statement are executed. (The test command does not allow the use of wildcards when testing expressions, and spaces must surround the square brackets, as well as the = operators. See Table 12.3.) $answer is double quoted to hold it together as a single string. Otherwise the test command will fail.
3. The fi terminates the if on line 2.
4. The test command fails if more than one word appears before the = operator. For example, if the user entered yes, you betcha, the answer variable would evaluate to three words, causing the test to fail, unless $answer is enclosed in double quotes. The resulting error message is shown here.

5. The compound command operators [[ ]] allow the expansion of shell metacharacters in a string expression. The variable does not need quotes surrounding it, even if it contains more than one word, as it did with the old test command.
6. The shopt built−in, if set to extglob, allows expanded parameter expansion. See Table 11.12.
7. The answer variable is set to the string "not really".
8. Extended pattern matching is used here. The expression reads, if the value of the answer variable matches a string starting with no or No and if followed by zero or one occurrences of the expression in the parentheses, the expression is true. The expression could be evaluated to no, No, no way, No way, not really, or Not really.

The exit Command and the ? Variable. The exit command is used to terminate the script and return to the command line. You may want the script to exit if some condition occurs. The argument given to the exit command is a number ranging from 0 to 255. If the program exits with zero as an argument, the program exited with success. A nonzero argument indicates some kind of failure. The argument given to the exit command is stored in the shell's ? variable.

Example 12.21

```
(The Script)
$ cat bigfiles

    # Name: bigfiles
    # Purpose: Use the find command to find any files in the root
    # partition that have not been modified within the past n (any
    # number within 30 days) days and are larger than 20 blocks
    # (512−byte blocks)
1   if (( $# != 2 ))[a]        # [ $# −ne 2 ]
    then
       echo  "Usage:   $0 mdays size " 1>&2
       exit 1
2   fi
3   if (( $1 <  0 || $1 > 30 ))[b]     # [ $1 −lt 0 −o $1 −gt 30 ]
    then

       echo "mdays is out of range"
       exit 2
4   fi
5   if (( $2 <= 20 ))      # [ $2 −le 20 ]
    then
       echo "size is out of range"
       exit 3
6   fi

7   find / −xdev −mtime $1 −size +$2

(The Command Line)
$ bigfiles
Usage: bigfiles mdays size

$ echo $?
1

$ bigfiles 400 80
mdays is out of range

$ echo $?
2
```

```
$ bigfiles 25 2
size is out of range

$ echo $?
3

$ bigfiles 2 25
(Output of find prints here)
```

[a] Not implemented on versions prior to bash 2.x. On older versions could also be written `if let $(( $# != 2 ))`.

[b] Same as above. On older versions could also be written `if let $(( $1 < 0 || $1 > 30 ))`.

EXPLANATION

1. The statement reads: If the number of arguments is not equal to 2, print the error message and send it to standard error, then exit the script with an exit status of 1. Either the built−in test command or the let command can be used to test numeric expressions.
2. The fi marks the end of the block of statements after then.
3. The statement reads: If the value of the first positional parameter passed in from the command line is less than 0 or greater than 30, then print the message and exit with a status of 2. See Table 12.4 for numeric operators.
4. The fi ends the if block.
5. The statement reads: If the value of the second positional parameter passed in at the command line is less than or equal to 20 (512−byte blocks), then print the message and exit with a status of 3.
6. The fi ends the if block.
7. The find command starts its search in the root directory. The –xdev option prevents find from searching other partitions. The –mtime option takes a number argument, which is the number of days since the file was modified, and the –size option takes a number argument, which is the size of the file in 512−byte blocks.

Checking for Null Values. When checking for null values in a variable, use double quotes to hold the null value or the test command will fail.

Example 12.22

```
(The Script)
1   if [ "$name" = "" ]     # Alternative to  [ ! "$name" ]
                            # or [ −z "$name" ]
    then
       echo The name variable is null
    fi

(From System showmount program, which displays all remotely mounted
systems)
    remotes=$(/usr/sbin/showmount)
2   if [ "X${remotes}" != "X" ]
    then
       /usr/sbin/wall ${remotes}
                    ...
3   fi
```

EXPLANATION

1. If the name variable evaluates to null, the test is true. The double quotes are used to represent null.
2. The showmount command lists all clients remotely mounted from a host machine. The command will list either one or more clients, or nothing. The variable remotes will either have a value assigned or will be null. The letter X precedes the variable remotes when being tested. If remotes evaluates to null, no clients are remotely logged on and X will be equal to X, causing the program to start execution again on line 3. If the variable has a value, for example, the hostname pluto, the expression would read if Xpluto != X, and the wall command would be executed. (All users on remote machines will be sent a message.) The purpose of using X in the expression is to guarantee that even if the value of remotes is null, there will always be a placeholder on either side of the != operator in the expression.
3. The fi terminates the if.

Nested if Commands. When if statements are nested, the fi statement always goes with the nearest if statement. Indenting the nested ifs makes it easier to see which if statement goes with which fi statement.

12.5.4 The if/else Command

The if/else commands allow a two−way decision−making process. If the command after the if fails, the commands after the else are executed.

FORMAT

```
if  command
then
    command(s)
else
    command(s)
fi
```

Example 12.23

```
(The Script)
    #!/bin/bash
    # Scriptname: grepit
1   if grep "$name" /etc/passwd >& /dev/null; then
        echo Found $name!
3   else
4       echo "Can't find $name."
        exit 1
5   fi
```

EXPLANATION

1. The grep command searches for its argument, name, in the NIS passwd database. Because the user does not need to see the output, standard output and standard error are redirected to /dev/null, the UNIX bit bucket.
2. If the exit status of the ypmatch command is zero, program control goes to the then statement and executes commands until else is reached.

3. The commands under the else statement are executed if the ypmatch command fails to find $name in the passwd database; that is, the exit status of ypmatch must be nonzero for the commands in the else block to be executed.
4. If the value in $name is not found in the passwd database, this echo statement is executed and the program exits with a value of 1, indicating failure.
5. The fi terminates the if.

Example 12.24

```
(The Script)
#!/bin/bash
# Scriptname: idcheck
# purpose:check user id to see if user is root.
# Only root has a uid of 0.
# Format for id output:uid=9496(ellie) gid=40 groups=40
# root's uid=0

1   id='id | gawk –F'[=(]'  '{print $2}''      # get user id
    echo your user id is: $id
2   if  (( id == 0 ))[a]   # [ $id –eq 0 ] (See cd file: idcheck2)
    then
3       echo "you are superuser."
4   else
        echo "you are not superuser."
5   fi

    (The Command Line)
6   $ idcheck
    your user id is: 9496
    you are not superuser.
7   $ su
    Password:
8   # idcheck
    your user id is: 0
    you are superuser
```

[a] Not implemented on versions of bash prior to 2.x.

EXPLANATION

1. The id command is piped to the gawk command. Nawk uses an equal sign and open parenthesis as field separators, extracts the user ID from the output, and assigns the output to the variable id.

2,3,4. If the value of id is equal to zero, then line 3 is executed. If id is not equal to zero, the else statements are executed.

5. The fi marks the end of the if command.

6. The idcheck script is executed by the current user, whose UID is 9496.

7. The su command switches the user to root.

8. The # prompt indicates that the superuser (root) is the new user. The UID for root is 0.

12.5.5 The if/elif/else Command

The if/elif/else commands allow a multiway decision−making process. If the command following the if fails, the command following the elif is tested. If that command succeeds, the commands under its then statement are executed. If the command after the elif fails, the next elif command is checked. If none of the commands succeeds, the else commands are executed. The else block is called the default.

FORMAT

```
if  command
then
    command(s)
elif command
then
    commands(s)
elif command
then
    command(s)
else
    command(s)
fi
```

Example 12.25

```
(The Script)
    #!/bin/bash
    # Scriptname: tellme
    # Using the old−style test command

1   echo −n "How old are you? "
    read age
2   if [ $age −lt 0 −o $age −gt 120 ]
    then
       echo  "Welcome to our planet! "
       exit 1
    fi
3   if  [ $age −ge 0 −a $age −le 12 ]
    then
       echo "A child is a garden of verses"
    elif [ $age −ge 12 −a $age −le 19 ]
    then
       echo "Rebel without a cause"
    elif [ $age −ge 20 −a  $age −le 29 ]
    then
       echo "You got the world by the tail!!"
    elif [ $age −ge  30 −a  $age −le 39 ]
    then
       echo "Thirty something..."
4   else
       echo "Sorry I asked"
5   fi


(The Output)
$ tellme
How old are you? 200
Welcome to our planet!

$ tellme
```

```
How old are you? 13
Rebel without a cause

$ tellme
How old are you? 55
Sorry I asked
----------------------------------------------------------
    #!/bin/bash
    # Using the new (( )) compound let command
    # Scriptname: tellme2

1   echo -n "How old are you? "
    read age
2   if (( age < 0 || age > 120 ))
    then
       echo "Welcome to our planet! "
       exit 1
    fi
3   if ((age >= 0 && age <= 12))
    then
       echo "A child is a garden of verses"
    elif ((age >= 13 && age <= 19 ))
    then
       echo "Rebel without a cause"
    elif (( age >= 19 &&  age <=  29 ))
    then
       echo "You got the world by the tail!!"
    elif  (( age >=  30 &&  age <= 39 ))
    then
       echo "Thirty something..."
4   else
       echo "Sorry I asked"
5   fi
```

EXPLANATION

1. The user is asked for input. The input is assigned to the variable age.
2. A numeric test is performed by the test command. If age is less than 0 or greater than 120, the echo command is executed and the program terminates with an exit status of one. The interactive shell prompt will appear.
3. A numeric test is performed by the test command. If age is greater than or equal to 0 and less than or equal to 12, the test command returns exit status zero, true, and the statement after the then is executed. Otherwise, program control goes to the elif. If that test is false, the next elif is tested.
4. The else construct is the default. If none of the above statements are true, the else commands will be executed.
5. The fi terminates the initial if statement.

12.5.6 File Testing

Often when you are writing scripts, your script will require that there are certain files available and that those files have specific permissions, are of a certain type, or have other attributes. You will find file testing a necessary part of writing dependable scripts.

Table 12.5. File Test Operators

Test Operator Tests True If–b filenameBlock special file.–c filenameCharacter special file.–d filenameDirectory existence.–e filenameFile existence.–f filenameRegular file existence and not a directory.–G filenameTrue if file exists and is owned by the effective group ID.–g filenameSet−group−ID is set.–k filenameSticky bit is set.–L filenameFile is a symbolic link.–p filenameFile is a named pipe.–O filenameFile exists and is owned by the effective user ID.–r filenameFile is readable.–S filenameFile is a socket.–s filenameFile is nonzero size.–t fdTrue if fd (file descriptor) is opened on a terminal.–u filenameSet−user−ID bit is set.–w filenameFile is writeable.–x filenameFile is executable.

Example 12.26

```
(The Script)
    #!/bin/bash
    # Using the old style test command
    # filename: perm_check
    file=./testing


1   if [ −d $file ]
    then
       echo "$file is a directory"
2   elif [ −f $file ]
    then
3      if [ −r $file −a −w $file −a −x $file ]
       then     # nested if command
            echo "You have read,write,and execute \
            permission on $file."
4      fi
5   else
       echo "$file is neither a file nor a directory. "
6   fi

−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
    #!/bin/bash
    # Using the new compound operator for test (( ))[a]
    # filename: perm_check2
    file=./testing


1   if [[ −d $file ]]
    then
       echo "$file is a directory"
2   elif [[ −f $file ]]
    then
3      if [[ −r $file && −w $file && −x $file ]]
       then     # nested if command
           echo "You have read,write,and execute \
           permission on $file."
4      fi
5   else
       echo "$file is neither a file nor a directory. "
6   fi
```

[a] New−style test with compound operators not implemented before bash 2.x.

EXPLANATION

1. If the file testing is a directory, print testing is a directory.
2. If the file testing is not a directory, else if the file is a plain file, then…
3. If the file testing is readable and writeable, and executable, then…
4. The fi terminates the innermost if command.
5. The else commands are executed if lines 1 and 2 are not true.
6. This fi goes with the first if.

12.5.7 The null Command

The null command, represented by a colon, is a built−in, do−nothing command that returns an exit status of zero. It is used as a placeholder after an if command when you have nothing to say, but need a command or the program will produce an error message because it requires something after the then statement. Often the null command is used as an argument to the loop command to make the loop a forever loop.

Example 12.27

```
(The Script)
    #!/bin/bash
    # filename: name_grep
1   name=Tom
2   if grep "$name" databasefile >& /dev/null
    then
3      :
4   else
       echo "$1 not found in databasefile"
       exit 1
    fi
```

EXPLANATION

1. The variable name is assigned the string Tom.
2. The if command tests the exit status of the grep command. If Tom is found in the database file, the null command, a colon, is executed and does nothing. Both output and errors are redirected to /dev/null.
3. The colon is the null command. It does nothing other than returning a 0 exit status.
4. What we really want to do is print an error message and exit if Tom is not found. The commands after the else will be executed if the grep command fails.

Example 12.28

```
(The Command Line)
1   $ DATAFILE=
2   $ : ${DATAFILE:=$HOME/db/datafile}
    $ echo $DATAFILE
    /home/jody/ellie/db/datafile
3   $ : ${DATAFILE:=$HOME/junk}
    $ echo $DATAFILE
    /home/jody/ellie/db/datafile
```

EXPLANATION

1. The variable DATAFILE is assigned null.
2. The colon command is a do−nothing command. The modifier (:=) returns a value that can be assigned to a variable or used in a test. In this example, the expression is passed as an argument to the do−nothing command. The shell will perform variable substitution; that is, assign the pathname to DATAFILE if DATAFILE does not already have a value. The variable DATAFILE is permanently set.
3. Because the variable has already been set, it will not be reset with the default value provided on the right of the modifier.

Example 12.29

```
(The Script)
    #!/bin/bash
1   # Scriptname: wholenum
    # Purpose:The expr command tests that the user enters an
    # integer
    #
    echo "Enter an integer."
    read number
2   if expr "$number" + 0 >& /dev/null
    then
3      :
    else
4      echo "You did not enter an integer value."
       exit 1
5   fi
```

EXPLANATION

1. The user is asked to enter an integer. The number is assigned to the variable number.
2. The expr command evaluates the expression. If addition can be performed, the number is a whole number and expr returns a successful exit status. All output is redirected to the bit bucket /dev/null.
3. If expr is successful, it returns a zero exit status, and the colon command does nothing.
4. If the expr command fails, it returns a nonzero exit status, the echo command displays the message, and the program exits.
5. The fi ends the if block.

12.5.8 The case Command

The case command is a multiway branching command used as an alternative to if/elif commands. The value of the case variable is matched against value1, value2, and so forth, until a match is found. When a value matches the case variable, the commands following the value are executed until the double semicolons are reached. Then execution starts after the word esac (case spelled backward).

If the case variable is not matched, the program executes the commands after the *), the default value, until ;; or esac is reached. The *) value functions the same as the else statement in if/else conditionals. The case values allow the use of shell wildcards and the vertical bar (pipe symbol) for oring two values.

FORMAT

```
case variable in
value1)
   command(s)
   ;;
value2)
   command(s)
   ;;
*)
command(s)
   ;;
esac
```

Example 12.30

```
(The Script)
    #!/bin/bash
    # Scriptname: xcolors
1   echo -n "Choose a foreground color for your xterm window: "
    read color
2   case "$color" in
3   [Bb]l??)
4       xterm -fg blue -fn terminal &
5       ;;
6   [Gg]ree*)
        xterm -fg darkgreen -fn terminal &
        ;;
7   red | orange)              # The vertical bar means "or"
        xterm -fg "$color"  -fn terminal &
        ;;
8   *)
        xterm -fn terminal
        ;;
9   esac
10  echo  "Out of case command"
```

EXPLANATION

1. The user is asked for input. The input is assigned to the variable color.
2. The case command evaluates the expression $color.
3. If the color begins with a B or b, followed by the letter l and any two characters, the case expression matches the first value. The value is terminated with a single closed parenthesis. The wildcards are shell metacharacters used for filename expansion.The xterm command sets the foreground color to blue.
4. The statement is executed if the value in line number 3 matches the case expression.
5. The double semicolons are required after the last command in this block of commands. Control branches to line 10 when the semicolons are reached. The script is easier to debug if the semicolons are on their own line.
6. If the case expression matches a G or g, followed by the letters ree and ending in zero or more of any other characters, the xterm command is executed. The double semicolons terminate the block of statements and control branches to line 10.
7. The vertical bar is used as an or conditional operator. If the case expression matches either red or orange, the xterm command is executed.

8. This is the default value. If none of the above values match the case expression, the commands after the *) are executed.
9. The esac statement terminates the case command.
10. After one of the case values are matched, execution continues here.

Creating Menus with the here document and case Command. The here document and case command are often used together. The here document is used to create a menu of choices that will be displayed to the screen. The user will be asked to select one of the menu items, and the case command will test against the set of choices to execute the appropriate command.

Example 12.31

```
(From the .bash_profile File)
    echo "Select a terminal type:  "
1   cat <<− ENDIT
       1) unix
       2) xterm
       3) sun
2   ENDIT
3   read choice
4   case "$choice" in
5   1)  TERM=unix
        export TERM
        ;;
    2)  TERM=xterm
        export TERM
        ;;
6   3)  TERM=sun
        export TERM
        ;;
7   esac
8   echo "TERM is $TERM."

(The Output)
$ . .bash_profile
    Select a terminal type:
    1) unix
    2) xterm
    3) sun
    2                <−− User input
    TERM is xterm.
```

EXPLANATION

1. If this segment of script is put in the .bash_profile, when you log on, you will be given a chance to select the proper terminal type. The here document is used to display a menu of choices.
2. The user−defined ENDIT terminator marks the end of the here document.
3. The read command stores the user input in the variable TERM.
4. The case command evaluates the variable TERM and compares that value with one of the values preceding the closing parenthesis: 1, 2, or *.
5. The first value tested is 1. If there is a match, the terminal is set to a unix. The TERM variable is exported so that subshells will inherit it.
6. A default value is not required. The TERM variable is normally assigned in /etc/profile at login time. If the choice is 3, the terminal is set to a sun.
7. The esac terminates the case command.

8. After the case command has finished, this line is executed.

12.6 Looping Commands

Looping commands are used to execute a command or group of commands a set number of times or until a certain condition is met. The bash shell has three types of loops: the for loop, the while loop, and the until loop.

12.6.1 The for Command

The for looping command is used to execute commands a finite number of times on a list of items. For example, you might use this loop to execute the same commands on a list of files or usernames. The for command is followed by a user−defined variable, the keyword in, and a list of words. The first time in the loop, the first word from the wordlist is assigned to the variable, and then shifted off the list. Once the word is assigned to the variable, the body of the loop is entered, and commands between the do and done keywords are executed. The next time around the loop, the second word is assigned to the variable, and so on. The body of the loop starts at the do keyword and ends at the done keyword. When all of the words in the list have been shifted off, the loop ends and program control continues after the done keyword.

FORMAT

```
for variable in word_list
do
   command(s)
done
```

Example 12.32

```
(The Script)
    #!/bin/bash
    # Scriptname: forloop
1   for pal in Tom Dick Harry Joe
2   do
3       echo "Hi $pal"
4   done
5   echo "Out of loop"

(The Output)
$ forloop
Hi Tom
Hi Dick
Hi Harry
Hi Joe
Out of loop
```

EXPLANATION

1. This for loop will iterate through the list of names, Tom, Dick, Harry, and Joe, shifting each one off (to the left and assigning its value to the user−defined variable, pal) after it is used. As soon as all of the words are shifted and the wordlist is empty, the loop ends and execution starts after the done keyword. The first time in the loop, the variable pal will be assigned the word Tom. The second time through the loop, pal will be assigned Dick, the next time pal will be assigned Harry, and the last time pal will be assigned Joe.

2. The do keyword is required after the wordlist. If it is used on the same line, the list must be terminated with a semicolon. Example:

   ```
   for pal in Tom Dick Harry Joe; do
   ```
3. This is the body of the loop. After Tom is assigned to the variable pal, the commands in the body of the loop (i.e., all commands between the do and done keywords) are executed.
4. The done keyword ends the loop. Once the last word in the list (Joe) has been assigned and shifted off, the loop exits, and execution starts at line 2.
5. Control resumes here when the loop exits.

Example 12.33

```
(The Command Line)
1   $ cat mylist
    tom
    patty
    ann
    jake

(The Script)
    #!/bin/bash
    # Scriptname: mailer
2   for person in $(cat mylist)
    do
3      mail $person < letter
       echo $person was sent a letter.
4   done
5   echo "The letter has been sent."
```

EXPLANATION

1. The contents of a file called mylist are displayed.
2. Command substitution is performed and the contents of mylist becomes the wordlist. The first time in the loop, tom is assigned to the variable person, then it is shifted off to be replaced with patty, and so forth.
3. In the body of the loop, each user is mailed a copy of a file called letter.
4. The done keyword marks the end of this loop iteration.
5. When all of the users in the list have been sent mail and the loop has exited, this line is executed.

Example 12.34

```
(The Script)
    #!/bin/bash
    # Scriptname: backup
    # Purpose: Create backup files and store
    # them in a backup directory.
    #
1   dir=/home/jody/ellie/backupscripts
2   for file in memo[1-5]
    do
3      if [ -f $file ]
       then
            cp $file $dir/$file.bak
            echo "$file is backed up in $dir"
       fi
4   done
```

```
(The Output)
memo1 is backed up in /home/jody/ellie/backupscripts
memo2 is backed up in /home/jody/ellie/backupscripts
memo3 is backed up in /home/jody/ellie/backupscripts
memo4 is backed up in /home/jody/ellie/backupscripts
memo5 is backed up in /home/jody/ellie/backupscripts
```

EXPLANATION

1. The variable dir is assigned the directory where the backup scripts are to be stored.
2. The wordlist will consist of all files in the current working directory with names starting with memo and ending with numbers between 1 and 5. Each filename will be assigned, one at time, to the variable file for each iteration of the loop.
3. When the body of the loop is entered, the file will be tested to make sure it exists and is a real file. If so, it will be copied into the directory /home/jody/ellie/backupscripts with the .bak extension appended to its name.
4. The done marks the end of the loop.

The $* and $@ Variables in Wordlists. When expanded, the $* and $@ are the same unless enclosed in double quotes. $* evaluates to one string, whereas $@ evaluates to a list of separate words.

Example 12.35

```
(The Script)
    #!/bin/bash
    # Scriptname: greet
1   for name in $*        # same as for name in $@
2   do
       echo Hi $name
3   done
(The Command Line)
$ greet Dee Bert Lizzy Tommy
Hi Dee
Hi Bert
Hi Lizzy
Hi Tommy
```

EXPLANATION

1. $* and $@ expand to a list of all the positional parameters, in this case, the arguments passed in from the command line: Dee, Bert, Lizzy, and Tommy. Each name in the list will be assigned, in turn, to the variable name in the for loop.
2. The commands in the body of the loop are executed until the list is empty.
3. The done keyword marks the end of the loop body.

Example 12.36

```
(The Script)
    #!/bin/bash
    # Scriptname: permx

1   for file         # Empty wordlist
    do

2     if [ -f $file -a ! -x $file ] or if [[ -f $file && ! -x $file ]][a]
      then
```

```
3          chmod +x $file
           echo $file now has execute permission
      fi
    done

(The Command Line)
4   $ permx *
    addon now has execute permission
    checkon now has execute permission

    doit now has execute permission
```

[a] Bash 2.x only.

EXPLANATION

1. If the for loop is not provided with a wordlist, it iterates through the positional parameters. This is the same as for file in $*.
2. The filenames are coming in from the command line. The shell expands the asterisk (*) to all filenames in the current working directory. If the file is a plain file and does not have execute permission, line 3 is executed.
3. Execute permission is added for each file being processed.
4. At the command line, the asterisk will be evaluated by the shell as a wildcard and all files in the current directory will be replaced for the *. The files will be passed as arguments to the permx script.

12.6.2 The while Command

The while command evaluates the command following it and, if its exit status is zero, the commands in the body of the loop (commands between do and done) are executed. When the done keyword is reached, control is returned to the top of the loop and the while command checks the exit status of the command again. Until the exit status of the command being evaluated by the while becomes nonzero, the loop continues. When the exit status reaches nonzero, program execution starts after the done keyword.

FORMAT

```
while command
do
   command(s)
done
```

Example 12.37

```
(The Script)
    #!/bin/bash
    # Scriptname: num
1   num=0      # Initialize num
2   while (( $num < 10 ))[a]  # or  while [ num −lt 10 ]
    do
       echo  −n "$num "
3      let num+=1           # Increment num
    done
4   echo −e "\nAfter loop exits, continue running here"

(The Output)
    0 1 2 3 4 5 6 7 8 9
```

```
4   After loop exits, continue running here
```

[a] Versions of bash 2.x use this form.

EXPLANATION

1. This is the initialization step. The variable num is assigned 0.
2. The while command is followed by the let command. The let command evaluates the arithmetic expression, returning an exit status of 0 (true) if the condition is true; i.e., if the value of num is less than 10, the body of the loop is entered.
3. In the body of the loop, the value of num is incremented by one. If the value of num never changes, the loop would iterate infinitely or until the process is killed.
4. After the loop exits, the echo command (with the –e option) prints a newline and the string.

Example 12.38

```
(The Script)
    #!/bin/bash
    # Scriptname: quiz
1   echo "Who was the 2nd U.S. president to be impeached?"
    read answer
2   while [[ "$answer" != "Bill Clinton" ]]
3   do
         echo "Wrong try again!"
4        read answer
5   done
6   echo You got it!

(The Output)
$ quiz
Who was the 2nd U.S. president to be impeached? Ronald Reagan
Wrong try again!
Who was the 2nd U.S. president to be impeached?  I give up
Wrong try again!
Who was the 2nd U.S. president to be impeached?  Bill Clinton
You got it!
```

EXPLANATION

1. The echo command prompts the user, Who was the 2nd U.S. president to be impeached? The read command waits for input from the user. The input will be stored in the variable answer.
2. The while loop is entered and the test command, the bracket, tests the expression. If the variable answer does not exactly equal the string Bill Clinton, the body of the loop is entered and commands between the do and done are executed.
3. The do keyword is the start of the loop body.
4. The user is asked to re−enter input.
5. The done keyword marks the end of the loop body. Control is returned to the top of the while loop, and the expression is tested again. As long as answer does not evaluate to Bill Clinton, the loop will continue to iterate. When the user enters Bill Clinton, the loop ends. Program control goes to line 6.
6. When the body of the loop ends, control starts here.

Example 12.39

```
(The Script)
$ cat sayit
    #!/bin/bash
    # Scriptname: sayit
    echo  Type q to quit.
    go=start
1   while [ -n "$go" ]   # Make sure to double quote the variable
    do
2      echo -n I love you.
3      read word
4      if [[ $word == [Qq] ]]
       then         # [ "$word" = q -o "$word" = Q ]  Old style
           echo "I'll always love you!"
           go=
       fi
    done

(The Output)
$ sayit
Type q to quit.
I love you.         <-- When user presses Enter, the program continues
I love you.
I love you
I love you.
I love you.q
I'll always love you!
$
```

1. The command after the while is executed and its exit status tested. The –n option to the test command tests for a non−null string. Because go initially has a value, the test is successful, producing a zero exit status. If the variable go is not enclosed in double quotes and the variable is null, the test command would complain

   ```
   go: test: argument expected
   ```
2. The loop is entered. The string I love you is echoed to the screen.
3. The read command waits for user input.
4. The expresson is tested. If the user enters a q or Q, the string I'll always love you! is displayed, and the variable go is set to null. When the while loop is re−entered, the test is unsuccessful because the variable is null. The loop terminates. Control goes to the line after the done statement. In this example, the script will terminate because there are no more lines to execute.

12.6.3 The until Command

The until command is used like the while command, but executes the loop statements only if the command after until fails, i.e., if the command returns an exit status of nonzero. When the done keyword is reached, control is returned to the top of the loop and the until command checks the exit status of the command again. Until the exit status of the command being evaluated by until becomes zero, the loop continues. When the exit status reaches zero, the loop exits, and program execution starts after the done keyword.

FORMAT

```
until command
do
   command(s)
done
```

Example 12.40

```
    #!/bin/bash
1   until who | grep linda
2   do
       sleep 5
3   done
    talk linda@dragonwings
```

EXPLANATION

1. The until loop tests the exit status of the last command in the pipeline, grep. The who command lists who is logged on this machine and pipes its output to grep. The grep command will return a zero exit status (success) only when it finds user linda.
2. If user linda has not logged on, the body of the loop is entered and the program sleeps for five seconds.
3. When linda logs on, the exit status of the grep command will be zero and control will go to the statements following the done keyword.

Example 12.41

```
(The Script)
$ cat hour
    #!/bin/bash
    # Scriptname: hour
1   let hour=0
2   until (( hour > 24 ))[a] # or [ $hour -gt 24 ]
    do
3      case "$hour" in
       [0-9]|1[0-1])   echo "Good morning!"
            ;;
       12) echo "Lunch time."

           ;;
       1[3-7]) echo "Siesta time."
           ;;
       *)  echo "Good night."
           ;;
       esac
4      let hour+=1    # Don't forget to increment the hour
5   done

(The Output)
$ hour
Good morning!
Good morning
    ...
Lunch time.
Siesta time.
    ...
Good night.
```

...

[a] Versions of bash 2.x use this form.

EXPLANATION

1. The variable hour is initialized to 0.
2. The let command tests the arithmetic expression to test for an hour greater than or equal to 24. If the hour is not greater than or equal to 24, the body of the loop is entered. The until loop is entered if the command following it returns a nonzero exit status. Until the condition is true, the loop continues to iterate.
3. The case command evaluates the hour variable and tests each of the case statements for a match.
4. The hour variable is incremented with the let command before control returns to the top of the loop.
5. The done command marks the end of the loop body.

12.6.4 The select Command and Menus

The here document is an easy method for creating menus, but bash introduces another looping mechanism, called the select loop, used primarily for creating menus. A menu of numerically listed items is displayed to standard error. The PS3 prompt is used to prompt the user for input; by default, PS3 is #?. After the PS3 prompt is displayed, the shell waits for user input. The input should be one of the numbers in the menu list. The input is stored in the special shell REPLY variable. The number in the REPLY variable is associated with the string to the right of the parentheses in the list of selections.

The case command is used with the select command to allow the user to make a selection from the menu and, based on that selection, execute commands. The LINES and COLUMNS variables can be used to determine the layout of the menu items displayed on the terminal. (These variables are built in to versions of bash 2.x, but are not built in to earlier versions; if they have not been defined, you can define and export them in the .bash_profile.) The output is displayed to standard error, each item preceded by a number and closing parenthesis, and the PS3 prompt is displayed at the bottom of the menu. Because the select command is a looping command, it is important to remember to use either the break command to get out of the loop, or the exit command to exit the script.

FORMAT

```
select var in wordlist
do
   command(s)
done
```

Example 12.42

```
(The Script)
    #!/bin/bash
    # Scriptname: runit
1   PS3="Select a program to execute: "
2   select program  in 'ls -F' pwd date
3   do
4       $program
5   done
```

```
(The Command Line)
Select a program to execute: 2
1) ls −F
2) pwd
3) date
/home/ellie
Select a program to execute: 1
1) ls −F
2) pwd
3) date
12abcrty abc12  doit* progs/  xyz
Select a program to execute: 3
1) ls −F
2) pwd
3) date
Sun Mar 12 13:28:25 PST 2001
```

EXPLANATION

1. The PS3 prompt is assigned the string that will appear below the menu that the select loop displays. This prompt is $# by default and is sent to standard error, the screen.
2. The select loop consists of a variable called program and the three−word list that will be displayed in the menu: ls –F, pwd, and date. The words in this list are UNIX commands, but they could be any words, e.g., red, green, yellow, or cheese, bread, milk, crackers. If the word has a space, it must be quoted; e.g., 'ls –F'
3. The do keyword starts the body of the select loop.
4. When the user selects numbers in the menu, that number will be equated with the word value to the right of the number after the parentheses. For example, if he selects number 2, that is associated with pwd and pwd is stored in the program variable. $program evaluates to the executable command, pwd; the command is executed.
5. The done keyword marks the end of the body of statements in the select loop. Control will return to the top of the loop. This loop will continue to execute until the user presses ^C.

Example 12.43

```
(The Script)
    #!/bin/bash
    # Scriptname name: goodboys
1   PS3="Please choose one of the three boys : "
2   select choice in tom dan guy
3   do
4      case $choice in
       tom)
          echo Tom is a cool dude!
5         break;;           # break out of the select loop
6      dan | guy )
          echo Dan and Guy are both wonderful.
          break;;
       *)
7         echo "$REPLY is not one of your choices" 1>&2
          echo "Try again."
          ;;
8      esac
9   done

(The Command Line)
$ goodboys
1) tom
2) dan
```

```
3) guy
Please choose one of the three boys : 2
Dan and Guy are both wonderful.

$ goodboys
1) tom
2) dan
3) guy
Please choose one of the three boys : 4
4 is not one of your choices
Try again.
Please choose one of the three boys : 1
Tom is a cool dude!
$
```

EXPLANATION

1. The PS3 prompt will be printed above the menu created by the select loop on line 2.
2. The select loop is entered. It causes the words in its list to be displayed as a numbered menu.
3. The loop body starts here.
4. The variable choice is assigned the first value on the list, after which the value is shifted off the list and the next item will be first.
5. The break statement sends loop control after line 9.
6. If either dan or guy are selected, the following echo command is executed, followed by the break command, sending control after line 9.
7. The built−in REPLY variable contains the number of the current list item; i.e., 1, 2, or 3.
8. This marks the end of the case command.
9. The done marks the end of the select loop.

Example 12.44

```
(The Script)
    #!/bin/bash
    # Scriptname: ttype
    # Purpose: set the terminal type
    # Author: Andy Admin
1   COLUMNS=60
2   LINES=1
3   PS3="Please enter the terminal type: "
4   select choice in wyse50 vt200 xterm sun
    do
5      case $REPLY in
       1)
6          export TERM=$choice
           echo "TERM=$choice"
           break;;            # break out of the select loop
       2 | 3 )
           export TERM=$choice

           echo "TERM=$choice"
           break;;
       4)
           export TERM=$choice
           echo "TERM=$choice"
           break;;
       *)
7          echo −e "$REPLY is not a valid choice. Try again\n" 1>&2
8          REPLY=    # Causes the menu to be redisplayed
```

```
              ;;
       esac
9   done
(The Command Line)
$ ttype
1) wyse50    2) vt200   3) xterm    4) sun
Please enter the terminal type : 4
TERM=sun

$ ttype
1) wyse50    2) vt200   3) xterm    4) sun
Please enter the terminal type : 3
TERM=xterm

$ ttype
1) wyse50    2) vt200   3) xterm    4) sun
Please enter the terminal type : 7
7 is not a valid choice. Try again.

1) wyse50    2) vt200   3) xterm    4) sun
Please enter the terminal type: 2
TERM=vt200
```

EXPLANATION

1. The COLUMNS variable is set to the width of the terminal display in columns for menus created with the select loop. The default is 80.
2. The LINES variable controls the vertical display of the select menu on the terminal. The default is 24 lines. When you change the LINES value to 1, the menu items will be printed on one line, instead of vertically as in the last example.
3. The PS3 prompt is set and will appear under the menu choices.
4. The select loop will print a menu with four selections: wyse50, vt200, xterm, and sun. The variable choice will be assigned one of these values based on the user's response held in the REPLY variable. If REPLY is 1, wyse50 is assigned to choice; if REPLY is 2, vt200 is assigned to choice; if REPLY is 3, xterm is assigned to choice; and if REPLY is 4, sun is assigned to choice.
5. The REPLY variable evaluates to the user's input selection.
6. The terminal type is assigned, exported, and printed.
7. If the user does not enter a number between 1 and 4, he or she will be prompted again. Note that the menu does not appear, just the PS3 prompt.
8. If the REPLY variable is set to null, e.g., REPLY=, the menu will be redisplayed.
9. The end of the select loop.

12.6.5 Loop Control

If some condition occurs, you may want to break out of a loop, return to the top of the loop, or provide a way to stop an infinite loop. The bash shell provides loop control commands to handle these kinds of situations.

The shift Command. The shift command shifts the parameter list to the left a specified number of times. The shift command without an argument shifts the parameter list once to the left. Once the list is shifted, the parameter is removed permanently. Often, the shift command is used in a while loop when iterating through a list of positional parameters.

FORMAT

```
shift [n]
```

Example 12.45

```
(Without a Loop)
(The Script)
    #!/bin/bash
    # Scriptname: shifter
1   set joe mary tom sam
2   shift
3   echo $*
4   set $(date)
5   echo  $*
6   shift 5
7   echo  $*
8   shift 2

(The Output)
3   mary tom sam
5   Thu Mar 16 10:00:12 PST 2001
7   2001
8   shift: shift count must be <= $#
```

EXPLANATION

1. The set command sets the positional parameters. $1 is assigned joe, $2 is assigned mary, $3 is assigned tom, and $4 is assigned sam. $* represents all of the parameters.
2. The shift command shifts the positional parameters to the left; joe is shifted off.
3. The parameter list is printed after the shift.
4. The set command resets the positional parameters to the output of the UNIX date command.
5. The new parameter list is printed.
6. This time the list is shifted 5 times to the left.
7. The new parameter list is printed.
8. By attempting to shift more times than there are parameters, the shell sends a message to standard error stating that the shift command cannot shift more off more parameters that it has. $# is the total number of positional parameters. On versions of bash 2.x, no error message occurs.

Example 12.46

```
(With a Loop)
(The Script)
    #!/bin/bash
    # Name: doit
    # Purpose: shift through command line arguments
    # Usage: doit [args]
1    while (( $# > 0 ))[a]  # or [ $# -gt 0 ]
     do
2       echo  $*
3       shift
4    done

(The Command Line)
$ doit a b c d e
```

```
a b c d e
b c d e
c d e
d e
e
```

[a] Not implemented of versions of bash prior to 2.x.

EXPLANATION

1. The let command tests the numeric expression. If the number of positional parameters ($#) is greater than 0, the body of the loop is entered. The positional parameters are coming from the command line as arguments. There are five.
2. All positional parameters are printed.
3. The parameter list is shifted once to the left.
4. The body of the loop ends here; control returns to the top of the loop. Each time the loop is entered, the shift command causes the parameter list to be decreased by one. After the first shift, $# (number of positional parameters) is four. When $# has been decreased to zero, the loop ends.

Example 12.47

```
(The Script)
    #!/bin/bash
    # Scriptname: dater
    # Purpose: set positional parameters with the set command
    # and shift through the parameters.

1   set $(date)
2   while (( $# > 0 )) # or  [ $# -gt 0 ]  Old style
    do
3       echo $1
4       shift
    done

(The Output)
$ dater
Wed
Mar
15
19:25:00
PST
2001
```

EXPLANATION

1. The set command takes the output of the date command and assigns the output to positional parameters $1 through $6.
2. The while command tests whether the number of positional parameters ($#) is greater than 0. If true, the body of the loop is entered.
3. The echo command displays the value of $1, the first positional parameter.
4. The shift command shifts the parameter list once to the left. Each time through the loop, the list is shifted until the list is empty. At that time, $# will be zero and the loop terminates.

The break Command. The built−in break command is used to force immediate exit from a loop, but not from a program. (To leave a program, the exit command is used.) After the break command is executed, control starts after the done keyword. The break command causes an exit from the innermost loop, so if you have nested loops, the break command takes a number as an argument, allowing you to break out of a specific outer loop. If you are nested in three loops, the outermost loop is loop number 3, the next nested loop is loop number 2, and the innermost nested loop is loop number 1. The break is useful for exiting from an infinite loop.

FORMAT

```
break [n]
```

Example 12.48

```
    #!/bin/bash
    # Scriptname: loopbreak
1   while true; do
2       echo Are you ready to move on\?
        read answer
3       if [[  "$answer"  ==  [Yy] ]]
        then
4            break
5       else
             ....commands...
        fi
6   done
7   print "Here we are"
```

EXPLANATION

1. The true command is a UNIX command that always exits with zero status. It is often used to start an infinite loop. It is okay to put the do statement on the same line as the while command, as long as a semicolon separates them. The body of the loop is entered.
2. The user is asked for input. The user's input is assigned to the variable answer.
3. If $answer evaluates to Y or y, control goes to line 4.
4. The break command is executed, the loop is exited, and control goes to line 7. The line Here we are is printed. Until the user answers with a Y or y, the program will continue to ask for input. This could go on forever!
5. If the test fails in line 3, the else commands are executed. When the body of the loop ends at the done keyword, control starts again at the top of the while at line 1.
6. This is the end of the loop body.
7. Control starts here after the break command is executed.

The continue Command. The continue command returns control to the top of the loop if some condition becomes true. All commands below the continue will be ignored. If nested within a number of loops, the continue command returns control to the innermost loop. If a number is given as its argument, control can then be started at the top of any loop. If you are nested in three loops, the outermost loop is loop number 3, the next nested loop is loop number 2, and the innermost nested loop is loop number 1.[4]

FORMAT

```
continue [n]
```

Example 12.49

```
(The mailing List)
    $ cat mail_list
    ernie
    john
    richard
    melanie
    greg
    robin

(The Script)
    #!/bin/bash
    # Scriptname: mailem
    # Purpose: To send a list
1   for name in $(cat  mail_list)
    do
2       if [[ $name == richard ]] ; then
3            continue
        else
4            mail $name < memo
        fi
5   done
```

EXPLANATION

1. After command substitution, $(cat mail_list) or `'cat mail_list'`, the for loop will iterate through the list of names from the file called mail_list.
2. If the name matches richard, the continue command is executed and control goes back to top of the loop where the loop expression is evaluated. Because richard has already been shifted off the list, the next user, melanie, will be assigned to the variable name. Old style: if ["$name" = richard] ; then
3. The continue command returns control to the top of the loop, skipping any commands in the rest of the loop body.
4. All users in the list, except richard, will be mailed a copy of the file memo.
5. This is the end of the loop body.

Nested Loops and Loop Control. When you are using nested loops, the break and continue commands can be given a numeric, integer argument so that control can go from the inner loop to an outer loop.

Example 12.50

```
(The Script)
    #!/bin/bash
    # Scriptname: months
1   for month in Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
    do
2       for week in  1 2 3 4
        do
            echo -n "Processing the month of $month. OK? "
            read ans
3           if [ "$ans" = n  -o -z "$ans" ]
            then
4               continue 2
            else
                echo -n "Process week $week of $month? "
                read ans
                if [ "$ans" = n -o -z "$ans"  ]
                then
5                   continue
                else
                    echo "Now processing week $week of $month."
                    sleep 1
                        # Commands go here
                    echo  "Done processing..."
                fi
            fi
6       done
7   done

(The Output)
$ months
Processing the month of Jan. OK?
Processing the month of Feb. OK? y
Process week 1 of Feb? y
Now processing  week 1 of Feb.
Done processing...
Processing the month of Feb. OK? y
Process week 2 of Feb? y
Now processing week 2 of Feb.
Done processing...
Processing the month of Feb. OK? n
Processing the month of Mar. OK? n
Processing the month of Apr. OK? n
Processing the month of May. OK? n
```

EXPLANATION

1. The outer for loop is started. The first time in the loop, Jan is assigned to month.
2. The inner for loop starts. The first time in this loop, 1 is assigned to week. The inner loop iterates completely before going back to the outer loop.
3. If the user enters either an n or presses Enter, line 4 is executed.
4. The continue command with an argument of 2 starts control at the top of the second outermost loop. The continue without an argument returns control to the top of the innermost loop.
5. Control is returned to the innermost for loop.
6. This done terminates the innermost loop.
7. This done terminates the outermost loop.

12.6.6 I/O Redirection and Subshells

Input can be piped or redirected to a loop from a file. Output can also be piped or redirected to a file from a loop. The shell starts a subshell to handle I/O redirection and pipes. Any variables defined within the loop will not be known to the rest of the script when the loop terminates.

Redirecting the Output of the Loop to a File. Output from a bash loop can be sent to a file rather than to the screen. See Example 12.51.

Example 12.51

```
(The Command Line)
1   $ cat memo
    abc
    def
    ghi

(The Script)
    #!/bin/bash
    # Program name: numberit
    # Put line numbers on all lines of memo
2   if let $(( $# <  1 ))
    then
3       echo "Usage: $0 filename " >&2
        exit 1
    fi
4   count=1                      # Initialize count
5   cat $1 | while read line
    # Input is coming from file provided at command line
    do
6      let $((count == 1)) && echo "Processing file $1..." > /dev/tty
7      echo -e "$count\t$line"
8      let count+=1
9   done > tmp$$              # Output is going to a temporary file
10  mv tmp$$ $1

(The Command Line)
11  $ numberit memo
    Processing file memo...

12  $ cat memo
    1   abc
    2   def
    3   ghi
```

EXPLANATION

1. The contents of file memo are displayed.
2. If the user did not provide a command line argument when running this script, the number of arguments ($#) will be less than one and the error message appears.
3. The usage message is sent to stderr (>&2) if the number of arguments is less than 1.
4. The count variable is assigned the value 1.
5. The UNIX cat command displays the contents of the filename stored in $1, and the output is piped to the while loop. The read command is assigned the first line of the file the first time in the loop, the second line of the file the next time through the loop, and so forth. The read command returns a zero exit status if it is successful in reading input and one if it fails.
6. If the value of count is 1, the echo command is executed and its output is sent to /dev/tty, the screen.
7. The echo command prints the value of count, followed by the line in the file.

8. The count is incremented by one.
9. The output of this entire loop, each line of the file in $1, is redirected to the file tmp$$, with the exception of the first line of the file, which is redirected to the terminal, /dev/tty.[a]
10. The tmp file is renamed to the filename assigned to $1.
11. The program is executed. The file to be processed is called memo.
12. The file memo is displayed after the script has finished, demonstrating that line numbers have been prepended to each line.

[a] $$ expands to the PID number of the current shell. By appending this number to the filename, the filename is made unique.

Piping the Output of a Loop to a UNIX Command. Output can be either piped to another command(s) or redirected to a file.

Example 12.52

```
(The Script)
    #!/bin/bash
1   for i in 7 9 2 3 4  5
2   do
       echo  $i
3   done | sort –n

(The Output)
2
3
4
5
7
9
```

EXPLANATION

1. The for loop iterates through a list of unsorted numbers.
2. In the body of the loop, the numbers are printed. This output will be piped into the UNIX sort command, a numerical sort.
3. The pipe is created after the done keyword. The loop is run in a subshell.

Running Loops in the Background. Loops can be executed to run in the background. The program can continue without waiting for the loop to finish processing.

Example 12.53

```
(The Script)
    #!/bin/bash
1   for person in bob jim joe sam
    do
2       mail $person < memo
3   done &
```

EXPLANATION

1. The for loop shifts through each of the names in the wordlist: bob, jim, joe, and sam. Each of the names is assigned to the variable person, in turn.

2. In the body of the loop, each person is sent the contents of the memo file.
3. The ampersand at the end of the done keyword causes the loop to be executed in the background. The program will continue to run while the loop is executing.

12.6.7 IFS and Loops

The shell's internal field separator (IFS) evaluates to spaces, tabs, and the newline character. It is used as a word (token) separator for commands that parse lists of words, such as read, set, and for. It can be reset by the user if a different separator will be used in a list. Before changing its value, it is a good idea to save the original value of the IFS in another variable. Then it is easy to return to its default value, if needed.

Example 12.54

```
(The Script )
$ cat runit2
    #/bin/bash
    # Script is called runit.
    # IFS is the internal field separator and defaults to
    # spaces, tabs, and newlines.
    # In this script it is changed to a colon.
1   names=Tom:Dick:Harry:John
2   oldifs="$IFS"           # Save the original value of IFS
3   IFS=":"
4   for persons in $names
    do
5       echo  Hi $persons
    done
6   IFS="$oldifs"            # Reset the IFS to old value
7   set Jill Jane Jolene     # Set positional parameters
8   for girl in $*
    do
9       echo Howdy $girl
    done

(The Output)
    $ runit2
5   Hi Tom
    Hi Dick
    Hi Harry
    Hi John
9   Howdy Jill
    Howdy Jane
    Howdy Jolene
```

EXPLANATION

1. The names variable is set to the string Tom:Dick:Harry:John. Each of the words is separated by a colon.
2. The value of IFS, whitespace, is assigned to another variable, oldifs. Since the value of the IFS is whitespace, it must be quoted to preserve it.
3. The IFS is assigned a colon. Now the colon is used to separate words.
4. After variable substitution, the for loop will iterate through each of the names, using the colon as the internal field separator between the words.
5. Each of the names in the wordlist are displayed.
6. The IFS is reassigned its original value stored in oldifs.
7. The positional parameters are set. $1 is assigned Jill, $2 is assigned Jane, and $3 is

assigned Jolene.
8. $* evaluates to all the positional parameters, Jill, Jane, and Jolene. The for loop assigns each of the names to the girl variable, in turn, through each iteration of the loop.
9. Each of the names in the parameter list is displayed.

12.7 Functions

Functions were introduced to the Bourne shell in AT&T's UNIX SystemVR2 and have been enhanced in the Bourne Again shell. A function is a name for a command or group of commands. Functions are used to modularize your program and make it more efficient. They are executed in context of the current shell. In other words, a child process is not spawned as it is when running an executable program such as ls. You may even store functions in another file and load them into your script when you are ready to use them.

Here is a review of some of the important rules about using functions.

1. The shell determines whether you are using an alias, a function, a built−in command, or an executable program (or script) found on the disk. It looks for aliases first, then functions, built−in commands, and last, executables.
2. A function must be defined before it is used.
3. The function runs in the current environment; it shares variables with the script that invoked it, and lets you pass arguments by assigning them as positional parameters. Local variables can be created within a function by using the local function.
4. If you use the exit command in a function, you exit the entire script. If you exit the function, you return to where the script left off when the function was invoked.
5. The return statement in a function returns the exit status of the last command executed within the function or the value of the argument given.
6. Functions can be exported to subshells with the export –f built−in command.
7. To list functions and definitions, use the declare –f command. To list just function names, use declare –F.[5]
8. Traps, like variables, are global within functions. They are shared by both the script and the functions invoked in the script. If a trap is defined in a function, it is also shared by the script. This could have unwanted side effects.
9. If functions are stored in another file, they can be loaded into the current script with the source or dot command.
10. Functions can be recursive; i.e., they can call themselves. There is no limit imposed for the number of recursive calls.

FORMAT

```
function function_name { commands ; commands; }
```

Example 12.55

```
function dir { echo "Directories: ";ls −l|awk '/^d/ {print $NF}'; }
```

EXPLANATION

The keyword function is followed by the name of the function dir. (Sometimes empty parentheses follow the function name, but they are not necessary.) The commands within the curly braces will be executed when dir is typed. The purpose of the function is to list only the subdirectories below the present working directory. The spaces surrounding the first curly brace are required.

To Unset a Function. To remove a function from memory, use the unset command.

FORMAT

```
unset −f function_name
```

Exporting Functions. Functions may be exported so that subshells know about them.

FORMAT

```
export −f function_name
```

12.7.1 Function Arguments and the Return Value

Because the function is executed within the current shell, the variables will be known to both the function and the shell. Any changes made to your environment in the function will also be made to the shell.

Arguments. Arguments can be passed to functions by using positional parameters. The positional parameters are private to the function; that is, arguments to the function will not affect any positional parameters used outside the function. See Example 12.56.

The Built−In local Function. To create local variables that are private to the function and will disappear after the function exits, use the built−in local function. See Example 12.57.

The Built−In return Function. The return command can be used to exit the function and return control to the program at the place where the function was invoked. (Remember, if you use exit anywhere in your script, including within a function, the script terminates.) The return value of a function is really just the value of the exit status of the last command in the script, unless you give a specific argument to the return command. If a value is assigned to the return command, that value is stored in the ? variable and can hold an integer value between zero and 256. Because the return command is limited to returning only an integer between zero and 256, you can use command substitution to capture the output of a function. Place the entire function in parentheses preceded by a $, e.g., $(function_name), or traditional backquotes to capture and assign the output to a variable just as you would if getting the output of a UNIX command.

Example 12.56

```
(Passing Arguments)
(The Script)
    #!/bin/bash
    # Scriptname: checker
    # Purpose: Demonstrate function and arguments

1   function Usage { echo "error: $*" 2>&1; exit 1; }

2   if (( $# != 2 ))
    then
3       Usage "$0: requires two arguments"
    fi
4   if [[ ! ( −r $1 && −w $1 ) ]]
    then
5       Usage "$1: not readable and writeable"
    fi
```

```
6   echo The arguments are: $*
 <  Program continues here >


(Output)
$ checker
error: checker: requires two arguments

$ checker file1 file2
error: file1: not readable and writeable

$ checker filex file2
The arguments are filex file2
```

EXPLANATION

1. The function called Usage is defined. It will be used to send an error message to standard error (the screen). Its arguments consist of any string of characters sent when the function is called. The arguments are stored in $*, the special variable that contains all positional parameters. Within a function, positional parameters are local and have no effect on those positional parameters used outside the function.

2. If the number of arguments begin passed into the script from the command line does not equal 2, the program branches to line 3.

3. When the Usage function is called, the string $0: requires two arguments is passed to the function and stored in the $* varable. The echo statement will then send the message to standard error and the script will exit with an exit status of 1 to indicate that something went wrong.[a]

4,5. If the first argument coming into the program from the command line is not the name of a readable and writeable file, the Usage function will be called with $1: not readable and writeable as its argument.

6. The arguments coming into the script from the command line are stored in $*. This has no effect on the $* in the function.

[a] With the old test form, the expression is written `if [ ! \( -r $1 -a -w $1 \) ]`.

Example 12.57

```
(Using the return Command)
(The Script)
$ cat do_increment
    #!/bin/bash
    # Scriptname: do_increment
    increment ()  {
       local sum;     # sum is known only in this function
       let "sum=$1 + 1"
       return $sum    # Return the value of sum to the script.
    }
    echo  -n "The sum is "
    increment 5    # Call function increment; pass 5 as a
```

```
                  # parameter. 5 becomes $1 for the increment
                  # function.
7   echo $?       # The return value is stored in $?
8   echo  $sum    # The variable "sum" is not known here

(The Output)
    $ do_increment
4,6 The sum is 6
8
```

EXPLANATION

1. The function called increment is defined.
2. The built−in local function makes variable sum local (private) to this function. It will not exist outside the function. When the function exits, it will be removed.
3. When the function is called, the value of the first argument, $1, will be incremented by one and the result assigned to sum.
4. The return built−in command, when given an argument, returns to the main script after the line where the function was invoked. It stores its argument in the ? variable.
5. The string is echoed to the screen.
6. The increment function is called with an argument of 5.
7. When the function returns, its exit status is stored in the ? variable. The exit status is the exit value of the last command executed in the function unless an explicit argument is used in the return statement. The argument for return must be an integer between 0 and 255.
8. Although the sum was defined in the function increment, it is local in scope, and therefore also not known outside the function. Nothing is printed.

Example 12.58

```
(Using Command Substitution)
(The Script)
$ cat do_square
    #!/bin/bash
    # Scriptname: do_square
1   function square {
      local sq     # sq is local to the function
      let "sq=$1 * $1"
      echo "Number to be squared is $1."
2     echo "The result is $sq "
    }
3   echo "Give me a number to square. "
    read number
4   value_returned=$(square $number) # Command substitution
5   echo   "$value_returned"

(The Output)
    $ do_square
3   Give me a number to square.
    10
5   Number to be squared is 10.
    The result is 100
```

EXPLANATION

1. The function called square is defined. Its purpose, when called, is to multiply its argument, $1, times itself.
2. The result of squaring the number is printed.
3. The user is asked for input. This is the line where the program starts executing.
4. The function square is called with a number (input from the user) as its argument. Command substitution is performed because the function is enclosed in parentheses preceded by a $. The output of the function, both of its echo statements, is assigned to the variable value_returned.
5. The value returned from the command substitution is printed.

12.7.2 Functions and the source (or dot) Command

Storing Functions. Functions are often defined in the .profile file so that when you log in, they will be defined. Functions can be exported, and they can be stored in a file. Then when you need the function, the source or dot command is used with the name of the file to activate the definitions of the functions within it.

Example 12.59

```
1   $ cat myfunctions
2   function go() {
       cd $HOME/bin/prog
       PS1=''pwd' > '
       ls
    }
3   function greetings() { echo "Hi $1! Welcome to my world." ; }

4   $ source myfunctions
5   $ greetings george
    Hi george! Welcome to my world.
```

EXPLANATION

1. The file myfunctions is displayed. It contains two function definitions.
2. The first function defined is called go. It sets the primary prompt to the present working directory.
3. The second function defined is called greetings. It will greet the name of the user passed in as an argument.
4. The source or dot command loads the contents of the file myfunctions into the shell's memory. Now both functions are defined for this shell.
5. The greetings function is invoked and executed.

Example 12.60

```
(The dbfunctions file shown below contains functions to be used by the
main program.  See cd for complete script.)
1   $ cat dbfunctions
2   function addon () {    # Function defined in file dbfunctions
3      while true
       do
          echo "Adding information "
          echo "Type the full name of employee "
          read name
          echo "Type address for employee "
          read address
```

```
          echo "Type start date for employee (4/10/88 ) :"
          read startdate
          echo $name:$address:$startdate
          echo –n "Is this correct? "
          read ans
          case "$ans"  in
          [Yy]*)
                  echo "Adding info..."
                  echo $name:$address:$startdate>>datafile
                  sort –u datafile –o datafile
                  echo –n "Do you want to go back to the main menu? "
             read ans
             if [[ $ans == [Yy] ]]
             then

4                return     # Return to calling program
             else

5                continue   # Go to the top of the loop
             fi
             ;;
          *)
          echo "Do you want to try again? "
          read answer
          case "$answer" in
          [Yy]*) continue;;
          *) exit;;
          esac
             ;;
       esac
    done
6   }   # End of function definition

–––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––
(The Command Line)
7   $ more mainprog
    #!/bin/bash
    # Scriptname: mainprog
    # This is the main script that will call the function, addon

    datafile=$HOME/bourne/datafile
8   source dbfunctions   # The file is loaded into memory
        if [ ! –e $datafile ]
    then
        echo "$(basename $datafile) does not exist" >&2
        exit 1
    fi
9      echo "Select one: "
       cat <<EOF
           [1] Add info
           [2] Delete info
           [3] Update info
           [4] Exit
       EOF
       read choice
       case $choice in
10        1) addon       # Calling the addon function
                 ;;
          2) delete      # Calling the delete function
                 ;;
          3) update
                 ;;
```

```
        4)
           echo Bye
           exit 0
                ;;
        *) echo Bad choice
           exit 2
                ;;
     esac
     echo Returned from function call
     echo The name is $name
     # Variable set in the function are known in this shell.
done
```

EXPLANATION

1. The dbfunctions file is displayed.
2. The addon function is defined. Its function is to add new information to the datafile.
3. A while loop is entered. It will loop forever unless a loop control statement such as break or cotinue is included in the body of the loop.
4. The return command sends control back to the calling program where the function was called.
5. Control is returned to the top of the while loop.
6. The closing curly brace ends the function definition.
7. This is the main script. The function addon will be used in this script.
8. The source command loads the file dbfunctions into the program's memory. Now the function addon is defined for this script and available for use. It is as though you had just defined the function right here in the script.
9. A menu is displayed with the here document. The user is asked to select a menu item.
10. The addon function is invoked.

12.8 Trapping Signals

While your program is running, if you press Control−C or Control−\, your program terminates as soon as the signal arrives. There are times when you would rather not have the program terminate immediately after the signal arrives. You could arrange to ignore the signal and keep running or perform some sort of cleanup operation before actually exiting the script. The trap command allows you to control the way a program behaves when it receives a signal.

A signal is defined as an asynchronous message that consists of a number that can be sent from one process to another, or by the operating system to a process if certain keys are pressed or if something exceptional happens.[6] The trap command tells the shell to terminate the command currently in execution upon the receipt of a signal. If the trap command is followed by commands within quotes, the command string will be executed upon receipt of a specified signal. The shell reads the command string twice, once when the trap is set, and again when the signal arrives. If the command string is surrounded by double quotes, all variable and command substitution will be performed when the trap is set the first time. If single quotes enclose the command string, variable and command substitution do not take place until the signal is detected and the trap is executed.

Use the command kill –l or trap –l to get a list of all signals. Table 12.6 provides a list of signal numbers and their corresponding names.

FORMAT

```
trap 'command; command' signal-number
trap 'command; command' signal-name
```

Example 12.61

```
trap 'rm tmp*; exit 1'  0 1 2 15
trap 'rm tmp*; exit 1'  EXIT HUP INT TERM
```

EXPLANATION

When any of the signals 1 (hangup), 2 (interrupt), or 15 (software termination) arrives, remove all the tmp files and exit.

If an interrupt comes in while the script is running, the trap command lets you handle the interrupt signal in several ways. You can let the signal behave normally (default), ignore the signal, or create a handler function to be called when the signal arrives.

Signal names such as HUP and INT are normally prefixed with SIG, for example, SIGHUP, SIGINT, and so forth.[7] The bash shell allows you to use symbolic names for the signals, which are the signal names without the SIG prefix, or you can use the numeric value for the signal. See Table 12.6. A pseudo signal name EXIT, or the number 0, will cause the trap to be executed when the shell exits.

Table 12.6. Signal Numbers and Signals (kill –l)

1) SIGHUP9) SIGKILL18) SIGCONT26) SIGVTALRM2) SIGINT10) SIGUSR119) SIGSTOP27) SIGPROF3) SIGQUIT11) SIGSEGV20) SIGTSTP28) SIGWINCH4) SIGILL12) SIGUSR221) SIGTTIN29) SIGIO5) SIGTRAP13) SIGPIPE22) SIGTTOU30) SIGPWR6) SIGABRT14) SIGALRM23) SIGURG 7) SIGBUS15) SIGTERM24) SIGXCPU 8) SIGFPE17) SIGCHLD25) SIGXFSZ

Resetting Signals. To reset a signal to its default behavior, the trap command is followed by the signal name or number. Traps set in functions are recognized by the shell that invoked the function, once the function has been called. Any traps set outside the function are also recognized with the function.

Example 12.62

```
trap 2  or  trap INT
```

EXPLANATION

Resets the default action for signal 2, SIGINT. The default action is to kill the process when the interrupt key (Control−C) is pressed.

Ignoring Signals . If the trap command is followed by a pair of empty quotes, the signals listed will be ignored by the process.

Example 12.63

```
trap " " 1 2  or    trap "" HUP INT
```

EXPLANATION

Signals 1 (SIGHUP) and 2 (SIGINT) will be ignored by the shell process.

Listing Traps. To list all traps and the commands assigned to them, type trap.

Example 12.64

```
(At the command line)
1   $ trap 'echo "Caught ya!; exit"' 2
2   $ trap
    trap -- 'echo "Caught ya!; exit 1"' SIGINT
3   $ trap -
```

EXPLANATION

1. The trap command is set to exit on signal 2 (Control−C).
2. The trap command without an argument lists all set traps.
3. If the argument is a dash, all signals are reset to their original values, i.e., whatever they were when the shell started up.

Example 12.65

```
(The Script)
    #!/bin/bash
    # Scriptname: trapping
    # Script to illustrate the trap command and signals
    # Can use the signal numbers or bash abbreviations seen
    # below. Cannot use SIGINT, SIGQUIT, etc.
1   trap 'echo "Control-C will not terminate $0."'  INT
2   trap 'echo "Control-\ will not terminate $0."'  QUIT
3   trap 'echo "Control-Z will not terminate $0."'  TSTP
4   echo  "Enter any string after the prompt.
    When you are ready to exit, type \"stop\"."
5   while true
    do
6       echo -n "Go ahead...> "
7       read
8       if [[ $REPLY == [Ss]top ]]
        then
9          break
        fi
10  done
(The Output)
    $ trapping
4   Enter any string after the prompt.
    When you are ready to exit, type "stop".
6   Go ahead...> this is it^C
1   Control-C will not terminate trapping.
6   Go ahead...> this is it again^Z
3   Control-Z will not terminate trapping.
6   Go ahead...> this is never it|^\
2   Control-\ will not terminate trapping.
6   Go ahead...> stop
    $
```

EXPLANATION

1. The first trap catches the INT signal, Control−C. If Control−C is pressed while the program is running, the command enclosed in quotes will be executed. Instead of aborting, the program will print Control−C will not terminate trapping and continue to prompt the user for input.
2. The second trap command will be executed when the user presses Control−\, the QUIT signal. The string Control−\ will not terminate trapping will be displayed and the program will continue to run. This signal, SIGQUIT by default, kills the process and produces a core file.
3. The third trap command will be executed when the user presses Control−Z, the TSTP signal. The string Control−Z will not terminate trapping will be displayed, and the program will continue to run. This signal normally causes the program to be suspended in the background if job control is implemented.
4. The user is prompted for input.
5. The while loop is entered.
6. The string Go ahead…> is printed and the program waits for input (see read on the next line).
7. The read command assigns user input to the built−in REPLY variable.
8. If the value of REPLY matches Stop or stop, the break command causes the loop to exit and the program will terminate. Entering Stop or stop is the only way we will get out of this program unless it is killed with the kill command.
9. The break command causes the body of the loop to be exited.
10. The done keyword marks the end of the loop.

Resetting Signals. To reset a signal to its default behavior, the trap command is followed by the signal name or number.

Example 12.66

```
trap 2
```

EXPLANATION

Resets the default action for signal 2, SIGINT, which is used to kill a process, i.e., Control−C.

Example 12.67

```
trap 'trap 2' 2
```

EXPLANATION

Sets the default action for signal 2 (SIGINT) to execute the command string within quotes when the signal arrives. The user must press Control−C twice to terminate the program. The first trap catches the signal, the second trap resets the trap back to its default action, which is to kill the process.

Traps in Functions. If you use a trap to handle a signal in a function, it will affect the entire script, once the function is called. The trap is global to the script. In the following example, the trap is set to ignore the interrupt key, ^C. This script had to be killed with the kill command to stop the looping. It demonstrates potential undesirable side effects when using traps in functions.

Example 12.68

```
(The Script)
    #!/bin/bash
1   function trapper () {
       echo "In trapper"
2      trap 'echo "Caught in a trap!"' INT
       # Once set, this trap affects the entire script. Anytime
       # ^C is entered, the script will ignore it.
    }
3   while :
    do
       echo "In the main script"
4      trapper
5      echo "Still in main"
       sleep 5
    done
(The Output)
$ trapper
In the main script
In trapper
Still in main
^CCaught in a trap!
In the main script
In trapper
Still in main
^CCaught in a trap!
In the main script
```

EXPLANATION

1. The trapper function is defined. All variables and traps set in the function are global to the script.
2. The trap command will ignore INT, signal 2, the interrupt key (^C). If ^C is pressed, the message Caught in a trap is printed, and the script continues forever. The script can be killed with the kill command or Ctrl−\.
3. The main script starts a forever loop.
4. The function trapper is called.
5. When the function returns, execution starts here.

12.9 Debugging

By using the –n option to the bash command, you can check the syntax of your scripts without really executing any of the commands. If there is a syntax error in the script, the shell will report the error. If there are no errors, nothing is displayed.

The most commonly used method for debugging scripts is the set command with the –x option, or bash invoked with the –x option and the scriptname. See Table 12.7 for a list of debugging options. These options allow an execution trace of your script. Each command from your script is displayed after substitution has been performed, and then the command is executed. When a line from your script is displayed, it is preceded with a plus (+) sign.

With the verbose option turned on, or by invoking the shell with the –v option (bash –v scriptname), each line of the script will be displayed just as it was typed in the script, and then executed.

Table 12.7. Debugging Options

Command OptionWhat It Doesbash –x scriptnameEcho optionDisplays each line of script after variable substitutions and before execution.bash –v scriptnameVerbose optionDisplays each line of script before execution, just as you typed it.bash –n scriptnameNoexec optionInterprets but does not execute commands.set –xTurns on echoTraces execution in a script.set +xTurns off echoTurns off tracing.

Example 12.69

```
(The Script)
$ cat todebug
    #!/bin/bash
    # Scriptname: todebug

1   name="Joe Shmoe"
    if [[ $name == "Joe Blow" ]]
    then
        printf "Hello $name\n"
    fi

    declare −i num=1
    while (( num < 5 ))
    do
        let num+=1
    done
    printf "The total is %d\n", $num

(The Output)
2 bash −x todebug
+ name=Joe Shmoe
+ [[ Joe Shmoe == \J\o\e\\B\l\o\w ]]
+ declare −i num=1
+ ((  num < 5  ))
+ let num+=1
+ ((  num < 5  ))
+ let num+=1
+ ((  num < 5  ))
+ let num+=1
+ ((  num < 5  ))
+ let num+=1
+ ((  num < 5  ))
+ printf 'The total is %d\n,' 5
The total is 5
```

EXPLANATION

1. The script is called todebug. You can watch the script run with the –x switch turned on. Each iteration of the loop is displayed and the values of variables are printed as they are set and when they change.
2. Bash is invoked with the –x option. Echoing is turned on. Each line of the script will be displayed to the screen prepended with a plus sign (+). Variable substitution is performed before the line is displayed. The result of the execution of the command appears after the line has been displayed.

12.10 Processing Command Line Options with getopts

If you are writing scripts that require a number of command line options, positional parameters are not always the most efficient. For example, the UNIX ls command takes a number of command line options and arguments. (An option requires a leading dash; an argument does not.) Options can be passed to the program in several ways: ls –laFi, ls –i –a –l –F, ls –ia –F, and so forth. If you have a script that requires arguments, positional parameters might be used to process the arguments individually, such as ls –l –i –F . Each dash option would be stored in $1, $2, and $3, respectively. But, what if the user listed all of the options as one dash option, as in ls –liF? Now the –liF would all be assigned to $1 in the script. The getopts function makes it possible to process command line options and arguments in the same way they are processed by the ls program.[8] The getopts function will allow the runit program to process its arguments using any variety of combinations.

Example 12.70

```
(The Command Line )
1   $ runit –x –n  200 filex

2   $ runit –xn200 filex

3   $ runit –xy

4   $ runit –yx –n 30

5   $ runit –n250 –xy filey

( any other combination of these arguments )
```

EXPLANATION

1. The program runit takes four arguments: x is an option, n is an option requiring a number argument after it, and filex is an argument that stands alone.
2. The program runit combines the options x and n and the number argument 200; filex is also an argument.
3. The program runit is invoked with the x and y options combined.
4. The program runit is invoked with the y and x options combined; the n option is passed separately, as is the number argument, 30.
5. The program runit is invoked with the n option combined with the number argument, the x and y options are combined, and the filey is separate.

Before getting into all the details of the runit program, we examine the line from the program where getopts is used to see how it processes the arguments.

Example 12.71

```
(A Line from the Script Called "runit")

while getopts :xyn: name
```

EXPLANATION

1. x, y, and n are the options. In this example the first option is preceded by a colon. This tells getopts to use silent error reporting. If there is a colon after one of the options, the

option expects an argument separated from it by whitespace. An argument is a word that does not begin with a dash. –n requires an argument.
2. Any options typed at the command line must begin with a dash.
3. Any options that do not contain a dash tell getopts that the option list has ended.
4. Each time getopts is called, it places the next option value it finds in the variable name. (You can use any variable name here.) If an illegal argument is given, name is assigned a question mark.

getopts Scripts. The following examples illustrate how getopts processes arguments.

Example 12.72

```
(The Script)
$ cat opts1
    #!/bin/bash
    # Program: opts1
    # Using getopts –– First try ––
1   while getopts xy options
    do
2       case $options in
3       x) echo "you entered –x as an option";;
        y) echo "you entered –y as an option";;
        esac
    done

(The Command Line)
4   $ opts1 –x
    you entered –x as an option
5   $ opts1 –xy
    you entered –x as an option
    you entered –y as an option
6   $ opts1 –y
    you entered –y as an option
7   $ opts1 –b
    opts1:   illegal option ––  b
8   $ opts1 b
```

EXPLANATION

1. The getopts command is used as a condition for the while command. The valid options for this program are listed after the getopts command; they are x and y. Each option is tested in the body of the loop, one after the other. Each option will be assigned to the variable options, without the leading dash. When there are no longer any arguments to process, getopts will exit with a nonzero status, causing the while loop to terminate.
2. The case command is used to test each of the possible options found in the options variable, either x or y.
3. If x was an option, the string you entered x as an option is displayed.
4. At the command line, the opts1 script is given an x option, a legal option to be processed by getopts.
5. At the command line, the opts1 script is given an xy option; x and y are legal options to be processed by getopts.
6. At the command line, the opts1 script is given a y option, a legal option to be processed by getopts.
7. The opts1 script is given a b option, an illegal option. Getopts sends an error message to stderr.

8. An option without a dash prepended to it is not an option and causes getopts to stop processing arguments.

Example 12.73

```
(The Script)
$ cat opts2
    #!/bin/bash
    # Program: opts2
    # Using getopts –– Second try ––
1   while getopts xy options 2> /dev/null
    do
2       case $options in
        x) echo "you entered –x as an option";;
        y) echo "you entered –y as an option";;
3       \?) echo "Only –x and –y are valid options"  1>&2;;
        esac
    done

(The Command Line)
    $ opts2 –x
    you entered –x as an option

    $ opts2 –y
    you entered –y as an option

    $ opts2 xy

    $ opts2 –xy
    you entered –x as an option
    you entered –y as an option

4   $ opts2 –g
    Only –x and –y are valid options

5   $ opts2 –c
    Only –x and –y are valid options
```

EXPLANATION

1. If there is an error message from getopts, it is redirected to /dev/null.
2. If the option is a bad option, a question mark will be assigned to the options variable. The case command can be used to test for the question mark, allowing you to print your own error message to standard error.
3. If the options variable is assigned the question mark, the case statement is executed. The question mark is protected with the backslash so that the shell does not see it as a wildcard and try to perform filename substitution.
4. g is not a legal option. A question mark is assigned to the variable options and the error message is displayed.
5. c is not a legal option. A question mark is assigned to the variable options and the error message is displayed.

Special getopts Variables. The getopts function provides two variables to help keep track of arguments: OPTIND and OPTARG. OPTIND is a special variable that is initialized to one and is incremented each time getopts completes processing a command line argument to the number of the next argument getopts will process. The OPTARG variable contains the value of a legal argument. See Examples 12.74 and 12.75.

Example 12.74

```
(The Script)
$ cat opts3
    #!/bin/bash
    # Program: opts3
    # Using getopts -- Third try --
1   while getopts dq: options
    do
       case $options in
2           d) echo "-d is a valid switch ";;
3           q) echo "The argument for -q is $OPTARG";;
            \?) echo "Usage:opts3 -dq filename ... " 1>&2;;
       esac
    done

(The Command Line)
4   $ opts3 -d
    -d is a valid switch

5   $ opts3 -q  foo
    The argument for -q is foo

6   $ opts3 -q
    Usage:opts3 -dq filename ...

7   $ opts3 -e
    Usage:opts3 -dq filename ...

8   $ opts3 e
```

EXPLANATION

1. The while command tests the exit status of getopts; if getopts can successfully process an argument, it returns zero exit status, and the body of the while loop is entered. The colon appended to the argument list means that the q option requires an argument. The argument will be stored in the special variable, OPTARG.
2. One of the legal options is d. If d is entered as an option, the d (without the dash) is stored in the options variable.
3. One of the legal options is q. The q option requires an argument. There must be a space between the q option and its argument. If q is entered as an option followed by an argument, the q, without the dash, is stored in the options variable and the argument is stored in the OPTARG variable. If an argument does not follow the q option, the question mark is stored in the variable options.
4. The d option is a legal option to opts3.
5. The q option with an argument is also a legal option to opts3.
6. The q option without an argument is an error.
7. The e option is invalid. A question mark is stored in the options variable if the option is illegal.
8. The option is prepended with neither a dash nor a plus sign. The getopts command will not process it as an option and returns a nonzero exit status. The while loop is terminated.

Example 12.75

```
$ cat opts4
    #!/bin/bash
    # Program: opts4
    # Using getopts −− Fourth try −−
1   while getopts xyz: arguments 2>/dev/null
    do
       case $arguments  in
2      x) echo "you entered −x as an option .";;
       y) echo "you entered −y as an option." ;;
3      z) echo "you entered −z as an option."
           echo "\$OPTARG is $OPTARG.";;
4      \?) echo "Usage opts4 [−xy] [−z  argument]"
           exit 1;;
       esac
    done
5   echo " The number of arguments passed was $(( $OPTIND − 1 ))"

(The Command Line)
$ opts4 −xyz foo
You entered −x as an option.
You entered −y as an option.
You entered −z as an option.
$OPTARG is foo.
The number of arguments passed was 2.
$ opts4 −x −y −z  boo
You entered −x as an option.
You entered −y as an option.
You entered −z as an option.
$OPTARG is boo.
The number of arguments passed was 4.

$ opts4 −d
Usage: opts4  [−xy] [−z argument]
```

EXPLANATION

1. The while command tests the exit status of getopts; if getopts can successfully process an argument, it returns zero exit status, and the body of the while loop is entered. The colon appended to the z option tells getopts that an argument must follow the –z option. If the option takes an argument, the argument is stored in the getopts built−in variable OPTARG.
2. If x is given as an option, it is stored in the variable arguments.
3. If z is given as an option with an argument, the argument is stored in the built−in variable OPTARG.
4. If an invalid option is entered, the question mark is stored in the variable arguments and an error message is displayed.
5. The special getopts variable OPTIND holds the number of the next option to be processed. Its value is always one more than the actual number of command line arguments.

12.11 The eval Command and Parsing the Command Line

The eval command evaluates a command line, performs all shell substitutions, and then executes the command line. It is used when normal parsing of the command line is not flexible enough for what we want to do.

Example 12.76

```
1   $ set a b c d
2   $ echo The last argument is \$$#
3   The last argument is $4

4   $ eval echo The last argument is \$$#
    The last argument is d

5   $ set -x
    $ eval echo The last argument is \$$#
    + eval echo the last argument is '$4'
    ++ echo the last argument is d
    The last argument is d
```

EXPLANATION

1. Four positional parameters are set.
2. The desired result is to print the value of the last positional parameter. The \$ will print a literal dollar sign. The $# evaluates to 4, the number of positional parameters. After the shell evaluates the $#, it does not parse the line again to get the value of $4.
3. $4 is printed instead of the last argument.
4. After the shell performs variable substitution, the eval command performs the variable substitution and then executes the echo command.
5. Turn on the echoing to watch the order of parsing.

Example 12.77

```
(From Shutdown Program)
1   eval '/usr/bin/id | /usr/bin/sed 's/[^a-z0-9=].*//''
2   if [ "${uid:=0}" -ne 0 ]
    then
3      echo $0: Only root can run $0
       exit 2
    fi
```

EXPLANATION

1. This is a tricky one. The id program's output is sent to sed to extract the uid part of the string. The output for id is

   ```
   uid=9496(ellie) gid=40 groups=40
   uid=0(root) gid=1(daemon) groups=1(daemon)
   ```

   The sed regular expression reads: Starting at the beginning of the string, find any character that is not a letter, number, or an equal sign and remove that character and all characters following it. The result is to substitute everything from the first opening parenthesis to the end of the line with nothing. What is left is either: uid=9496 or uid=0.

   After eval evaluates the command line, it then executes the resulting command:

   ```
   uid=9496
   ```

   or

```
uid=0
```

For example, if the user's ID is root, the command executed would be uid=0. This creates a local variable in the shell called uid and assigns zero to it.

2. The value of the uid variable is tested for zero, using command modifiers.
3. If the uid is not zero, the echo command displays the scriptname ($0) and the message.

12.12 bash Options

12.12.1 Shell Invocation Options

When the shell is started using the bash command, it can take options to modify its behavior. There are two types of options: single−character options and multicharacter options. The single−character options consist of a single leading dash followed by a single character. The multicharacter options consist of two leading dashes and any number of characters. Multicharacter options must appear before single−character options. An interactive login shell normally starts up with –i (start an interactive shell), –s (read from standard input), and –m (enable job control). See Table 12.8.

Table 12.8. bash 2.x Shell Invocation Options

Option Meaning–c stringCommands are read from string. Any arguments after string are assigned to positional parameters, starting at $0.–DA list of double quoted strings, preceded by a $, are printed to standard output. These strings are subject to language translation when the current locale is not C or POSIX. The –n option is implied; no commands will be executed.–iShell is in the interactive mode. TERM, QUIT, and INTERRUPT are ignored.–sCommands are read from standard input and allow the setting of positional parameters.–rStarts a restricted shell.– –Signals the end of options and disables further option processing. Any arguments after – – or – are treated as filenames and arguments.– –dump–stringsSame as –D.– –helpDisplays a usage message for a built−in command and exits.– –loginCauses bash to be invoked as a login shell.– –noeditingWhen bash is running interactively, does not use the Readline library.– –noprofileWhen starting up, bash does not read the initialization files: /etc/profile, ~/.bash_profile, ~/.bash_login, or ~/.profile.– –norcFor interactive shells, bash will not read the ~/.bashrc file. Turned on by default, if running shell as sh.– –posixChanges the behavior of bash to match the POSIX 1003.2 standard, if otherwise it wouldn't.– –quietDisplays no information at shell startup, the default.– –rcfile fileIf bash is interactive, uses this intialization file instead of ~/.bashrc.– –restrictedStarts a restricted shell.– –verboseTurns on verbose; same as –v.– –versionDisplays version information about this bash shell and exit.

Table 12.9. bash (Versions Prior to 2.x) Shell Invocation Options

–c stringCommands are read from string. Any arguments after string are assigned to positional parameters, starting at $0.–DA list of double quoted strings, preceded by a $, are printed to standard output. These strings are subject to language translation when the current locale is not C or POSIX. The –n option is implied; no commands will be executed.–iShell is in the interactive mode. TERM, QUIT, and INTERRUPT are ignored.–sCommands are read from standard input and allows the setting of positional parameters.–rStarts a restricted shell.–Signals the end of options and disables further option processing. Any arguments after – – or – are treated as filenames and arguments.–loginCauses bash to be invoked as a login shell.–nobraceexpansionCurly brace expansion is turned off.–nolineeditingWhen bash is running interactively, does not use the Readline library.–noprofileWhen starting up, bash does not read the initialization files: /etc/profile, ~/.bash_profile, ~/.bash_login, or ~/.profile.–posixChanges the behavior of bash to match the

POSIX standard, if otherwise it wouldn't.–quietDisplays no information at shell startup, the default.–rcfile fileIf bash is interactive, uses this intialization file instead of ~/.bashrc.–verboseTurns on verbose; same as –v.–versionDisplays version information about this bash shell and exit.

12.12.2 The set Command and Options

The set command can be used to turn shell options on and off, as well as for handling command line arguments. To turn an option on, the dash (–) is prepended to the option; to turn an option off, the plus sign (+) is prepended to the option. See Table 12.10 for a list of set options.

Example 12.78

```
1   $ set −f

2   $ echo *
    *

3   $ echo ??
    ??

4   $ set +f
```

EXPLANATION

1. The f option is turned on, disabling filename expansion.
2. The asterisk is not expanded.
3. The question marks are not expanded.
4. The f is turned off; filename expansion is enabled.

Table 12.10. The Built−In set Command Options

Name of Option Shortcut SwitchWhat It Doesallexport–aAutomatically marks new or modified variables for export from the time the option is set, until unset.braceexpand–BEnables brace expansion, and is a default setting.[a]emacs For command line editing, uses the emacs built−in editor, and is a default setting.errexit–eIf a command returns a nonzero exit status (fails), exits. Not set when reading initialization files.histexpand–HEnables ! and !! when performing history substitution, and is a default setting.[a]history Enables command line history; on by default.[a]ignoreeof Disables EOF (Control−D) from exiting a shell; must type exit. Same as setting shell variable, IGNOREEOF=10.keyword–kPlaces keyword arguments in the environment for a command.[a] interactive−comments For interactive shells, a leading # is used to comment out any text remaining on the line.monitor–mAllows job control.noclobber–CProtects files from being overwritten when redirection is used.noexec–nReads commands, but does not execute them. Used to check the syntax of scripts. Not on when running interactively.noglob–dDisables pathname expansion; i.e., turns off wildcards.notify–bNotifies user when background job finishesnounset–uDisplays an error when expanding a variable that has not been set.onecmd–tExits after reading and executing one command.[a]physical–PIf set, does not follow symbolic links when typing cd or pwd. The physical directory is used instead.posix Shell behavior is changed if the default operation doesn't match the POSIX standard.privileged–pWhen set, the shell does not read the .profile or ENV file and shell functions are not inherited from the environment; automatically set for setuid scripts.posix Changes the default behavior to POSIX 1003.2.verbose–vTurns on the verbose mode for debugging.vi For command line editing, uses the vi built−in editor.xtrace–xTurns on the echo mode for debugging.

[a] Option applies only to versions of bash 2.x.

12.12.3 The shopt Command and Options

The shopt (bash 2.x) command can also be used to turn shell options on and off.

Table 12.11. The shopt Command Options

Option Meaningcdable_varsIf an argument to the cd built−in command is not a directory, it is assumed to be the name of a variable whose value is the directory to change to.cdspellCorrects minor errors in the spelling of a directory name in a cd command. The errors checked for are transposed characters, a missing character, and a character too many. If a correction is found, the corrected path is printed, and the command proceeds. Only used by interactive shells.checkhashBash checks that a command found in the hash table exists before trying to execute it. If a hashed command no longer exists, a normal path search is performed.checkwinsizeBash checks the window size after each command and, if necessary, updates the values of LINES and COLUMNS.cmdhistBash attempts to save all lines of a multiple−line command in the same history entry. This allows easy re−editing of multiline commands.dotglobBash includes filenames beginning with a dot (.) in the results of filename expansion.execfailA noninteractive shell will not exit if it cannot execute the file specified as an argument to the exec built−in command. An interactive shell does not exit if exec fails. expand_aliasesAliases are expanded. Enabled by default.extglobThe extended pattern matching features (regular expression metacharacters derived from Korn shell for filename expansion) are enabled.histappendThe history list is appended to the file named by the value of the HISTFILE variable when the shell exits, rather than overwriting the file.histreeditIf readline is being used, a user is given the opportunity to re−edit a failed history substitution.histverifyIf set, and readline is being used, the results of history substitution are not immediately passed to the shell parser. Instead, the resulting line is loaded into the readline editing buffer, allowing further modification.hostcompleteIf set, and readline is being used, bash will attempt to perform hostname completion when a word containing an @ is being completed. Enabled by default.huponexitIf set, bash will send SIGHUP (hangup signal) to all jobs when an interactive login shell exits. interactive_commentsAllows a word beginning with # to cause that word and all remaining characters on that line to be ignored in an interactive shell. Enabled by default.lithistIf enabled, and the cmdhist option is enabled, multiline commands are saved to the history with embedded newlines rather than using semicolon separators where possible.mailwarnIf set, and a file that bash is checking for mail has been accessed since the last time it was checked, the message The mail in mailfile has been read is displayed.nocaseglobIf set, bash matches filenames in a case−insensitive fashion when performing filename expansion.nullglobIf set, bash allows filename patterns that match no files to expand to a null string, rather than themselves.promptvarsIf set, prompt strings undergo variable and parameter expansion after being expanded. Enabled by default. restricted_shellThe shell sets this option if it is started in restricted mode. The value may not be changed. This is not reset when the startup files are executed, allowing the startup files to discover whether or not a shell is restricted. shift_verboseIf this is set, the shift built−in prints an error message when the shift count exceeds the number of positional parameters.sourcepathIf set, the source built−in uses the value of PATH to find the directory containing the file supplied as an argument. Enabled by default.sourceA synonym for dot (.).

12.13 Shell Built−In Commands

The shell has a number of commands that are built−in to its source code. Because the commands are built−in, the shell doesn't have to locate them on disk, making execution much faster. The help feature provided with bash give you online help for any built−in command. The built−in commands are listed in Table 12.12.

Table 12.12. Built−In Commands

CommandWhat It Does.Executes program in context of current process; same as source.. fileThe dot command reads and executes command from file.:Do−nothing command; returns 0 exit status.aliasLists and creates "nicknames" for existing commands.bgPuts a job in the background.bindDisplays current key and function bindings, or binds keys to a readline function or macro.[a]breakBreaks out of the innermost loop.break [n]See "The break Command" 780.builtin [sh–builtin [args]]Runs a shell built−in, passing it args, and returning 0 exit status. Useful if a function and built−in have the same name.[a]cd [arg]Changes the directory to home if no arg or to value of arg.command command [arg]Runs a command even if a function has the same name; i.e., bypasses function lookup.[a]continue [n]See "The continue Command" on page 781.declare [var]Displays all variables or declares variables with optional attributes.[a]dirsDisplays a list of currently remembered directories resulting from pushd.disownRemoves an active job from the job table.echo [args]Displays args terminated with a newline.enableEnables and disables shell built−in commands.[a]eval [args]Reads args as input to the shell and executes the resulting command(s).exec commandRuns command in place of this shell.exit [n]Exits the shell with status n.export [var]Makes var known to subshells.fcHistory's fix command for editing history commands.fgPuts background job into foreground.getoptsParses and processes command line options.hashControls the internal hash table for quicker searches for commands.help [command]Displays helpful info about built−in commands and, if command is specified, detailed help about that built−in command.[a]historyDisplays the history list with line numbers.jobsLists jobs put in the background.kill [–signal process]Sends the signal to the PID number or job number of the process. Type kill –l for a list of signals.letUsed for evaluating arithmetic expressions and assigning results of arithmetic calculations to variables.localUsed in functions to restrict the scope of variables to the function.logoutExits the login shell.popdRemoves entries from the directory stack.pushdAdds entries to the directory stack.pwdPrints present working directory.read [var]Reads line from standard input into variable var.readonly [var]Makes variable var read−only. Cannot be reset.return [n]Returns from a function where n is the exit value given to the return.setSets options and positional parameters. See Table 12.2.shift [n]Shifts positional parameters to the left n times.stop pidHalts execution of the process number PID.suspendStops execution of the current shell (but not if a login shell).testChecks file types and evaluates conditional expressions.timesPrints accumulated user and system times for processes run from this shell.trap [arg] [n]When shell receives signal n (0, 1, 2, or 15), executes arg.type [command]Prints the type of command; e.g., pwd is a built−in shell command.typesetSame as declare. Sets variables and gives them attributes.ulimitDiplays and sets process resource limits.umask [octal digits]Sets user file creation mode mask for owner, group, and others.unaliasUnsets aliases.unset [name]Unset value of variable or function.wait [pid#n]Waits for background process with PID number n and reports termination status.

[a] Option applies to bash 2.x. and later.

BASH SHELL LAB EXERCISES

Lab 49: First Script

1: Write a script called greetme that will do the following:

a. Contain a comment section with your name, the name of this script, and the purpose of this script.
b. Greet the user.
c. Print the date and the time.
d. Print a calendar for this month.
e. Print the name of your machine.
f. Print the name and release of this operating system, (cat /etc/motd).

g. Print a list of all files in your parent directory.
h. Print all the processesroot is running.
i. Print the value of the TERM, PATH, and HOME variables.
j. Print your disk usage (du).
k. Use theid command to print your group ID.
l. Print Please couldn't you loan me $50.00?
m. Tell the user Good bye and the current hour (see man pages for the date command).

2: Make sure your script is executable.

```
chmod +x greetme
```

3: What was the first line of your script? Why do you need this line?

Lab 50: Command Line Arguments

1: Write a script called rename that will take two arguments: the first argument is the name of the original file and the second argument is the new name for the file.

If the user does not provide two arguments, a usage message will appear on the screen and the script will exit. Here is an example of how the script works:

```
$ rename
Usage: rename oldfilename newfilename
$
$ rename file1 file2
file1 has been renamed file2
Here is a listing of the directory:
a file2
b file.bak
```

2: The following find command (SunOS) will list all files in the root partition that are larger than 100K and that have been modified in the last week. (Check your man pages for the correct find syntax on your system.)

```
find / –xdev –mtime –7 –size +200 –print
```

3: Write a script called bigfiles that will take two arguments: one will be the mtime and one the size value. An appropriate error message will be sent to stderr if the user does not provide two arguments.

4: If you have time, write a script called vib that creates backup files for vi. The backup files will have the extension .bak appended to the original name.

Lab 51: Getting User Input

1: Write a script called nosy that will do the following:

a. Ask the user's full name—first, last, and middle name.
b. Greet the user by his or her first name.
c. Ask the user's year of birth and calculate his or her age (useexpr).

d. Ask the user's login name and print his or her user ID (from /etc/passwd).
e. Tell the user his or her home directory.
f. Show the user the processes he or she is running.
g. Tell the user the day of the week, and the current time in nonmilitary time. The output should resemble

   The day of the week is Tuesday and the current time is 04:07:38 PM.

2: Create a text file called datafile (unless this file has already been provided for you). Each entry consists of fields separated by colons. The fields are as follows:

a. First and last name
b. Phone number
c. Address
d. Birth date
e. Salary

3: Create a script called lookup that will do the following:

a. Contain a comment section with the scriptname, your name, the date, and the reason for writing this script.The reason for writing this script is to display the datafile in sorted order.
b. Sort the datafile by last names.
c. Show the user the contents of the datafile.
d. Tell the user the number of entries in the file.

4: Try the –x and –v options for debugging your script. How did you use these commands? How do they differ?

Lab 52: Conditional Statements

1: Write a script called checking that will do the following:

a. Take a command line argument, a user's login name.
b. Test to see if a command line argument was provided.
c. Check to see if the user is in the /etc/passwd file. If so, will print

   Found <user> in the /etc/passwd file.

   Otherwise, will print

   No such user on our system.

2: In the lookup script, ask the user if he or she would like to add an entry to the datafile. If the answer is yes or y:

a. Prompt the user for a new name, phone, address, birth date, and salary. Each item will be stored in a separate variable. You will provide the colons between the fields and append the information to the datafile.
b. Sort the file by last names. Tell the user you added the entry, and show him or her the line preceded by the line number.

Lab 53: Conditionals and File Testing

1: Rewrite checking. After checking whether the named user is in the /etc/passwd file, the program will check to see if the user is logged on. If so, the program will print all the processes that are running; otherwise it will tell the user

<user> is not logged on.

2: Use the let command to evaluate a set of grades. The script will ask the user for his or her numeric grade on an examination. (Use declare –i). The script will test that the grade is within the allowable range between 0 and 100. If not, the program will exit. If the grade is within the range, the user's letter grade will be displayed, e.g., You received an A. Excellent! The range is as follows:

A (90–100) B (80–89) C (70–79) D (60–69) F (Below 60)

3: The lookup script depends on the datafile in order to run. In the lookup script, check to see if the datafile exists and if it is readable and writeable. Add a menu to the lookup script to resemble the following:

[1] Add entry.
[2] Delete entry.
[3] View entry.
[4] Exit.

You already have the Add entry part of the script written. The Add entry routine should now include code that will check to see if the name is already in the datafile and if it is, tell the user so. If the name is not there, add the new entry.

Now write the code for the Delete entry, View entry, and Exit functions.

The Delete part of the script should first check to see if the entry exists before trying to remove it. If it does, notify the user; otherwise, remove the entry and tell the user you removed it. On exit, make sure that you use a digit to represent the appropriate exit status.

How do you check the exit status from the command line?

Lab 54: The case Statement

1: The ps command is different on BSD (Berkeley UNIX) and System 5 (AT&T UNIX). UNIX uses the BSD options to ps. On System 5, the command to list all processes is

```
ps –ef
```

On UNIX, the command is

```
ps aux
```

Write a program called systype that will check for a number of different system types. The cases to test for will be

AIX
UNIX
HP–UX
SCO
OSF1
ULTRIX
SunOS (Solaris / SunOs)
OS

Solaris, HP–UX, SCO, and IRIX are AT&T−type systems. The rest are BSDish.

The version of UNIX you are using will be printed to stdout. The system name can be found with the uname –s command or from the /etc/motd file.

2: Write a script called timegreet that will do the following:

a. Provide a comment section at the top of the script, with your name, the date, and the purpose of the program.
b. Convert the following program to use the case command rather than if/elif.

```
#!/bin/bash
# Comment section
you=$LOGNAME
hour=$( date +%H )
echo "The time is: $( date +%T )"
if (( hour > 0 && hour < 12 ))
then
   echo "Good morning,s $you!"
elif (( hour == 12 ))
then
   echo "Lunch time!"
elif (( hour > 12 && hour < 16 ))
then
   echo "Good afternoon, $you!"
else
   echo "Good night, $you. Sweet dreams."
fi
```

Lab 55: Loops

Select one of the following:

1: Write a program called mchecker to check for new mail and write a message to the screen if new mail has arrived.

a. The program will get the size of the mail spool file for the user. (The spool files are found in /usr/mail/$LOGNAME on AT&T systems and /usr/spool/mail/$USER on UNIX and UCB systems. Use the find command if you cannot locate the file.) The script will execute in a continuous loop, once every 30 seconds. Each time the loop executes, it will compare the size of the mail spool file with its size from the previous loop. If the new size is greater than the old size, a message will be printed on your screen, saying Username, You have new mail.

The size of a file can be found by looking at the output fromls –l, wc –c or from the find command.

2: Write a script that will do the following:

a. Provide a comment section at the top of the script, with your name, the date, and the purpose of the program.
b. Use theselect loop to produce a menu of foods.
c. Produce output to resemble the following:

```
1) steak and potatoes
2) fish and chips
3) soup and salad
Please make a selection. 1
Stick to your ribs.
Watch your cholesterol.
Enjoy your meal.

1) steak and potatoes
2) fish and chips
3) soup and salad
Please make a selection. 2
British are coming!
Enjoy your meal.

1) steak and potatoes
2) fish and chips
3) soup and salad
Please make a selection. 3
Health foods...
Dieting is so boring.
Enjoy your meal.
```

3: Write a program called dusage that will mail a list of users, one at a time, a listing of the number of blocks they are currently using. The list of users will be in a file called potential_hogs. One of the users listed in the potential_hogs file will be admin.

a. Use file testing to check that potential_hogs file exists and is readable.
b. A loop will be used to iterate through the list of users. Only those users who are using over 500 blocks will be sent mail. The user admin will be skipped over (i.e., he or she does not get a mail message). The mail message will be stored in a here document in your dusage script.
c. Keep a list of the names of each person who received mail. Do this by creating a log file. After everyone on the list has been sent mail, print the number of people who received mail and a list of their names.

Lab 56: Functions

1: Rewrite the systype program as a function that returns the name of the system. Use this function to determine what options you will use with the ps command in the checking program.

2: The ps command to list all processes on AT&T UNIX is

```
ps –ef
```

3: On UNIX/BSD UNIX, the command is

```
ps –aux  or ps aux[9]
```

4: Write a function called cleanup that will remove all temporary files and exit the script. If the interrupt or hangup signal is sent while the program is running, the trap command will call the cleanup function.

5: Use a here document to add a new menu item to the lookup script to resemble the following:

[1] Add entry
[2] Delete entry
[3] Change entry
[4] View entry
[5] Exit

Write a function to handle each of the items in the menu. After the user has selected a valid entry, and the function has completed, ask if the user would like to see the menu again. If an invalid entry is entered, the program should print

Invalid entry, try again.

and the menu will be redisplayed.

6: Create a submenu under View entry in the lookup script. The user will be asked if he or she would like to view specific information for a selected individual:

a) Phone
b) Address
c) Birth date
d) Salary

7: Use the trap command in a script to perform a cleanup operation if the interrupt signal is sent while the program is running.

[1] When bash starts interactively, if the –norc or – –norc option is given, the BASH_ENV or ENV file will not be read.

[2] Options –a, –e, and –p are available only in bash versions 2.x.

[3] Remember, without arguments, the set command displays all the variables that have been set for this shell, local and exported. With options, the set command turns on and off shell control options such as –x and –v.

[4] If the continue command is given a number higher than the number of loops, the loop exits.

[5] Only on bash versions 2.x.

[6] Bolsky, Morris I. and Korn, David G., *The New KornShell Command and Programming Language* (Englewood Cliffs, NJ: Prentice Hall PTR, 1995), p. 327.

[7] SIGKILL, number 9, often called a "sure kill," is not trapable.

[8] See the UNIX manual pages (Section 3) for the C library function getopt.

[9] Using the leading dash with UNIX will produce a warning. See the man page.

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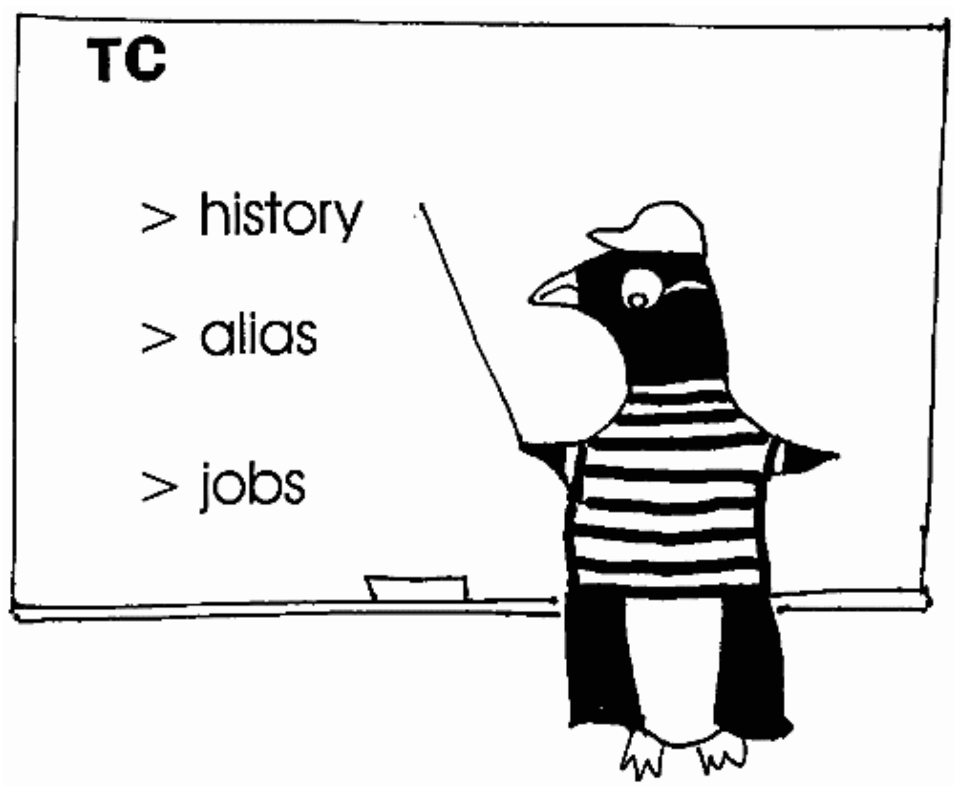
CONTENTS

Chapter 13. The Interactive TC Shell



13.1 Introduction

An interactive shell is one in which the standard input, output, and errors are connected to a terminal. When using the TC[1] shell (tcsh) interactively, you will type commands at the tcsh prompt and wait for a response. The TC shell is a program that starts up at login and interprets commands. It is a public domain enhanced version of its predecessor, the Berkeley UNIX C shell. Added features include command line editing, fancy prompts, programmable completions (filenames, commands, and variables), spelling correction, etc.

The primary tcsh source distribution is at ftp.astron.com, also ftp.gw.com, and ftp.primate.wisc.edu.[2]

Although tcsh is included in most Linux distributions, it can be ported to a number of operating systems, including Solaris, Windows NT, HP−UX, QNX, etc.

This chapter focuses on how to use the TC shell interactively and how to set up your initial working environment. The enhancements over the Berkeley C shell are extensive when working with the shell interactively, as you will see in this chapter. However, when used as a programming language, tcsh and csh are practically identical. Please refer to Chapter 10 for script writing with tcsh. The only change will be that where you see /bin/csh, you will use /bin/tcsh.

13.1.1 Versions of tcsh

To find out what version of tcsh you are using, type at the shell prompt:

```
which tcsh
```

To tell you in what directory tcsh is installed (normally /bin), and to print the version information, type the following:

```
/directory_path/tcsh −c 'echo $version'
```

Example 13.1

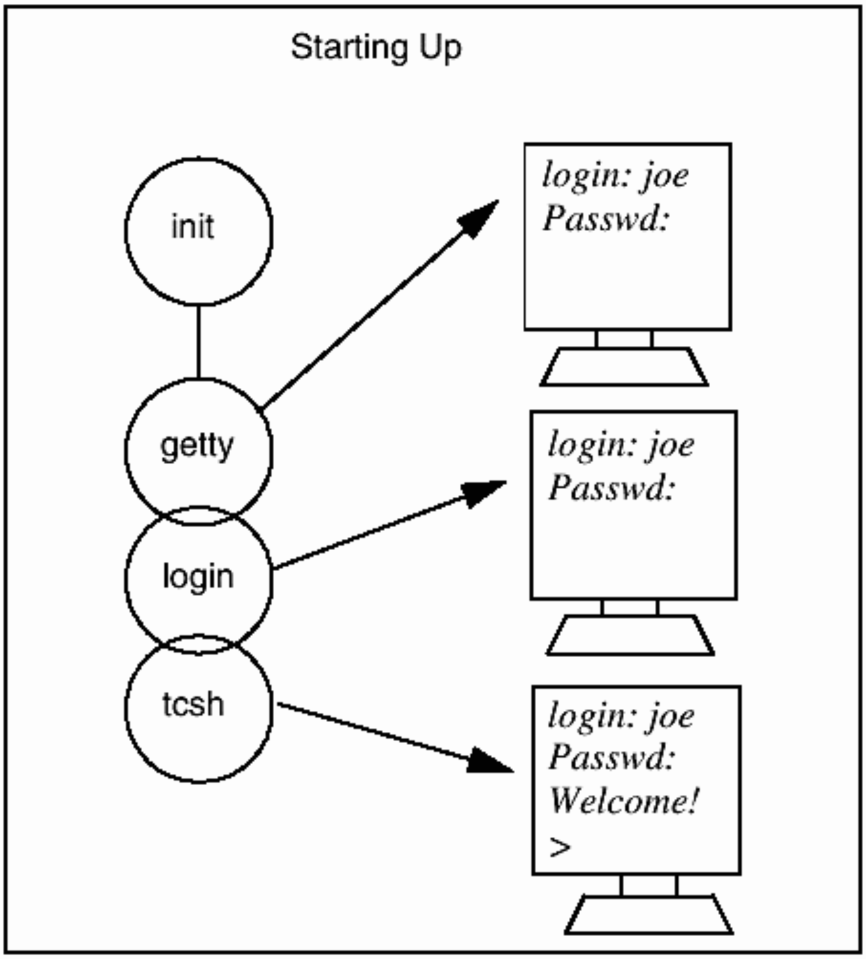
```
1   which tcsh
    /bin/tcsh

2   /bin/tcsh −c 'echo $version'
    tcsh 6.09.09 (Astron) 1998−08−16 (sparc−sun−solaris) options
    8b,nls,dl,al,rh,color
```

13.1.2 Startup

Before the TC shell displays a prompt, it is preceded by a number of processes. See Figure 13.1.

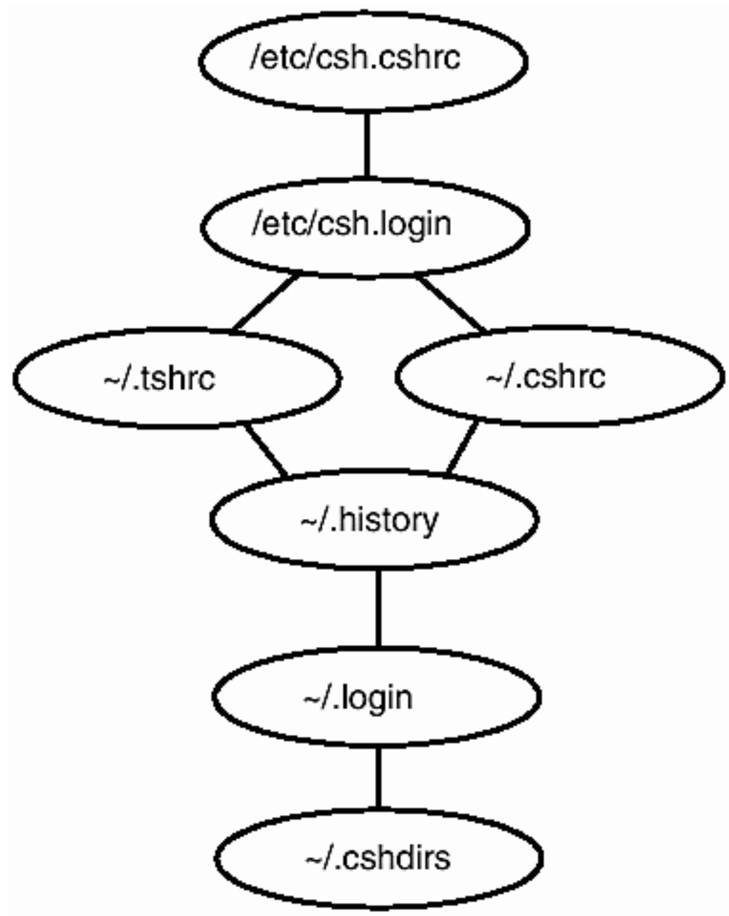
Figure 13.1. System startup and the TC shell.



After the system boots, the first process to run is called init, process identification number (PID) 1. It spawns a getty process. These processes are responsible for opening up the terminal ports, for providing a place where input comes from (stdin) and where standard output (stdout) and error (stderr) go, and for putting a login prompt on your screen. After the user types his user name, the /bin/login program is executed. The login program prompts for a password, encrypts and verifies your password, sets up an initial working environment, and then initiates the shell, /bin/tcsh. The TC shell looks in the /etc directory for a system startup file called /etc/csh.cshrc and /etc/csh.login (if it exists). It then looks in the user's home directory for a file called ~/.tcshrc, another initialization file used to customize the tcsh environment. If that file is not found, it will look for another file that does the same job, called ~/.cshrc (normally invoked when running csh). After executing commands in the .tcshrc file (or .cshrc), it will execute the history file, commonly called .history. Then commands in the ~/.login file are executed, and finally the .cshdirs file is executed. Each of these files will be explained in "The TC Shell Environment".[3]

The /etc/csh.cshrc and ~/.tcshrc files will be executed every time a new TC shell is started. The .login file is executed only once when the user logs on, and also contains commands and variables to initialize the user's environment. After executing commands from all the startup files, the prompt (> is the default) appears on your screen and the tcsh awaits commands. See Figure 13.2.

Figure 13.2. If any of these initialization files exist, they are sourced in this sequence.



When logging out, the user presses Control−D or will be automatically logged out if the autologout shell variable has been set. Before logging off, the shell looks for a file called /etc/csh.logout or ~/.logout in the home directory and if either is located, its commands will be executed. The .logout file normally contains commands to clean up temporary files, append data to logfiles, wish the user a good day, etc.

13.2 The TC Shell Environment

13.2.1 Initialization Files

After the tcsh program starts, it is programmed to execute a systemwide startup file, /etc/csh.cshrc, and then two shell initialization files in the user's home directory: the .tcshrc file and then the .login file. These files allow users to initialize their own environment.

Example 13.2

```
# /etc/csh.cshrc
# Systemwide environment and startup programs for csh users

1  if ($?PATH) then
2      setenv PATH "${PATH}:/usr/X11R6/bin"
   else
3       setenv PATH "/bin:/usr/bin:/usr/local/bin:/usr/X11R6/bin"
   endif

4  if ($?prompt) then
5       [ "$SHELL" = /bin/tcsh ]
```

```
6       if  ($status == 0) then
7            set prompt='[%n@%m %c]$ '
8       else
9            set prompt=\['id −nu'@'hostname −s'\]\$\
10      endif
   endif
11 limit coredumpsize 1000000

12  [ 'id −gn' = 'id −un' −a 'id −u' −gt 14 ]
13  if $status then
14      umask 022
    else
15      umask 002
    endif

16  setenv HOSTNAME '/bin/hostname'
17  set history=1000

18  test −d /etc/profile.d
19    if ($status == 0) then
20      set nonomatch
21        foreach i ( /etc/profile.d/*.csh )
22           test −f $i
             if ($status == 0) then
23                    source $i
             endif
        end
24     unset nonomatch
      endif
```

EXPLANATION

1. $?PATH is a test to see if the PATH variable has been set; it returns 1 if true.
2. If the PATH variable has been set, /usr/X11R6/bin is appended to it. This is a directory that contains the X windows files.
3. If the PATH variable has not been previously set, this line sets it to /bin:/usr/bin:/usr/local/bin:/usr/X11R6/bin
4. This line checks to see if the prompt has been set.
5. When you place the expression in square brackets, the expression will be tested and if the result of the expression is true, a zero exit status is returned; otherwise a nonzero exit status is returned. If the value of the SHELL environment variable is /bin/tcsh, the exit status will be 0.
6. The status variable contains the exit status of the last command executed, which in this example, is the previous test on line 5.
7. If the status from the last command was zero, the prompt for the /bin/tcsh is set. The prompt will be set to the user's name followed by an @ symbol, the hostname, and the current working directory (all enclosed in [ ]), followed by a dollar sign; e.g., [ellie@homebound ~]$
8. If the status was nonzero, the else branches program control to line 9.
9. This line sets the prompt for the standard csh program. It will print the user's name (id −un), an @ symbol, and the short name for his host machine, i.e., the hostname cut at the first dot, and a $.
10. The endif terminates the inner if block.
11. The size of core files (usually created when a program crashes for some illegal system operation) is limited to 1,000,000 bytes. Core files are created if you abort a running

program with Control−\.

12. If the group ID number and the user ID number are the same, and the user ID number is greater than 14, then the next line will be executed; otherwise, the line under the else will be executed. Typically, user IDs below 14 are for special users, such as root, daemon, adm, lp, etc. (See /etc/passwd. The user ID is in field number 3.)
13. If the test in the previous line returned a nonzero exit status, line 14 is executed, else line 15 is executed.
14. The umask command sets the file creation mask; i.e., the initial permissions for files and directories when created. Directories will get 755 (rwxr−xr−x) and files will get 644 (rw−r−−r−−) when they are created.
15. Umask is set so that when a directory is created, its permissions will be 775 (rwxrwxr−x) and files will get 664 (rw−rw−r−−).
16. The environment variable HOSTNAME is assigned the output of the /bin/hostname command.
17. The history variable is set to 1000. When commands are typed at the command line, they are saved in a history list. When you set the history variable to 1000, no more than 1,000 commands will be displayed when the history command is typed.
18. The test command returns zero exit status if the /etc/profile.d directory exists, and nonzero if it doesn't.
19. If the status is 0, the directory exists, and the program branches to line 20.
20. The nonomatch variable is set to prevent the shell from sending an error message if any of its special metacharacters (*, ?, []) cannot be matched.
21. The foreach loop assigns each file with a .csh extension (*.csh) in the /etc/profile.d directory to the variable i, in turn, looping until each file has been tested (lines 22–24).
22. If the filename assigned to variable i is a regular file (−f), then go to the next line.
23. If the test returned a 0 status (true), then source the file; i.e., execute it in the context of the current environment.
24. The end keyword marks the end of the loop body.

The ~/.tcshrc File. The .tcshrc file contains tcsh variable settings and is executed every time a tcsh subshell is started. Aliases and history are normally set here.

Example 13.3

```
(The .tcshrc File)
1  if ( $?prompt ) then
2    set prompt = "\! stardust > "
3    set history = 100
4    set savehist = 5
5    set noclobber
6    set rmstar

7    set cdpath = ( /home/jody/ellie/bin /usr/local/bin /usr/bin )
8    set ignoreeof
9    alias m more
     alias status 'date;du −s'
     alias cd 'cd \!*;set prompt = "\! <$cwd> "'
10 endif
```

EXPLANATION

1. If the prompt has been set ($?prompt), the shell is running interactively; i.e., it is not running in a script. Prompts are set only for interactive shells.

2. The primary prompt is set to the number of the current history event, the name stardust, and a > character. This will change the > prompt, the default.
3. The history variable is set to 100. This controls the number of history events that will appear on the screen. The last 100 commands you entered will be displayed when you type history. (See "History".)
4. Normally, when you log out, the history list is cleared. The savehist variable allows you to save a specified number of commands from the end of the history list. In this example, the last five commands will be saved in a file in your home directory, the .history file, so that when you log in again, the shell can check to see if that file exists and put the history lines saved at the top of the new history list.
5. The noclobber variable is set to protect the user from inadvertently removing files when using redirection. For example, sort myfile > myfile will destroy myfile. With noclobber set, the message file exists will appear on the screen if you attempt to redirect output to an existing file.
6. If the tcsh variable rmstar is set, the user will be asked if he really wants to remove all his files after entering rm *; i.e., he is given a chance to save himself from removing all files in his current working directory.
7. The cdpath variable is assigned a list of path elements. When changing directories, if you specify just the directory name, and that directory is not a subdirectory directly below the current working directory, the shell will search the cdpath directory entries to see if it can find the directory in any of those locations and then will change the directory.
8. The ignoreeof variable prevents you from logging out with ^D (Control−D). UNIX utilities that accept input from the keyboard, such as the mail program, are terminated by pressing ^D. Often, on a slow system, the user will be tempted to press ^D more than once. The first time, the mail program would be terminated; the second time, the user is logged out. By setting ignoreeof, you are required to type logout to log out.
9. The aliases are set to give a shorthand notation for a single command or group of commands. Now when you type the alias, the command(s) assigned to it will be executed. The alias for the more command is m. Every time you type m, the more command is executed. The status alias prints the date and a summary of the user's disk usage. The cd alias creates a new prompt every time the user changes directories. The new prompt will contain the number of the current history event (\!*) and the current working directory ($cwd) surrounded by < >. (See "Aliases".)
10. The endif marks the end of the block of statements following the if construct on line 1.

The ~/.login File. The .login file is executed one time when you first log in. It normally contains environment variables and terminal settings. It is the file where window applications are usually started. Because environment variables are inherited by processes spawned from this shell and only need to be set once, and terminal settings do not have to be reset for every process, those settings belong in the .login file.

Example 13.4

```
(The .login File)
1  stty −istrip
2  stty erase ^h
3  stty kill ^u
   #
   # If possible start the windows system.
   # Give a user a chance to bail out
   #
4  if ( $TERM == "linux" ) then
5              echo "Starting X windows.  Press control C \
                    to exit within the next 5 seconds "
               sleep 5
```

```
6             startx
7   endif
8   set autologout=60
```

EXPLANATION

1. The stty command sets options for the terminal. Input characters will not be stripped to seven bits if −istrip is used.
2. The stty command sets Control−H, the Backspace key, to erase.
3. Any line beginning with # is a comment. It is not an executable statement.
4. If the current terminal window (tty) is the console (linux), the next line is executed; otherwise, program control goes to the last endif.
5. This line is echoed to the screen, and if the user does not press Control−C to kill the process, the program will sleep (pause) for five seconds, and then the X windows program will start.
6. The startx program launches X windows.
7. The endif marks the end of the innermost if construct.
8. The autologout variable is set to 60 so that after 60 minutes of inactivity, the user will automatically be logged out (from the login shell).

13.2.2 The Search Path

The path variable is used by the shell to locate commands typed at the command line. The search is from left to right. The dot (.) represents the current working directory. If the command is not found in any of the directories listed in the path, or in the present working directory, the shell sends the message Command not found. to standard error. It is recommended that the path be set in the .login file.[4] The search path is set differently in the TC shell than it is in the Bash and Korn shells. Each element is separated by whitespace in the TC shell, but separated by colons in the other shells.

The TC shell internally updates the environment variable for PATH to maintain compatibility with other programs, such as the Bash, Bourne, or Korn shells, that may be started from this shell and will need to use the path variable.

Example 13.5

```
# Path is set in the ~/.tcshrc file.

1  set path = (/usr/bin /bin /usr/bsd /usr/local/bin  .)

2  echo $path
   /usr/bin /bin /usr/bsd /usr/local/bin .

# The environment variable PATH will display as a colon−separated list

3  echo $PATH
   /usr/bin:/bin:/usr/bsd:/usr/local/bin:.
```

EXPLANATION

1. The search path is set for tcsh. It consists of a space−separated list of directories searched from left to right by tcsh when a command is entered at the command line. The search path is local to the current shell. (See "Setting Local Variables" on page 905.)
2. The value of the path variable is displayed

3. The value of the environment variable, PATH, is displayed. It is a colon−separated list of the same directories as listed in the path variable, and is passed to other programs or applications invoked from the current shell. (Bash, sh, and ksh set the path as a colon−separated list.)

The rehash Command. The shell builds an internal hash table consisting of the contents of the directories listed in the search path. (If the dot is in the search path, the files in the dot directory, the current working directory, are not put in the hash table.) For efficiency, the shell uses the hash table to find commands that are typed at the command line, rather than searching the path each time. If a new command is added to one of the directories already listed in the search path, the internal hash table must be recomputed. You do this by typing the following:

```
rehash
```

The hash table is also automatically recomputed when you change your path or start another shell.

The hashstat Command. The hashstat command displays performance statistics to show the effectiveness of its search for commands from the hash table. The statistics are in terms of "hits" and "misses." If the shell finds most of its commands you used at the end of your path, it has to work harder than if they were at the front of the path, resulting in a higher number of misses than hits. In such cases, you can put the most heavily hit directory toward the front of the path to improve performance.[5] The unhash built−in command disables the use of the internal hash table.

```
> hashstat
1024 hash buckets of 16 bits each
```

The source Command. The source command is a built−in shell command, that is, part of the shell's internal code. It is used to execute a command or set of commands from a file. Normally, when a command is executed, the shell forks a child process to execute the command, so that any changes made will not affect the original shell, called the parent shell. The source command causes the program to be executed in the current shell, so that any variables set within the file will become part of the environment of the current shell. The source command is normally used to reexecute the .tcshrc, .cshrc or .login if either has been modified. For example, if the path is changed after logging in, type

```
> source .login or source .tcshrc
```

13.2.3 The Shell Prompts

The TC shell has three prompts: the primary prompt (a > symbol), the secondary prompt (a question mark [?] followed by a tcsh command such as while, foreach, or if), and a third prompt used for the spelling correction feature. The primary prompt is the prompt that is displayed on the terminal after you have logged in. It can be reset. If you are writing scripts at the prompt that require tcsh programming constructs, for example, decision−making or looping, the secondary prompt will appear so that you can continue on to the next line. It will continue to appear after each newline until the construct has been properly terminated. The third prompt appears to confirm automatic spelling correction if spelling correction is turned on. (See "Spelling Correction".) It contains the string CORRECT > corrected command (y|n|e|a)?. The prompts can be customized by adding special formatting sequences to the prompt string. See Table 13.1.

Table 13.1. Prompt Strings

StringWhat It Sets%/The current working directory.%~The current working directory, where ~ represents the user's home directory and other users' home directories are represented by ~user.%c[[0]n], %.[[0]n]The trailing component of the current working directory, or if n (a digit) is given, n trailing components.%CLike %c, but without ~ substitution.%h, %!, !The current history event number.%MThe full hostname.%mThe hostname up to the first ".".%S (%s)Start (stop) standout mode.%B (%b)Start (stop) boldfacing mode.%U (%u)Start (stop) underline mode.%t, %@The time of day in 12−hour AM/PM format.%TLike %t, but in 24−hour format.%pThe "precise" time of day in 12−hour AM/PM format, with seconds.%PLike %p, but in 24−hour format.^cc is parsed as in bindkey.\cc is parsed as in bindkey.%%A single %.%nThe user name.%dThe weekday in Day format.%DThe day in dd format.%wThe month in Mon format.%WThe month in mm format.%yThe year in yy format.%YThe year in yyyy format.%lThe shell's tty.%LClears from the end of the prompt to the end of the display or the end of the line.%$Expands the shell or environment variable name immediately after the $.%#> (or the first character of the promptchars shell variable) for normal users, # (or the second character of promptchars) for the superuser.%{string%}Includes string as a literal escape sequence. It should be used only to change terminal attributes and should not move the cursor location. This cannot be the last sequence in prompt.%?The return code of the command executed just before the prompt.%RIn prompt2, the status of the parser. In prompt3, the corrected string. In history, the history string.

The Primary Prompt. When running interactively, the prompt waits for you to type a command and press the Enter key. If you do not want to use the default prompt, reset it in the .tcshrc file and it will be set for this and all TC shells subsequently started. If you only want it set for this login session, set it at the shell prompt.

Example 13.6

```
1   > set prompt = '[ %n@%m %c]# '
2   [ ellie@homebound ~]#  cd ..
3   [ ellie@homebound /home]#  cd ..
```

EXPLANATION

1. The primary prompt is assigned the user's login name (%n), followed by the hostname (%m), a space, and the current working directory. The string is enclosed in square brackets, followed by a #.
2. The new prompt is displayed. The ~ appearing in the prompt represents the user's home directory. The cd command changes directory to the parent directory.
3. The new prompt indicates the current working directory, /home. In this way the user always know what directory he is in.

The Secondary Prompt. The secondary prompt appears when you are writing online scripts at the prompt. The secondary prompt can be changed. Whenever shell programming constructs are entered, followed by a newline, the secondary prompt appears and continues to appear until the construct is properly terminated. Writing scripts correctly at the prompt takes practice. Once the command is entered and you press Enter, you cannot back up, and the tcsh history mechanism does not save commands typed at the secondary prompt.

Example 13.7

```
1   > foreach pal (joe tom ann)
2   foreach? echo Hi $pal
3   foreach? end
    Hi joe
    Hi tom
    Hi ann
```

```
4   >
```

EXPLANATION

1. This is an example of online scripting. Because the TC shell is expecting further input after the foreach loop is entered, the secondary prompt appears. The foreach loop processes each word in the parenthesized list.
2. The first time in the loop, joe is assigned to the variable pal, and the string Hi joe is displayed. The next time through the loop, tom is assigned to the variable pal, and so on.
3. The end statement marks the end of the loop. When all of the items in the parenthesized list have been processed, the loop ends and the primary prompt is displayed.
4. The primary prompt is displayed.

Example 13.8

```
1   > set prompt2='%R %% '
2   > foreach name ( joe tom ann )
3   foreach % echo Hi $name
4   foreach % end
    Hi joe
    Hi tom
    Hi ann
5   >
```

EXPLANATION

1. The secondary prompt, prompt2, is reset to the formatted string where %R is the name of the conditional or looping construct entered in line 2 at the primary prompt. The two percent signs will evaluate to one percent sign.
2. The foreach command has been started. This is a looping construct that must end with the keyword end. The secondary prompt will continue to appear until the loop is properly terminated.
3. The secondary prompt is foreach %.
4. After the end keyword is typed, the loop executes.
5. The primary prompt reappears, awaiting user input.

13.2.4 The Command Line

After logging in, the TC shell displays its primary prompt, by default a > symbol. The shell is your command interpreter. When the shell is running interactively, it reads commands from the terminal and breaks the command line into words. A command line consists of one or more words (or tokens) separated by whitespace (blanks and/or tabs) and terminated by a newline, generated by pressing the Enter key. The first word is the command, and subsequent words are the command's options and/or arguments. The command may be a UNIX executable program such as ls or pwd, an alias, a built−in command such as cd or jobs, or a shell script. The command may contain special characters, called metacharacters, that the shell must interpret while parsing the command line. If the last character in the command line is a backslash, followed by a newline, the line can be continued to the next line.[6]

Exit Status and the printexitvalue Variable. After a command or program terminates, it returns an exit status to the parent process. The exit status is a number between 0 and 255. By convention, when a program exits, if the status returned is zero, the program was successful in its execution. When the exit status is nonzero, then it failed in some way. If the program terminated abnormally, then 0200 is added to the status. Built−in commands that fail return an exit status of 1; otherwise, they return a status of 0.

The tcsh status variable or ? variable is set to the value of the exit status of the last command that was executed. Success or failure of a program is determined by the programmer who wrote the program. By setting the tcsh variable printexitvalue, any time a program exits with a value other than zero, its status will automatically be printed.

Example 13.9

```
1   > grep "ellie" /etc/passwd
    ellie:GgMyBsSJavd16s:501:40:E Quigley:/home/jody/ellie:/bin/tcsh
2   > echo $status  or echo $?
    0
3   > grep "nicky" /etc/passwd
4   > echo $status
    1
5   > grep "scott" /etc/passsswd
    grep: /etc/passsswd: No such file or directory
6   > echo $status
    2
7   > set printexitvalue
    > grep "XXX" /etc/passwd
    Exit 1
   >
```

EXPLANATION

1. The grep program searches for the pattern ellie in the /etc/passwd file and is successful. The line from /etc/passwd is displayed.
2. The status variable is set to the exit value of the grep command; 0 indicates success. The ? variable also holds the exit status. This is also the variable used by the bash and ksh shells for checking exit status. (It is not used by csh.)
3. The grep program cannot find user nicky in the /etc/passwd file.
4. The grep program cannot find the pattern, so it returns an exit status of 1.
5. The grep fails because the file /etc/passsswd cannot be opened.
6. Grep cannot find the file, so it returns an exit status of 2.
7. The special tcsh variable printexitvalue is set. It will automatically print the exit value of any command that exits with a nonzero value.

Command Grouping A command line can consist of multiple commands. Each command is separated by a semicolon and the command line is terminated with a newline.

Example 13.10

```
> ls; pwd; cal 2001
```

EXPLANATION

The commands are executed from left to right until the newline is reached.

Commands may also be grouped so that all of the output is either piped to another command or redirected to a file. The shell executes commands in a subshell.

Example 13.11

```
1   > ( ls ; pwd; cal 2001 ) > outputfile
2   > pwd; ( cd / ; pwd ) ; pwd
    /home/jody/ellie
    /
    /home/jody/ellie
```

EXPLANATION

1. The output of each of the commands is sent to the file called outputfile. Without the parentheses, the output of the first two commands would go to the screen, and only the output of the cal command would be redirected to the output file.
2. The pwd command displays the present working directory. The parentheses cause the commands enclosed within them to be processed by a subshell. The cd command is built into the shell. While in the subshell, the directory is changed to root and the present working directory is displayed. When out of the subshell, the present working directory of the original shell is displayed.

Conditional Execution of Commands. With conditional execution, two command strings are separated by two special metacharacters: two ampersands (&&), or double vertical lines (||). The command on the right of either of these metacharacters will or will not be executed based on the exit condition of the command on the left.

Example 13.12

```
> grep '^tom:' /etc/passwd && mail tom < letter
```

EXPLANATION

If the first command is successful (has a zero exit status), the second command after the && is executed. If the grep command successfully finds tom in the passwd file, the command on the right will be executed: The mail program will send tom the contents of the letter file.

Example 13.13

```
> grep '^tom:' /etc/passwd || echo "tom is not a user here."
```

EXPLANATION

If the first command fails (has a nonzero exit status), the second command after the || is executed. If the grep command does not find tom in the passwd file, the command on the right will be executed: The echo program will print tom is not a user here to the screen.

Commands in the Background. Normally, when you execute a command, it runs in the foreground, and the prompt does not reappear until the command has completed execution. It is not always convenient to wait for the command to complete. When you place an ampersand at the end of the command line, the shell prompt will return immediately so that you do not have to wait for the last command to complete before starting another one. The command running in the background is called a background job and its output will be sent to the screen as it processes. It can be confusing if two commands are sending output to the screen concurrently. To avoid confusion, you can send the output of the job running in the background to a file or pipe it to another device such as a printer. It is often handy to start a new shell window in the background. Then you will have access to both the window from which you started and the new shell window.

Example 13.14

```
1   > man tcsh | lpr &
2   [1] 4664
3   >
```

EXPLANATION

1. The output from the man pages for the tcsh program is piped to the printer. The ampersand at the end of the command line puts the job in the background.
2. There are two numbers that appear on the screen: the number in square brackets indicates that this is the first job to be placed in the background; the second number is the PID of this job.
3. The shell prompt appears immediately. While your program is running in the background, the shell is prompting you for another command in the foreground.

13.3 Command Line Shortcuts

13.3.1 History

The history mechanism is built into the TC shell. It keeps in memory a sequentially numbered list of the commands, called events, that you have typed at the command line. In addition to the number of the history event, it also keeps track of the time the event was entered at the terminal. When the shell reads a command from the terminal, it breaks the command line into words (using whitespace to designate a word break), saves the line to the history list, parses it, and then executes it. The previous command typed is always saved. You can recall a command at any time from the history list and reexecute it without retyping the command. During a login session, the commands you type are appended to the history list until you exit, at which time they can be saved in a file in your home directory, called .history[7]. The terms history list and history file can be somewhat confusing. The history list consists of the command lines currently held in the shell's memory. The history file, normally called .history, is the text file where those commands are saved for future use. The built−in variable, savehist, saves the history list to the .history file when you log out and loads its contents into memory when you start up. (See −S and −L options to the history command in Table 13.2.) The history built−in command displays the history list. It supports a number of arguments to control how the history is displayed.

Table 13.2. The history Command and Options

Option	Meaning
−h	Prints history list without numbers.
−T	Prints timestamps in comment form.
−r	Prints history list in reverse.
−S [filename]	Saves history list to .history or filename if given.
−L [filename]	Appends history file (.history or filename) to the history list.
−M [filename]	Like −L, except merges contents of history file with current history list.
−c	Clears the history list in memory, not the history file.
n	n is a number, e.g., history 5, controlling the number of lines displayed.

Although the default name for the history file is .history, its name can be changed by assigning an alternative name to the built−in shell variable, histfile. The history shell variable is set to a number specifying how many commands to display and the histdup variable can be set so that duplicate entries are not added to the history file.

Example 13.15

```
(The Command Line)
> history
1 17:12   cd
2 17:13   ls
3 17:13   more /etc/fstab
4 17:24   /etc/mount
5 17:54   sort index
6 17:56   vi index
```

EXPLANATION

The history list displays the last commands that were typed at the command line. Each event in the list is preceded with a number (called an event number) and the time that it was entered at the command line.

The history Variable. The TC shell history variable can be set to the number of events from the history list that will be displayed on the terminal. Normally, this is set in the /etc/.cshrc or ~/.tcshrc file, the user's initialization file. It is set to 100 by default. You can also provide an optional second value for the history variable to control the way the history is formatted. This value uses the same formatting sequences as the prompt variable. (See Table 13.1.) The default format string for history is: %h\t%T\t%R\n.

Example 13.16

```
1   set history=1000

2   set history= ( 1000 '%B%h %R\n' )

3   history
    136 history
    137 set history = ( 1000 '%B%h %R\n' )
    138 history
    139 ls
    140 pwd
    141 cal
    141 pwd
    142 cd
```

EXPLANATION

1. The last 1,000 commands typed at the terminal can be displayed on the screen by typing the history command.
2. The last 1,000 commands typed at the terminal are displayed. The format string causes the history list to be displayed in bold text (%B) first with the event number (%h), then a space, and finally the command that was typed (%R) at the command line followed by a newline (\n).
3. When you type history, the new format is shown. This is only a selected section of the real history list.

Saving History and the savehist Variable. To save history events across logins, set the savehist variable. This variable is normally set in the .tcshrc file, the user's initialization file. If the first value assigned to savehist is a number, it cannot exceed the number set in the history variable, if the history variable is set. If the second value is set to merge, the history list is merged with the existing history file instead of replacing it. It is sorted by timestamp, and the most recent events saved.

Example 13.17

```
1   set savehist
2   set savehist = 1000
3   set savehist = 1000 merge
```

EXPLANATION

1. The commands from the history list are saved in the history file and will be at the top of the history list the next time you log in.
2. The history file is replaced with the last 1,000 commands from the history list, and saved. It will be displayed when you next log in.
3. Rather than replacing the existing history file, the current history list will be merged with the existing history file when you log out and loaded into memory after you log in.

Displaying History. The history command displays the events in the history list. The history command also has options that control the number of events and the format of the events that will be displayed. The numbering of events does not necessarily start at one. If you have 100 commands on the history list, and you have set the history variable to 25, you will only see the last 25 commands saved.

Example 13.18

```
1   > set history = 10
2   > history
    1 ls
    2 vi file1
    3 df
    4 ps −eaf
    5 history
    6 more /etc/passwd
    7 cd
    8 echo $USER
    9 set
    10 ls
```

EXPLANATION

1. The history variable is set to 10. Only the last 10 lines of the history list will be displayed, even if there may be many more.
2. The last 10 events from the history are displayed. Each command is numbered.

Example 13.19

```
1   > history −h        # Print without line numbers
    ls
    vi file1
    df
    ps −eaf
    history
    more /etc/passwd
    cd
    echo $USER
    set
    history −n

2   > history −c
```

EXPLANATION

1. With the h option, the history list is displayed without line numbers.
2. With the c option, the history list is cleared.

Example 13.20

```
> history −r        # Print the history list in reverse
11 history −r
10 history −h
 9 set
 8 echo $USER
 7 cd
 6 more /etc/passwd
 5 history
 4 ps −eaf
 3 df
 2 vi file1
 1 ls
```

EXPLANATION

The history list is displayed in reverse order.

Example 13.21

```
> history 5       # Print the last 5 events on the history list
7  echo $USER
8  cd
9  set
10 history −n
11 history 5
```

EXPLANATION

The last five commands on the history list are executed.

Accessing Commands from the History File. There are several ways to access and repeat commands from the history list. You can use the arrow keys to scroll up and down the history list, and to move left and right across lines, editing as you go; you can use a mechanism called history substitution to reexecute and fix spelling mistakes; or you can use the built−in emacs or vi editors to retrieve, edit, and execute previous commands. We'll step through each of these procedures and then you can choose whatever way works best for you.

1. The Arrow Keys

   To access commands from the history list, you can use the arrow keys on the keyboard to move up and down through the history list, and from left to right. You can edit any of the lines in the history list by using the standard keys for deleting, backspacing, etc. As soon as you have edited the line, pressing the carriage return (Enter key) will cause the command line to be reexecute. You can also use standard emacs or vi commands to edit the history list. (See Table 13.5 and Table 13.6). The arrow keys behave the same way for both the vi and emacs key bindings. (See Table 13.3.)

Table 13.3. The Arrow Keys

↑Up arrow moves up the history list. ↓Down arrow moves down the history list. ⟶Right arrow moves cursor to right on history command. ⟵Left arrow moves cursor to left on history command.

2. Reexecuting and Bang! Bang!

   To reexecute a command from the history list, use the exclamation point (bang) to start history substitution. The exclamation point can begin anywhere on the line and can be escaped with a backslash. If the ! is followed by a space, tab, or newline, it will not be interpreted. There are a number of ways to use history substitution to designate what part of the history list you want to redo. (See Table 13.4.) If you type two exclamation points (!!), the last command is reexecuted. If you type the exclamation point followed by a number, the number is associated with the command from the history list and the command is executed. If you type an exclamation point and a letter, the last command that started with that letter is executed. The caret (^) is also used as a shortcut method for editing the previous command.

   After history substitution is performed, the history list is updated with the results of the substitution shown in the command. For example, if you type !!, the last command will be reexecuted and saved in the history list in its expanded form. If you want the last command to be added to the history list in its literal form; i.e., !!, then set the histlit\1 shell variable.

Example 13.22

```
1   > date
    Mon Feb  8 12:27:35 PST 2001

2   > !!
    date
    Mon Aug  10 12:28:25 PST 2001

3   > !3
    date
    Mon Aug  10 12:29:26 PST 2001

4   > !d
    date
    Mon Aug  10 12:30:09 PST 2001

5   > dare
    dare: Command not found.

6   > ^r^t
    date
    Mon Apr  10 16:15:25 PDT 2001

7   > history
    1 16:16  ls
    2 16:16  date
    3 16:17  date
    4 16:18  date
    5 16:18  dare
    6 16:18  date

8   > set histlit

9   > history
```

```
1 16:18  ls
2 16:19  date
3 16:19  !!
4 16:20  !3
5 16:21  dare
6 16:21  ^r^t
```

EXPLANATION

1. The UNIX date command is executed at the command line. The history list is updated. This is the last command on the list.
2. The !! (bang bang) gets the last command from the history list; the command is reexecuted.
3. The third command on the history list is reexecuted.
4. The last command on the history list that started with the letter d is reexecuted.
5. The command is mistyped.
6. The carets are used to substitute letters from the last command on the history list. The first occurrence of an r is replaced with a t.
7. The history command displays the history list, after history substitution has been performed.
8. By setting histlit, the shell will perform history substitution, but will put the literal command typed, on the history list; i.e., just as it was typed.
9. When histlit is set, the output of the history command shows what commands were literally typed before history substitution took place. (This is just a demo; the history numbers are not accurate.)

Example 13.23

```
1   > cat file1 file2 file3

        <Contents of files displayed here>

    > vi !:1
    vi file1

2   > cat file1 file2 file3

    <Contents of file, file2, and file3 are displayed here>

    > ls !:2
    ls file2
    file2

3   > cat file1 file2 file3
    > ls  !:3
    ls file3
    file3

4   > echo a b c
    a b c
    > echo !$
    echo c
    c

5   > echo a b c
    a b c
    > echo !^
    echo a
```

```
    a

6   > echo a b c
    a b c
    > echo !*
    echo a b c
    a b c

7   > !!:p
    echo a b c
```

EXPLANATION

1. The cat command displays the contents of file1, file2, and file3 to the screen. The history list is updated. The command line is broken into words, starting with word number zero. If the word number is preceded by a colon, that word can be extracted from the history list. The !:1 notation means, get the first argument from the last command on the history list and replace it in the command string. The first argument from the last command is file1. (Word 0 is the command itself.)
2. The !:2 is replaced with the second argument of the last command, file2, and given as an argument to ls. file2 is printed. (file2 is the third word.)
3. ls !:3 reads, go to the last command on the history list and get the fourth word (words start at zero) and pass it to the ls command as an argument. (file3 is the fourth word.)
4. The bang (!) with the dollar sign ($) refers to the last argument of the last command on the history list. The last argument is c.
5. The caret (^) represents the first argument after the command. The bang (!) with the ^ refers to the first argument of the last command on the history list. The first argument of the last command is a.
6. The asterisk (*) represents all arguments after the command. The bang (!) with the * refers to all of the arguments of the last command on the history list.
7. The last command from the history list is printed but not executed. The history list is updated. You could now perform caret substitutions on that line.

Table 13.4. Substitution and History

Event Designators Meaning!Indicates the start of history substitution.!!Reexecutes the previous command.!NReexecutes the Nth command from the history list.!−NReexecutes the Nth command back from present command.!stringReexecutes the last command starting with string.!?string?Reexecutes the last command containing string.!?string?%Reexecutes the most recent command line argument from the history list containing string.!^Uses the first argument of the last history command in the current command line.!*Uses all of the arguments from the last history command in the current command line.!$Uses the last argument from the last history command in the current command line.!! stringAppends string to the previous command and executes.!N stringAppends string to Nth command in history list and executes.!N:s/old/new/In previous Nth command, substitutes the first occurrence of old string with new string.!N:gs/old/new/In previous Nth command, globally substitutes old string with new string.^old^new^In last history command, substitutes old string with new string.command !N:wnExecutes current command appending an argument (wn) from the Nth previous command. wn is a number starting at 0, 1, 2, … designating the number of the word from the previous command; word 0 is the command itself, and 1 is its first argument, etc.!N:pPuts the command at the bottom of the history list and prints it, but doesn't execute it.

13.3.2 The Built−In Command Line Editors

The command line can be edited by using the same type of key sequences that you use in either the emacs or vi editors. You can use editor commands to scroll up and down the history list. Once the command is found, it can be edited, and by pressing the Enter key, reexecuted. When the shell was compiled, it was given a default set of key bindings for the emacs editor.

The bindkey Built−In Command. The built−in bindkey command is used to select either vi or emacs for command line editing and to list and set key bindings for the respective editors. To use vi as your command line editor, use bindkey with the −v option:

```
bindkey −v
```

and to go back to emacs:

```
bindkey −e
```

To see a list of editor commands and a short description of what each does, type

```
bindkey −l
```

And to see the actual keys and how they are bound, type

```
bindkey
```

To actually bind keys to commands, see "Binding Keys" on page 858.

The vi Built−In Editor. To edit the history list, go to the command line and press the Esc key. Then press the K key if you want to scroll upward in the history list, and the J key to move downward, just like standard vi motion keys. When you find the command that you want to edit, use the standard keys that you would use in vi for moving left and right, deleting, inserting, and changing text. See Table 13.5. After making the edit, press the Enter key. The command will be executed and added to the bottom of the history list. If you want to add or insert text, then use any of the insertion commands (i, e, o, O, etc.). Remember, vi has two modes: the command mode and the insert mode. You are always in the insert mode when you are actually typing text. To get back to the command mode, press the Escape key (Esc).

Table 13.5. vi Commands

Command Function Moving Through the History FileEsc k or +Move up the history list.Esc j or −Move down the history list.GMove to first line in history file.5GMove to fifth command in history file./stringSearch upward through history file.?String search downward through history file. Moving Around on a LinehMove left on a line.lMove right on a line.bMove backward a word.e or wMove forward a word.^ or 0Move to beginning of first character on the line.$Move to end of line. Editing with via AAppend text.i IInsert text.dd dw xDelete text into a buffer (line, word, or character).cc CChange text.u UUndo.yy YYank (copy a line into buffer).p PPut yanked or deleted line down below or above the line.r RReplace a letter or any amount of text on a line.

The emacs Built−In Editor. If you are using the emacs built−in editor, like vi, start at the command line. To start moving upward through the history file, press ^P. To move down, press ^N . Use emacs editing commands to change or correct text, then press Enter, and the command will be reexecuted. See Table 13.6.

Table 13.6. emacs Commands

Command Function Ctrl−PMove up history file.Ctrl−NMove down history file.Ctrl−BMove backward one character.Ctrl−RSearch backward for string.Esc BMove back one word.Ctrl−FMove forward one character.Esc FMove forward one word.Ctrl−AMove to the beginning of the line.Ctrl−EMove to the end of the line.Esc <Move to the first line of the history file.Esc >Move to the last line of the history file. Editing with emacsCtrl−UDelete the line.Ctrl−YPut the line back.Ctrl−KDelete from cursor to the end line.Ctrl−DDelete a letter.Esc DDelete one word forward.Esc HDelete one word backward.Esc spaceSet a mark at cursor position.Ctrl−X Ctrl−XExchange cursor and mark.Ctrl−P Ctrl−YPush region from cursor to mark into a buffer (Ctrl−P) and put it down (Ctrl−Y).

Binding Keys. The bindkey built−in command lists all the standard key bindings including key bindings for emacs and vi. The key bindings are divided up into four groups: the standard key bindings, alternative key bindings, multicharacter key bindings, and the arrow key bindings. The bindkey command also allows you to change the current bindings of keys.

Example 13.24

```
1   > bindkey
    Standard key bindings
    "^@"           ->  is undefined
    "^A"           ->  beginning−of−line
    "^B"           ->  backward−char
    "^C"           ->  tty−sigintr
    "^D"           ->  list−or−eof
    "^E"           ->  end−of−line
    "^F"           ->  forward−char
    "^L"           ->  clear−screen
    "^M"           ->  newline
            ...   ....
    Alternative key bindings
    "^@"           ->  is undefined
    "^A"           ->  beginning−of−line
    "^B"           ->  is undefined
    "^C"           ->  tty−sigintr
    "^D"           ->  list−choices
    "^E"           ->  end−of−line
    "^F"           ->  is undefined
        ......  .....
    Multi−character bindings
    "^[[A"         -> up−history
    "^[[B"         -> down−history
    "^[[C"         -> forward−char
    "^[[D"         -> backward−char
    "^[OA"         -> up−history
    "^[OB"         -> down−history
         ...  ....
    Arrow key bindings
    down           -> down−history
    up             -> up−history
    left           -> backward−char
    right          -> forward−char
```

The −l option to bindkey lists the editor commands and what they do. See Example 13.25.

Example 13.25

```
>  bindkey  −l

backward−char
    Move back a character
backward−delete−char
    Delete the character behind cursor
backward−delete−word
    Cut from beginning of current word to cursor − saved in cut buffer
backward−kill−line
    Cut from beginning of line to cursor − save in cut buffer
backward−word
    Move to beginning of current word
beginning−of−line
    Move to beginning of line
capitalize−word
    Capitalize the characters from cursor to end of current word
change−case
    Vi change case of character under cursor and advance one character
change−till−end−of−line
    Vi change to end of line
clear−screen
Standard key bindings
           .....    ...
```

The bindkey command can also display the values for individual key bindings, as shown in Example 13.26. The emacs mappings are shown by default, but with the −a option to bindkey, the alternate mappings for vi keys are displayed. The arguments to bindkey are specified as a sequence of special characters to represent the key sequences followed by the editing command key to which the key will be bound. You can bind keys not only to emacs or vi editor commands, but also to UNIX commands and strings.

Table 13.7. Key Binding Characters

Characters	Meaning
^C	Control−C.
^[	Esc.
^?	Del.
\a	Control−G (bell).
\b	Control−H (backspace).
\e	Esc (escape).
\f	Formfeed.
\n	Newline.
\r	Return.
\t	Tab.
\v	Control−K (vertical tab).
\nnn	ASCII octal number.

Example 13.26

```
1   > bindkey ^L
    "^L"      −>     clear−screen

2   > bindkey ^C
    "^C"      −>     tty−sigintr

3   > bindkey "j"
    "j"       −>     self−insert−command

4   > bindkey −v

5   > bindkey −a "j"
    "j"       −>     down−history
```

EXPLANATION

1. The bindkey command with a Control key (^L) displays to what command the control key is bound. ^L causes the screen to be cleared.
2. Control−C (^C) is bound to the interrupt signal, which normally terminates a process.
3. Lowercase j is an emacs self−insert−command that does nothing but insert that letter into the buffer.
4. In order to see the alternate vi key bindings, be sure you have set the vi command line editor with bindkey −v, as shown here.
5. With the −a option, bindkey displays the alternate key mapping for j; i.e., the vi key for moving down the history list.

Example 13.27

```
1    > bindkey "^T" clear−screen

2    > bindkey "^T"
     "^T"      −>     clear−screen

3    > bindkey −a "^T"
     "^T"      −>     undefined−key

4    > bindkey −a  [Control−v Control t] clear−screen
          Press keys one after the other

5    > bindkey −a [Control−v Control t]
     "^T"       −>     clear−screen

6    > bindkey −s '\ehi'  'Hello to you!\n'
     > echo [Esc]hi    Press escape followed by 'h' and 'i'
       Hello to you!
     >
7    > bindkey '^[hi'
     "^[hi"    −>   "Hello to you!"

8    > bindkey −r '\[hi'

9    > bindkey '\ehi'
     Unbound extended key "^[hi"

10   > bindkey −c '\ex' 'ls | more'
```

EXPLANATION

1. Control−T is bound to the command to clear the screen, a default emacs key mapping. This key sequence was not originally bound to anything. Now when the Control and T keys are pressed together, the screen will be cleared.
2. The bindkey command, with the key sequence as an argument, will display the mapping for that sequence, if there is one.
3. With the −a option and a key sequence, bindkey displays the value of the alternate key map, vi. In this example, bindkey with the −a option and the key sequence shows that the alternate mapping (vi) does not have this sequence bound to anything.
4. With the −a option, bindkey can bind keys to the alternate key map, vi. By pressing Control−V followed by Control−T, the key sequence is created and assigned the value clear−screen. Control−V/Control−T can also be represented as "^T", as shown in the

previous example.
5. The bindkey function displays the alternate mapping for ^T and its command.
6. With the −s command, bindkey will bind a literal string to a key sequence. Here the string Hello to you!\n is bound to the escape sequence hi. By pressing the Esc key and then an h and an i, the string will be sent to standard output.
7. The bindkey command displays the binding for the escape sequence hi. The ^[is another way to represent Esc (escape).
8. With the −r option, bindkey removes a key binding.
9. Because the key binding was removed, the output says that this extended key sequence is not bound.
10. With the −c option, bindkey can bind a key sequence to a UNIX command. In this example, pressing the Escape key followed by the X key will cause the command ls to be piped to more.

Table 13.8. bindkey Options

bindkey Lists All Key Bindingsbindkey −aAllow alternate key mapping.bindkey −dRestore default bindings.bindkey −eUse emacs bindings.bindkey −lDisplay all editing commands and what they mean.bindkey −uDisplay usage message.bindkey −vUse vi key bindings.bindkey keyDisplay binding for key.bindkey key commandBind key to emacs or vi command.bindkey −c key commandBind key to UNIX command.bindkey −s key stringBind key to string.bindkey −r keyRemove key binding.

13.3.3 Command, Filename, and Variable Completion

To save typing, tcsh has a mechanism called completion that allows you to type part of a command, filename, or variable, and then, by pressing the Tab key, have the rest of the word completed for you.

If you type the first few letters of a command and press the Tab key, tcsh will attempt to complete the command name. If tcsh cannot complete the command because it doesn't exist, the terminal will beep and the cursor will stay at the end of the command. If there is more than one command starting with those characters, by pressing Control−D, all commands that start with those characters will be listed.

Filename and variable completion work the same as command completion. With filename completion, if there are several files starting with the same letters, tcsh will complete the shortest name that matches, expand out the filename until the characters differ, and then flash the cursor for you to complete the rest. See Example 13.28.

The autolist Variable. If the autolist variable is set, and there are a number of possible completions, all of the possible commands, variables, or filenames will be listed depending on what type of completion is being performed when the Tab key is pressed.

Example 13.28

```
1   > ls
    file1 file2 foo foobarckle fumble

2   > lsfu[tab]        # eExpands to filename to fumble

3   > ls fx[tab]       # Terminal beeps, nothing happens
```

```
4   > ls fi[tab]       # Expands to file_  (_ is a cursor)

5   > set autolist

6   > ls f[tab]        # Lists all possibilities
    file1 file2 foo foobarckle fumble

7   > ls foob[tab]     # Expands to foobarckle

8   > da[tab]          # Completes the date command
    date
    Fri Aug 9 21:15:38 PDT 2001

9   > ca[tab]          # Lists all commands starting with ca
    cal    captoinfo  case  cat

10  > echo $ho[tab]me   # Expands shell variables
    /home/ellie/

11  > echo $h[tab]
    history home
```

EXPLANATION

1. All files are listed for the current working directory.
2. After fu is typed, the Tab key is pressed, causing the filename to be completed to fumble, and listed.
3. Because none of the files start with fx, the terminal beeps and the cursor remains but does nothing.
4. There are a number of files starting with fi; the filenames are completed until the letters are no longer the same. When you press Control−D, all files with that spelling are listed.
5. The autolist variable is set. If there are a number of choices when you press the Tab key, autolist displays all the possibilities.
6. After you press the Tab key, a list of all files beginning with f are printed.
7. When the Tab key is pressed, the filename is expanded to foobarckle.
8. When the Tab key is pressed after da, the only command that begins with da is the date command. The command name is expanded and executed.
9. Because autolist is set, when the Tab key is pressed after ca, all commands starting with ca are listed. If autolist is not set, type Control−D to get a list.
10. The leading $ on a word indicates that the shell should perform variable expansion when the Tab key is pressed to complete the word. The variable home is completed.
11. Variable completion is ambiguous in this example. When completion is attempted by pressing the Tab key, all possible shell variables are listed.

The fignore Variable. The shell variable, fignore, can be set to ignore certain filename extensions when filename completion is in use. For example, you may not want to expand files that end in .o because they are unreadable object files. Or maybe you don't want the .gif files to be accidently removed when filenames are expanded. For whatever reason, the fignore variable can be assigned a list of extensions for files that will be excluded from filename expansion.

Example 13.29

```
1   > ls
    baby       box.gif   file2    prog.c
    baby.gif   file1     file3    prog.o
```

```
2   > set fignore = (.o .gif )

3   > echo ba[tab]    # Completes baby but ignores baby.gif
    baby

4   > echo box[tab].gif    # fignore is ignored if only one completion
    box.gif                # is possible

5   > vi prog[tab]         # Expands to prog.c
    Starts vi with prog.c as its argument
```

EXPLANATION

1. The files in the current working directory are listed. Note that some of the files have extensions on their names.
2. The fignore variable allows you to list those filename extensions that should be ignored when filename completion is performed. All filenames ending in either .o or .gif will be ignored.
3. By pressing the Tab key, only the file baby is listed, not baby.gif. The .gif files are ignored.
4. Even though .gif is listed as a suffix to be ignored, fignore will not take effect when there are no other possible completions, such as the same filename without the .gif extension as in line 3.
5. When the vi editor is invoked, prog is expanded to prog.c.

The complete Shell Variable. This is a variable that does a lot! It is a little tricky trying to decipher all it can do from the tcsh man page, but you may find some of these examples helpful for a start. You can control what kind of completion you are doing. For example maybe you only want completion to expand directory names, or a filename depending on its position in the command line, or maybe you would like certain commands to be expanded and others excluded, or even create a list of possible words that can be expanded. Whatever it is you want to do with completion, no doubt, the complete shell variable will accommodate you.

Filename completion can be even more sophisticated if the complete shell variable is set to enchance. This causes tab completion to ignore case; to treat hyphens, periods, and underscores as word separators; and to consider hyphens and underscores as equivalent.

Example 13.30

```
1   > set complete=enchance

2   > ls g..[tab]   expands to gawk−3.0.3
    gawk−3.0.3

3   > ls GAW[tab]   expands to gawk−3.0.3
    gawk−3.0.3
```

EXPLANATION

1. By setting the complete shell variable to enchance, Tab completion will ignore case; will treat hyphens, periods, and underscores as word separators; and will consider hyphens and underscores as equivalent.
2. With enchance set, filename completion expands g.. to any files starting with a g, followed by any two characters (..), and any characters to complete the filename,

including hyphens, periods, etc.
3. With enchance set, filename completion expands GAW to any files starting with GAW, where GAW can be any combination of upper and lowercase letters, and the remaining characters can be any characters even if they contain hyphens, periods, and underscores.

Programming Completions. To customize completions to a more specific functionality, you can program the completions, and then store them in the ~/.tcshrc file, making them part of your tcsh environment each time you start a new TC shell. The purpose of programming completions is to improve efficiency and select types of commands and arguments that will be affected. (The Tab key for word completion and Control−D to list possible completions still work the same way as they did for simple completions.)

Types of Completions. There three types of completions: p, n, and c. A p−type completion is position−dependent. It rules the way a completion is performed based on the position of a word in the command line, where position 0 is the command, position 1 is the first argument, position 2 is the second argument, etc. Suppose, for example, you wanted to guarantee that any time a completion is performed for the built−in cd command, the first (and only) argument to cd is completed only if it is a directory name, nothing else; then you can program the completion as shown in the following example:

```
complete  cd   'p/1/d/'
```

The complete command is followed by the cd command and what is called the completion rule. The p stands for the word position in the command line. The cd command is position 0 and its first argument is position 1. The pattern part of the rule is enclosed in slashes (p/1/ means position 1, the first argument to cd), and will be affected by the completion rule. The d part of the pattern is called a word type. See Table 13.9 for a complete list of word types. The d word type means that only directories are to be affected by the completion. A filename or alias, for example, would not be completed if given as the first argument to cd. The rule states that whenever tab completion is performed on the cd command, it will only take place if the first argument is a directory, and Control−D will only list directories if the match is ambiguous; i.e., there is more than one possible completion. See Example 13.31 for p−type completions.

Example 13.31

```
# p−type completions (positional completion)

1   > complete
    alias     'p/1/a/'
    cd        'p/1/d/'
    ftp       'p/1/( owl ftp.funet.fi prep.ai.mit.edu )'
    man       'p/*/c/'

2   > complete  vi  'p/*/t/'

3   > complete vi
    vi  'p/*/t/'

4   > set autolist

5   > man fin[tab]    # Completes command names
    find     find2perl   findaffix  findsmb  finger

6   > vi b[tab]       # Completes only filenames, not directories
    bashtest binded bindings bindit

7   > vi na[tab]mes

8   > cd sh[tab]ellsolutions/
```

```
9   > set hosts = ( netcom.com 192.100.1.10 192.0.0.200 )

10  > complete telnet 'p/1/$hosts/'

11  > telnet net[tab]com.com
    telnet netcom.com

12  > alias m[tab]   # Completes alias names
    mc mroe mv

13  > ftp prep[tab]
```

EXPLANATION

1. The complete built−in command, without arguments, lists all programmed completions. The following examples (lines 2 through 11) use these completion rules.
2. This rule states that if Tab completion is used when typing arguments to the vi command, that all arguments (*), must be of type t (i.e., plain text files) for completion to performed.
3. The complete command, with the name of a command as its argument, displays the completion rule for that command. The completion rule for vi is displayed.
4. By setting the autolist built−in command all possible Tab completions will automatically be printed. (You don't have to press Control−D.)
5. The man command has a programmed completion: complete man 'p/1/c/'. This rule states that the first argument given to the man command must be a command, because c is defined as a command word type. In this example, completion is attempted with the letters fin as the argument to man. All manual commands starting with fin will be displayed.
6. Only filenames will be completed, because the vi editor completion was programmed to complete only text files, not directories.
7. According to the vi completion rule, only text filenames will be completed, no matter how many arguments are passed.
8. When filename completion is performed on the first argument to the built−in cd command, the only word that will be completed must be the name of a directory as stated in the completion rule. The argument in this example will expand to a directory called shellsolutions.
9. The variable hosts is set to a list of IP addresses or hostnames.
10. The completion rule for telnet states that completion will be performed if position 1 contains one of the hostnames set in the hosts variable. This is a list word type completion.
11. The telnet command is executed and the word beginning with net, followed by pressing the Tab key, is completed to netcom.com, which is one of the hostnames in the hosts variable, previously set.
12. The alias completion is performed if the user types the word alias followed by a word that will be expanded to all aliases that contain that word. Word type a means only aliases are expanded for p, postition 1.

Table 13.9. Completion Word Types

WordTypeaAlias.bEditor key−binding commands.cCommands (built−in or external).CExternal commands that begin with the supplied path prefix.dDirectory.DDirectories that begin with the supplied path prefix.eEnvironment variables.fFilenames (not directory).FFilenames that begin with the supplied path prefix.gGroupnames.jJobs.lLimits.nNothing.sShell variables.SSignals.tPlain (text) files.TPlain (text) files beginning with the supplied path prefix.vAny variables.uUsernames.XCommand names for which completions have been defined.xLike n, but prints a message if ^D is typed.C, D, F, TLike c,d,f,t, but selects completions from a given directory.(list)Selects completions from words in a list.

A c−type completion is used to complete a pattern in the current word. The current word refers to the pattern enclosed in forward slashes. It rules that if the pattern is matched, any completion performed will finish the pattern.

Example 13.32

```
# c−type completions

1   > complete
    stty     'c/−/(raw xcase noflsh)/'
    bash     'c/−no/(profile rc braceexpansion)/'
    find     'c/−/(user name type exec)/'
    man      'c/perl/(delta faq toc data modlib locale)/'

2   > stty −r[tab]aw
    stty −raw
3   > bash −nop[tab]rofile
    bash −noprofile

4   > find / −n[tab]ame .tcshrc −p[tab]rint
    find / −name .tcshrc −print

5   > man perlde[tab]lta
    man perldelta

6   > uncomplete stty
    > complete
    bash     'c/−no/(profile rc braceexpansion)/'
    find     'c/−/(user name type exec)/'
    man      'c/perl/(delta faq toc data modlib locale)/'

7   > uncomplete *
```

EXPLANATION

1. These examples demonstrate a c−type completion. If the pattern in the first set of forward slashes is typed, that pattern will be completed by one of the words listed in the parentheses when a character(s) from that list is typed, followed by the Tab key.
2. When the stty command is typed, followed by a dash (–) character, the word will be completed to −raw, if a dash, an r, and the Tab key are entered. One of the words from the rule list in parentheses (raw xcase noflsh) can be completed.
3. When the bash command is typed, followed by the pattern, −no, that pattern will be completed to −noprofile, if the pattern −no is followed by a p and the Tab key. Completion is performed from one of the words in the rule list (profile rc braceexpansion); in this example, resulting in −noprofile.
4. Arguments to the find command are completed if the dash (–) character is completed by typing significant characters from any of the words in the find rule list (user name type exec).
5. When the man command is typed, the pattern perl is completed to perldelta since the pattern is followed by one of the words from the list (delta faq toc data modlib locale).

6. The uncomplete built−in command removes the completion rule for stty. The other completion rules remain.
7. The uncomplete built−in command, with the asterisk as its argument, removes all completion rules.

An n−type completion matches the first word and completes the second one.

Example 13.33

```
# n−type completions (next word completion)

1   > complete
    rm   'n/−r/d/'
    find 'n/−exec/c/'

2   > ls −ld testing
    drwxr−sr−x  2  ellie  root   1024 Aug 29 11:02 testing

3   > rm −r te[tab]sting
```

EXPLANATION

1. These examples demonstrate an n−type completion. If the word in the first set of forward slashes is typed (the current word) and matched, the next word (in the second set of forward slashes) will be completed according to the word type. The complete command lists two n−type completions, one for the rm command and one for the find command. When the rm command is executed with the −r switch, the word following −r must be of type directory if completion is to be performed. The rule for the find command is: if the −exec option is given, any words following it must be commands if completion is to be performed.
2. The output of the ls command shows that testing is a directory.
3. Filename completion is successful for the rm command because word completion is attempted for a directory named testing. If testing were a plain file, the completion would not have been performed.

13.3.4 Manipulating the Directory Stack

If you find that as you work, you cd up and down the directory tree into many of the same directories, you can make it easy to access those directories by pushing them onto a directory stack and manipulating the stack. The directory stack is often compared to stacking trays in a cafeteria where the trays are stacked on top of each other, the first one being at the bottom of the stack. The pushd built−in command pushes directories onto a stack and the popd command removes them. (See following Examples.) The stack is a numbered list of directories with the top directory being the most recent directory pushed onto the stack. The directories are numbered starting with the top directory at 0, the next one numbered 1, etc. The dirs built−in command, with a −v option, displays the numbered directory stack.

The pushd and popd Commands. The pushd command with a directory as an argument causes the new directory to be added to the directory stack and, at the same time, changes to that directory. If the argument is a dash (–), the dash refers to the previous working directory. If the argument is a + and a number (n), pushd extracts the nth directory from the stack and pushes it onto the top, then changes to that directory. Without arguments, pushd exchanges the top two elements of the directory stack, making it easy to switch back and forth between directories. There are a number of shell variables that control the way pushd works. (See "Setting Local Variables" on page 905.)

To save a directory stack across login sessions, you must set the savedirs variable in one of the tcsh initialization files (e.g., ~/.tcshrc). The directory stack will be stored in a file called ~/.cshdirs and will be automatically sourced when the shell starts up.

The popd command removes a directory from the top of the stack, and changes to that directory.

Table 13.10. Directory Stack Variables

pushdtohomeIf set, pushd without arguments is same as pushd ~ or cd.duniqueBefore pushing a directory onto the stack, removes any directories with the same name.pushdsilentDoesn't print the directory stack when pushd is executed.deextractIf set, pushd +n extracts the nth directory from the directory stack before pushing it onto the stack.pushtohomeWithout arguments, pushes to ~, the user's home directory.dirsfileCan be assigned a filename where the directory stack can be saved across logins.savedirsSaves the directory stack across logins.dirstackUsed to display the stack or assign directories to it.

Example 13.34

```
1   > pwd
    /home/ellie

    > pushd ..
    /home ~

    > pwd
    /home

2   > pushd       # Swap the two top directories on the stack
    ~ /home

    > pwd
    /home/ellie
```

```
3   > pushd perlclass
    ~/perlclass  ~  /home

4   > dirs -v
    0       ~/perlclass
    1       ~
    2       /home

5   > popd
    ~       /home
    > pwd
    /home/ellie

6   > popd
    /home

    > pwd
    /home

7   > popd
    popd: Directory stack empty.
```

Directory stack

0	~/perlclass
1	~
2	/home

EXPLANATION

1. First the pwd command displays the present working directory, /home/ellie. Next the pushd command, with .. as its argument, pushes the parent directory (..) onto the directory stack. The output of pushd indicates that /home is at the top of the directory stack and the user's home directory (~), /home/ellie, is at the bottom of the stack. pushd also changes the directory to the one that was pushed onto the stack; i.e., .. , which translates to /home. The new directory is displayed with the second pwd command.
2. pushd, without arguments, exchanges the two top directory entries on the stack and changes to the swapped directory; in this example, the directory is switched back to the user's home directory, /home/ellie.
3. The pushd command will push its argument, ~/perlclass, onto the stack, and change to that directory.
4. The built−in dirs command displays the numbered directory stack, with 0 being the top level. See the directory stack chart on the right side of this Example.
5. The popd command removes a directory from the top of the stack and changes to that directory.
6. The popd command removes another directory from the top of the stack and changes to that directory.
7. The popd command cannot remove any more directory entries because the stack is empty, and issues an error message saying so.

13.3.5 Spelling Correction

Spelling correction, a feature added to the TC shell, is the ability to correct spelling errors in filenames, commands, and variables. If using the emacs built−in editor, the spelling error can be corrected by using the spelling correction keys, bound to the Meta−s or Meta−S keys (use the Alt or Esc key if you don't have Meta) and Meta−$ to correct an entire line. The value of the prompt, prompt3, displays the spelling correction prompt.[8]

If you are using the vi built−in editor, set the built−in variable correct, and the shell will prompt you to fix the spelling.

Example 13.35

```
1   > fimger[Alt−s]    # Replaces fimger with finger

2   > set correct=all

3   > dite

    CORRECT>date (y|n|e|a)? yes
    Wed Aug 11 19:26:27 PDT 2001

4   > dite

    CORRECT>date (y|n|e|a)? no
    dite: Command not found.
    >

5   > dite

    CORRECT>date (y|n|e|a)? edit
    > dite         # Waits for user to edit and then executes command
```

```
6   > dite

    CORRECT>date (y|n|e|a)? abort
    >
```

EXPLANATION

1. By pressing the Meta (or Alt or Esc) key together with an s, the spelling of a command, filename, or variable can be corrected. This does not work if you are using the built−in vi editor.
2. By setting correct to all, tcsh will attempt to correct all spelling errors in the command line. This feature is available for both emacs and vi key bindings.
3. Because the command was incorrectly spelled, the third prompt, prompt3, CORRECT>date (y|n|e|a)? appears on the screen, and the user is supposed to type the letter y if he wants the spelling corrected, an n if he doesn't, an e if he wants to edit the line himself, or an a if he wants to abort the whole operation.
4. If the user wants the command to be unchanged, he types an n for no.
5. If the user wants to edit the correction, he types an e, and he will be prompted to fix or enhance the command himself.
6. If the correction is incorrect or not wanted, the user types an a, and the spelling correction is aborted.

Table 13.11. The correct Variable Arguments

ArgumentWhat It DoescmdSpell−corrects commands.completeCompletes commands.allSpell−corrects entire command line.

13.3.6 Aliases

An alias is a TC shell user−defined abbreviation for a command. Aliases are useful if a command has a number of options and arguments or the syntax is difficult to remember. Aliases set at the command line are not inherited by subshells. Aliases are normally set in the .tcshrc file. Because the .tcshrc is executed when a new shell is started, any aliases set there will get reset for the new shell. Aliases may also be passed into shell scripts but will cause potential portability problems, unless they are directly set within the script.

The TC shell has some additional preset aliases, which remain undefined until you define them. They are: beepcmd\1, cwdcmd\1, periodic\1, and precomd\1. These aliases are listed and defined in "Special Aliases".

Listing Aliases. The alias built−in command lists all set aliases. The alias is printed first, followed by the real command or commands it represents.

Example 13.36

```
> alias
apache  $HOME/apache/httpd −f $HOME/apache/conf/httpd.conf
co      compress
cp      cp −i
ls1     enscript −B −r −Porange −f Courier8 !* &
mailq   /usr/lib/sendmail −bp
mc      setenv MC '/usr/bin/mc −P !*'; cd $MC; unsetenv MC
```

```
mroe    more
mv      mv −i
uc      uncompress
uu      uudecode
vg      vgrind −t −s11 !:1 | lpr −t
weekly  (cd /home/jody/ellie/activity; ./weekly_report; echo
Done)
```

EXPLANATION

The alias command lists the alias (nickname) for the command in the first column and the real command the alias represents in the second column.

Creating Aliases. The alias command is used to create an alias. The first argument is the name of the alias, the nickname for the command. The rest of the line consists of the command or commands that will be executed when the alias is executed. Multiple commands are separated by a semicolon, and commands containing spaces and metacharacters are surrounded by single quotes.

FORMAT

```
alias
alias aliasname command
alias aliasname 'command command(s)'
unalias aliasname
```

Example 13.37

```
1   > alias m more
2   > alias mroe more
3   > alias lf ls−F
4   > alias cd ' cd \!*; set prompt = "%/ > "'
5   > cd ..
6   /home/jody >  cd /         # New prompt displayed
    / >

7   > set tperiod = 60
    > alias periodic 'echo You have worked an hour, nonstop'
8   > alias Usage ' echo "Error: \!* " ; exit 1'
```

EXPLANATION

1. The nickname for the more command is set to m.
2. The alias for the more command is set to mroe. This is handy if you can't spell.
3. The alias lf is a nickname for the tcsh built−in command ls −F. It lists files like ls −F, but is faster.
4. When cd is executed, the alias for cd will cause cd to go to the directory named as an argument and will then reset the prompt to the current working directory (%/) followed by the string >. The !* is used by the alias in the same way it is used by the history mechanism. The backslash prevents the history mechanism from evaluating the !* first before the alias has a chance to use it. The \!* represents the arguments from the most recent command on the history list. The alias definition is enclosed in quotes because of the whitespace.
5. After the cd command changes to the parent directory, the prompt is expanded to the current working directory (%/) and a > symbol.[a]

6. The new directory is /home/jody, which is reflected in the prompt; after changing directory to root (/), the prompt again reflects the change.
7. The tperiod variable is set to 60 minutes.The alias, periodic, is a preset alias. Every 60 minutes, the echo statement will be displayed.
8. This alias is useful in scripts to produce a diagnostic message and to then exit the script.

[a] If using /bin/csh as your shell, replace %/ with $cwd when setting the prompt.

Deleting Aliases. The unalias command is used to delete an alias. To temporarily turn off an alias, precede the alias name by a backslash.

Example 13.38

```
1   > unalias mroe
2   > \cd ..
```

EXPLANATION

1. The unalias command deletes the alias mroe from the list of defined aliases.
2. The alias cd is temporarily turned off for this execution of the command only.

Alias Loop. An alias loop occurs when an alias definition references another alias that references back to the original alias.

Example 13.39

```
1   > alias m more
2   > alias mroe m
3   > alias m mroe       # Causes a loop
4   > m datafile
    Alias loop.
```

EXPLANATION

1. The alias is m. The alias definition is more. Every time m is used, the more command is executed.
2. The alias is mroe. The alias definition is m. If mroe is typed, the alias m is invoked and the more command is executed.
3. This is the culprit. If alias m is used, it invokes alias mroe, and alias mroe references back to m, causing an alias loop. Nothing bad happens. You just get an error message.
4. Alias m is used. It is circular. M calls mroe and mroe calls m, then m calls mroe, etc. Rather than looping forever, the TC shell catches the problem and displays an error message.

13.4 Job Control

Job control is a powerful feature of the TC shell that allows you to run programs, called jobs, in the background or foreground. Normally, a command typed at the command line is running in the foreground and will continue until it has finished. If you have a windowing program, job control may not be necessary because you can simply open another window to start a new task. On the other hand, with a single terminal, job control is a very useful feature. For a list of job commands, see Table 13.12.

Table 13.12. Job Control Commands

Command MeaningjobsLists all the jobs running.^Z (Ctrl−Z)Stops (suspends) the job; the prompt appears on the screen.bgStarts running the stopped job in the background.fgBrings a background job to the foreground.killSends the kill signal to a specified job.

Argument to Jobs Command	Represents
%n	Job number n.
%string	Job name starting with string.
%?string	Job name containing string.
%%	Current job.
%+	Current job.
%−	Previous job, before current job.

13.4.1 Background Jobs

The Ampersand. If a command takes a long time to complete, you can append the command with an ampersand and the job will execute in the background. The tcsh prompt returns immediately and now you can type another command. Now the two commands are running concurrently, one in the background and one in the foreground. They both send their standard output to the screen. If you place a job in the background, it is a good idea to redirect its output either to a file or pipe it to a device such as a printer.

Example 13.40

```
1   > find . −name core −exec rm {} \; &
2   [1]  543
3   >
```

EXPLANATION

1. The find command runs in the background. (Without the −print option, the find command does not send any output to the screen).[a]
2. The number in square brackets indicates this is the first job to be run in the background and the PID for this process is 543.
3. The prompt returns immediately. The shell waits for user input.

[a] The find syntax requires a semicolon at the end of an exec statement. The semicolon is preceded by a backslash to prevent the shell from interpreting it.

The Suspend Key Sequence. To suspend a program, the suspend key sequence, ^Z, is issued. The job is now suspended (stopped), the shell prompt is displayed, and the program will not resume until the fg or bg commands are issued. (When using the vi editor, the ZZ command writes and saves a file. Do not confuse this with ^Z, which would suspend the vi session.) If you try to log out when a job is suspended, the message There are suspended jobs appears on the screen.

The jobs Command and the listjobs Variable. The tcsh built−in command jobs displays the programs that are currently active and either running or suspended in the background. Running means the job is executing in the background. When a job is suspended, it is stopped; it is not in execution. In both cases, the terminal is free to accept other commands. If you attempt to exit the shell while jobs are stopped, the warning, There are suspended jobs will appear on the screen. When you attempt to exit immediately a second time, the shell will go ahead and terminate the suspended jobs. You set the tcsh built−in listjobs variable if you want to automatically print a message when you suspend a job.

Example 13.41

```
(The Command Line)
1   > jobs
2   [1]  +           Suspended    vi filex
    [2]  −           Running      sleep 25
3   > jobs −l
    [1]  +   355     Suspended    vi filex
    [2]  −   356     Running      sleep 25
4   [2] Done                      sleep 25
5   > set listjobs = long
    > sleep 1000
    Press Control−Z to suspend job
    [1]  +  3337 Suspended           sleep 1000
    >
6   > set notify
```

EXPLANATION

1. The jobs command lists the currently active jobs.
2. The notation [1] is the number of the first job; the plus sign indicates that the job is not the most recent job to be placed in the background; the dash indicates that this is the most recent job put in the background; Suspended means that this job was stopped with ^Z and is not currently active.
3. The −l option (long listing) displays the number of the job as well as the PID of the job. The notation [2] is the number of the second job, in this case, the last job placed in the background. The dash indicates that this is the most recent job. The sleep command is running in the background.
4. After sleep has been running for 25 seconds, the job will complete and a message saying that it has finished appears on the screen.
5. The tcsh listjobs variable, when set to long, will print the number of a job as well as its process ID number when it is suspended. (See Table 13.25 for a list of built−in tcsh variables.).
6. Normally the shell notifies you if a job is stopped just before it prints a prompt, but if the shell variable notify is set, the shell will notify you immediately if there is any change in the status of a background job. For example, if you are working in the vi editor, and a background job is terminated, a message will appear immediately in your vi window like this:

```
[1]     Terminated                 sleep 20
```

13.4.2 Foreground and Background Commands

The fg command brings a background job into the foreground. The bg command starts a suspended job running in the background. A percent sign and the number of a job can be used as arguments to fg and bg if you want to select a particular job for job control.

Example 13.42

```
1   > jobs
2   [1] + Suspended                vi filex
    [2] − Running                  cc prog.c −o prog
```

```
3   > fg %1
    vi filex
    (vi session starts)

4   > kill %2
    [2] Terminated                  c prog.c −o prog

5   > sleep 15
    (Press ^z)

    Suspended
6   > bg
    [1] sleep 15 &
    [1] Done   sleep 15
```

EXPLANATION

1. The jobs command lists currently running processes, called jobs.
2. The first job is the vi session (suspended), the second job is the cc command (running).
3. The job numbered [1] is brought to the foreground. The number is preceded with a percent sign.
4. The kill command is built−in. It sends the TERM (terminate) signal, by default, to a process. The argument is either the number or the PID of the process.
5. The sleep command is stopped by pressing ^Z. The sleep command is not using the CPU and is suspended in the background.
6. The bg command causes the last background job to start executing in the background. The sleep program will start the countdown in seconds before execution resumes. [a]

[a] Programs such as grep, sed, and awk have a set of metacharacters, called regular expression metacharacters, for pattern matching. These should not be confused with shell metacharacters.

13.4.3 Scheduling Jobs

The sched built−in command allows you to create a list of jobs that will be scheduled to run at some specific time. The sched command, without arguments, displays a numbered list of all the scheduled events. It sets times in the form hh:mm (hour:minute) where hour can be in military or 12−hour AM/PM format. Time can also be specified as a relative time with a + sign; i.e., relative to the current time, and with a − sign, the event is removed from the list.[9]

FORMAT

```
sched
sched [+]hh:mm  command
sched −n
```

Example 13.43

```
1   > sched 14:30  echo '^G Time to start your lecture!'

2   > sched 5PM  echo Time to go home.

3   > sched +1:30 /home/ellie/scripts/logfile.sc

4   > sched
```

```
    1     17:47 /home/scripts/logfile.sc
    2     5PM  echo Time to go home.
    3     14:30  echo '^G Time to start your lecture!'

5   > sched −2
    > sched
    1     17:47 /home/scripts/logfile.sc
    2     14:30  echo '^G Time to start your lecture!'
```

EXPLANATION

1. The sched command schedules the echo command to be executed at 14:30. At that time a beep will sound (Control−G)[a] and the message will be displayed.
2. The sched command will schedule the echo command to be executed at 5 PM.
3. The script, logfile.sc, is scheduled to be executed 1 hour and 30 minutes from now.
4. The sched command displays the scheduled events, in numeric order, the last one first.
5. With a numeric argument, sched will remove the numbered job from the scheduled list. Job number 2 was removed, as shown in the output of sched.

[a] To get the ^G into the echo statement, type Ctrl−M followed by Ctrl−V, followed by Ctrl−G.

13.5 Metacharacters

Metacharacters are special characters that are used to represent something other than themselves. As a rule of thumb, characters that are neither letters nor numbers may be metacharacters. The shell has its own set of metacharacters, often called shell wildcards. Shell metacharacters can be used to group commands together, to abbreviate filenames and pathnames, to redirect and pipe input/output, to place commands in the background, and so forth. Table 13.13 presents a partial list of shell metacharacters.

Table 13.13. Shell Metacharacters

Metacharacter Purpose Example Meaning$Variable substitutionset name=Tom echo $name TomSets the variable name to Tom; displays the value stored there.!History substitution!3Reexecutes the third event from the history list.*Filename substitutionrm *Removes all files.?Filename substitutionls ??Lists all two−character files.[ ]Filename substitutioncat f[123]Displays contents of f1, f2, f3.;Command separatorls;date;pwdEach command is executed in turn.&Background processinglp mbox&Printing is done in the background. Prompt returns immediately.>Redirection of outputls > fileRedirects standard output to file.<Redirection of inputls < fileRedirects standard input from file.>&Redirection of output and errorls >& fileRedirects both output and errors to file.>!If noclobber is set, override itls >! fileIf file exists, truncate and overwrite it, even if noclobber is set.>>!If noclobber is set, override itls >>! fileIf file does not exist, create it, even if noclobber is set.( )Groups commands to be executed in a subshell(ls ; pwd) >tmpExecutes commands and sends output to tmp file.{ }Groups commands to be executed in this shell{ cd /; echo $cwd }Changes to root directory and displays current working directory.

13.5.1 Filename Substitution

When evaluating the command line, the shell uses metacharacters to abbreviate filenames or pathnames that match a certain set of characters. The filename substitution metacharacters listed in Table 13.14 are expanded into an alphabetically listed set of filenames. The process of expanding a metacharacter into filenames is also called globbing. Unlike the other shells, when the C shell cannot substitute a filename for the metacharacter it is supposed to represent, the shell reports No match.

Table 13.14. Shell Metacharacters and Filename Substitution

Metacharacter Meaning*Matches zero or more characters.?Matches exactly one character.[abc]Matches one character in the set a, b, or c.[a–z]Matches one character in the range a to z.[^abc]Matches any character that is not a, b, or c.{a, ile, ax}Matches for a character or set of characters.~Substitutes the user's home directory for tilde.\Escapes or disables the metacharacter.

Expanding the Metacharacters. The shell performs filename substitution by evaluating its metacharacters and replacing them with the appropriate letters or digits in a filename.

The Asterisk. The asterisk matches zero or more characters in a filename.

Example 13.44

```
1   > ls
    a.c b.c abc ab3 file1 file2 file3 file4 file5

2   > echo *
    a.c b.c abc ab3 file1 file2 file3 file4 file5

3   > ls  *.c
    a.c b.c

4   > ls ^*.c
    abc ab3 file1 file2 file3 file4 file5

5   > rm  z*p
    No match.
```

EXPLANATION

1. All the files in the current directory are listed.
2. The echo program prints all its arguments to the screen. The asterisk (also called a splat) is a wildcard that means, match for zero or more of any characters found in a filename. All the files in the directory are matched and echoed to the screen.
3. Filenames ending in .c are listed.
4. All files not ending in .c are listed.
5. Because none of the files in the directory start with z, the shell reports No match.

The Question Mark. The question mark matches exactly one character in a filename.

Example 13.45

```
1   > ls
    a.c b.c abc ab3 file1 file2 file3 file4 file5

2   > ls ???
    abc ab3

3   > echo How are you?
    No match.

4   > echo How are you\?
```

```
How are you?
```

EXPLANATION

1. All the files in the current directory are listed.
2. The question mark matches for a single−character filename. Any filenames consisting of three characters are listed.
3. The shell looks for a filename spelled y−o−u followed by one character. There is not a file in the directory that matches these characters. The shell prints No match.
4. The backslash preceding the question mark is used to turn off the special meaning of the question mark. Now the shell treats the question mark as a literal character.

The Square Brackets. The square brackets ([])match a filename for one character from a set or range of characters.

Example 13.46

```
1   > ls
    a.c b.c abc ab3 file1 file2 file3 file4 file5 file10
    file11  file12

2   > ls file[123]
    file1 file2 file3

3   > ls file[^123]
    file4 file5

4   > ls [A−Za−z][a−z][1−5]
    ab3

5   > ls file1[0−2]
    file10 file11 file12
```

EXPLANATION

1. All the files in the current directory are listed.
2. Filenames starting with file followed by 1, 2, or 3 are matched and listed.
3. Filenames starting with file followed by a single character other than 1, 2, or 3 are matched and listed.
4. Filenames starting with one letter (uppercase or lowercase), followed by one lowercase letter, and followed by a number between 1 and 5 are matched and listed.
5. Filenames starting with file1 and followed by a 0, 1, or 2 are listed.

The Curly Braces. The curly braces ({})match for a character or string of characters in a filename that may or may not already exist.

Example 13.47

```
1   > ls
    a.c b.c abc ab3 ab4 ab5 file1 file2 file3 file4 file5 foo
    faa fumble

2   > ls f{oo,aa,umble}
    foo faa fumble

3   > ls a{.c,c,b[3−5]}
```

```
    a.c ab3 ab4 ab5

4   > mkdir prog{1,2,3}

5   > echo tweedle{dee,dum}, {l,cl,m}ove{r}
    tweedledee tweedledum, lover clover mover
```

EXPLANATION

1. All the files in the current directory are listed.
2. Files starting with f and followed by the strings oo, aa, or umble are listed. Spaces inside the curly braces will cause the error message Missing }.
3. Files starting with a followed by .c, c, or b3, b4, or b5 are listed. (The square brackets can be used inside the curly braces.)
4. Rather than typing prog1, prog2, and prog3 and separate arguments to the mkdir command, you can use the braces to generate the new directory names.
5. Each of the words is expanded using the braced portions either as prefixes or suffixes. It is important that the words in braces contain no whitespace.

Escaping Metacharacters and nonomatch. The backslash is used to escape the special meaning of a single character. The escaped character will represent itself.

Example 13.48

```
1   > got milk?
    got: No match.

2   > got milk\?
    got: Command not found.

3   > set nonomatch
    > got milk?
    got: Command not found.
```

EXPLANATION

1. The question mark is a file substitution metacharacter and evaluates to a single character. The shell looks for a file in the present working directory that contains the characters m−i−l−k, followed by a single character. If the shell cannot find the file, it reports No match. This shows you something about the order in which the shell parses the command line. The metacharacters are evaluated before the shell tries to locate the got command.
2. The backslash protects the metacharacter from interpretation, often called escaping the metacharacter. Now the shell does not complain about a No match, but searches the path for the got command, which is not found.
3. The built−in nonomatch variable, when set, turns off error reporting when a metacharacter is not matched. Instead of reporting No match, UNIX reports that got is not a command.

Tilde Expansion. The tilde character (~) by itself expands to the full pathname of the user's home directory. When the tilde is prepended to a username, it expands to the full pathname of that user's home directory. When prepended to a path, it expands to the home directory and the rest of the pathname.

Example 13.49

```
1   > echo ~
    /home/jody/ellie

2   > cd ~/desktop/perlstuff
    > pwd
    /home/jody/ellie/desktop/perlstuff

3   > cd ~joe
    > pwd
    /home/bambi/joe
```

EXPLANATION

1. The tilde expands to the user's home directory.
2. The tilde followed by a pathname expands to the user's home directory, followed by /desktop/perlstuff.
3. The tilde followed by a username expands to the home directory of the user. In this example, the directory is changed to that user's home directory.

Turning Off Metacharacters with noglob. If the noglob variable is set, filename substitution is turned off, meaning that all metacharacters represent themselves; they are not used as wildcards. This can be useful when searching for patterns in programs like grep, sed, or awk, which may contain metacharacters that the shell may try to expand.

Example 13.50

```
1   > set noglob
2   > echo * ?? [] ~
    * ?? [] ~
```

EXPLANATION

1. The variable noglob is set. It turns off the special meaning of the wildcards.
2. The metacharacters are displayed as themselves without any interpretation.

13.6 Redirection and Pipes

Normally, standard output (stdout) from a command goes to the screen, standard input (stdin) comes from the keyboard, and error messages (stderr) go to the screen. The shell allows you to use the special redirection metacharacters to redirect the input/output to or from a file. The redirection operators (<, >, >>, >&) are followed by a filename. This file is opened by the shell before the command on the left−hand side is executed.

Pipes, represented by a vertical bar (|) symbol, allow the output of one command to be sent to the input of another command. The command on the left−hand side of the pipe is called the writer because it writes to the pipe. The command on the right−hand side of the pipe is the reader because it reads from the pipe. See Table 13.15 for a list of redirection and pipe metacharacters.

Table 13.15. Redirection Metacharacters

Metacharacter Meaningcommand < fileRedirects input from file to command.command > fileRedirects output from command to file.command >& fileRedirects output and errors to file.command >> fileRedirects output of command and appends it to file.command >>& fileRedirects and appends output and errors of command to file.command << WORDRedirects input from first WORD to terminating WORD to command.<input>User input goes here. It will be treated as a doubly quoted string of text.WORDWORD marks the termination of input to command.command | commandPipes output of first command to input of second command.command |& commandPipes output and errors of first command to input of second command.command >! fileIf the noclobber variable is set, overrides its effects for this command and either open or overwrite file.command >>! fileOverrides noclobber variable; if file does not exist, it is created and output from command is appended to it.command >>&! fileOverrides noclobber variable; if file does not exist, it is created and both output and errors are appended to it.

13.6.1 Redirecting Input

Instead of the input coming from the terminal keyboard, it can be redirected from a file. The shell will open the file on the right−hand side of the < symbol and the program on the left will read from the file. If the file does not exist, the error No such file or directory will be reported by the shell.

FORMAT

```
command < file
```

Example 13.51

```
mail bob < memo
```

EXPLANATION

The file memo is opened by the shell, and the input is redirected to the mail program. Simply, the user bob is sent a file called memo by the mail program.

13.6.2 The here document

The here document is another way to redirect input to a command in the form of a quoted block of text. It is used in shell scripts for creating menus and processing input from other programs. Normally, programs that accept input from the keyboard are terminated with Control−D (^D). The here document provides an alternate way of sending input to a program and terminating the input without typing ^D. The << symbol is followed by a user−defined word, often called a terminator. Input will be directed to the command on the left−hand side of the << symbol until the user−defined terminator is reached. The final terminator is on a line by itself, and cannot be surrounded by any spaces. Variable and command substitution are performed within the here document. Normally, here documents are used in shell scripts to create menus and provide input to commands such as mail, bc, ex, ftp, etc.

FORMAT

```
command << MARK
       ... input ...
MARK
```

Example 13.52

```
(Without the here document)
```

```
(The Command Line)
1   > cat
2   Hello There.
    How are you?
    I'm tired of this.
3   ^d

(The Output)
4   Hello There.
    How are you?
    I'm tired of this.
```

EXPLANATION

1. The cat program, without arguments, waits for keyboard input.
2. The user types input at the keyboard.
3. The user types ^D to terminate input to the cat program.
4. The cat program sends its output to the screen.

Example 13.53

```
(With the here document)

(The Command Line)
1   > cat << DONE
2   ? Hello There.
    ? How are you?
    ? I'm tired of this.
3   ? DONE
4   Hello There.   <----The output from the here document
    How are you?
    I'm tired of this.
```

EXPLANATION

1. The cat program will receive input from the first DONE to the terminating DONE. The words are user−defined terminators.
2. The question mark (?) is the secondary prompt, prompt2. It will appear until the here document is terminated with the user−defined terminator, DONE. These lines are input. When the word DONE is reached, no more input is accepted.
3. The final terminator marks the end of input. There cannot be any spaces on either side of this word.
4. The text between the first word DONE and the final word DONE is the output of the cat command (from here to here) and is sent to the screen. The final DONE must be against the left margin with no space or other text to the right of it.

Example 13.54

```
(The Command Line)
1   > set name = steve
2   > mail $name << EOF
3   ? Hello there, $name
4   ? The hour is now 'date +%H'
5   ? EOF
6   >
```

EXPLANATION

1. The shell variable name is assigned the username steve. (Normally, this example would be included in a shell script.)
2. The variable name is expanded within the here document.
3. The question mark (?) is the secondary prompt, prompt2. It will appear until the here document is terminated with the user−defined terminator, EOF. The mail program will receive input until the terminator EOF is reached.
4. Command substitution is performed within the here document; that is, the command within the backquotes is executed and the output of the command is replaced within the string.
5. The terminator EOF is reached, and input to the mail program is stopped.

13.6.3 Redirecting Output

By default, the standard output of a command or commands goes to the terminal screen. To redirect standard output from the screen to a file, use the > symbol. The command is on the left−hand side of the > symbol, and a filename is on the right−hand side. The shell will open the file on the right−hand side of the > symbol. If the file does not exist, the shell will create it; if it does exist, the shell will open the file and truncate it. Often files are inadvertently removed when using redirection. (A special tcsh variable, called noclobber, can be set to prevent redirection from clobbering an existing file. See Table 13.16.)

FORMAT

```
command > file
```

Example 13.55

```
cat file1 file2 > file3
```

EXPLANATION

The contents of file1 and file2 are concatenated and the output is sent to file3. Remember that the shell opens file3 before it attempts to execute the cat command. If file3 already exists and contains data, the data will be lost. If file3 does not exist, it will be created.

Appending Output to an Existing File. To append output to an existing file, use the >> symbol. If the file on the right−hand side of the >> symbol does not exist, it is created; if it does exist, the file is opened and output is appended to the end of the file.

FORMAT

```
command >> file
```

Example 13.56

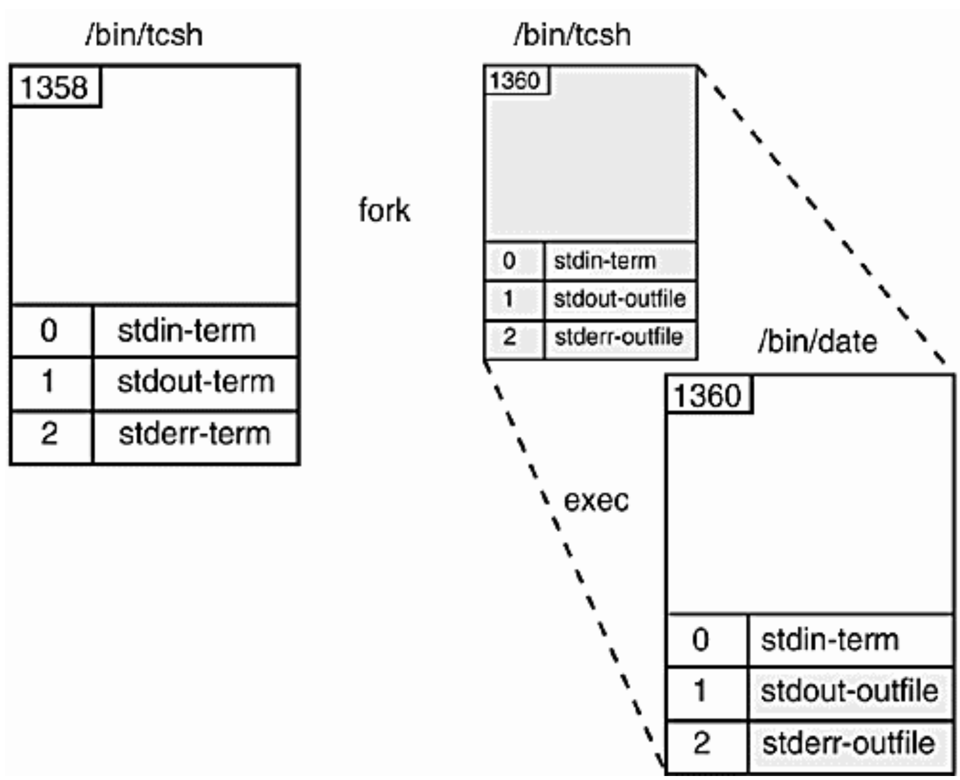
```
date >> outfile
```

EXPLANATION

The standard output of the date command is redirected and appended to outfile.

Redirecting Output and Error. The >& symbol is used to redirect both standard output and standard error to a file. Normally, a command is either successful and sends its output to stdout, or fails and sends its error messages to stderr. Some recursive programs, such as find and du, send both standard output and errors to the screen as they move through the directory tree. When you use the >& symbol, both standard output and standard error can be saved in a file and examined. The TC shell does not provide a symbol for redirection of only standard error, but it is possible to get just the standard error by executing the command in a subshell. See Figure 13.3.

Figure 13.3. Redirecting stdout and stderr. See Example 13.57.



Example 13.57

```
1   > date
    Tue Aug 3 10:31:56  PDT  2001
2   > date >& outfile
3   > cat outfile
    Tue Aug 3 10:31:56  PDT  2001
```

EXPLANATION

1. The output of the date command is sent to standard output, the screen.
2. The output and errors are sent to outfile.
3. Because there were no errors, the standard output is sent to outfile and the contents of the file are displayed.

Example 13.58

```
1   > cp file1 file2
2   > cp file1
    cp: missing destination file
    Try 'cp --help' for more information
3   > cp file1 >& errorfile
4   > cat errorfile
    cp: missing destination file
    Try 'cp --help' for more information
```

EXPLANATION

1. To copy a file, the cp command requires both a source file and a destination file. The cp command makes a copy of file1 and puts the copy in file2. Because the cp command is given the correct syntax, nothing is displayed to the screen. The copy was successful.
2. This time the destination file is missing and the cp command fails, sending an error to stderr, the terminal.
3. The >& symbol is used to send both stdout and stderr to errorfile. Because the only output from the command is the error message, that is what is saved in errorfile.
4. The contents of errorfile are displayed, showing that it contains the error message produced by the cp command.

Separating Output and Errors. Standard output and standard error can be separated by enclosing the command in parentheses. When a command is enclosed in parentheses, the TC shell starts up a subshell, handles redirection from within the subshell, and then executes the command. By using the technique shown in Example 13.59, you can separate the standard output from the errors.

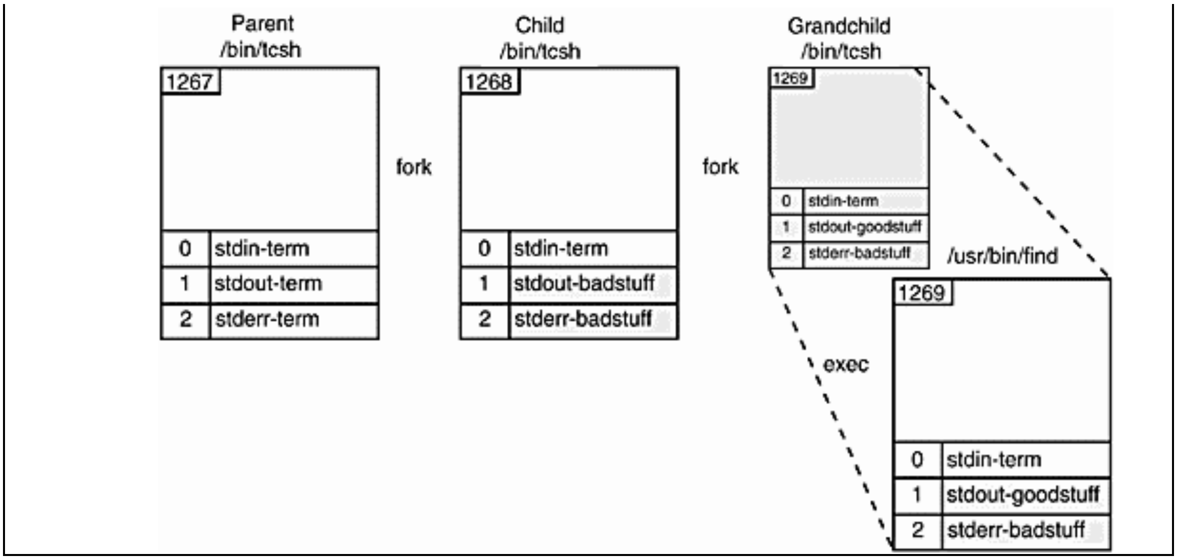
Example 13.59

```
(The Command Line)
1   > find . -name '*.c' >& outputfile
2   > (find . -name '*.c' > goodstuff) >& badstuff
```

EXPLANATION

1. The find command will start at the current directory, searching for all files ending in .c, and will print the output to outputfile. If an error occurs, that will also go into outputfile.
2. The find command is enclosed within parentheses. The shell will create a subshell to handle the command. Before creating the subshell, the words outside the parentheses will be processed; that is, the badstuff file will be opened for both standard output and error. When the subshell is started, it inherits the standard input, output, and errors from its parent. The subshell then has standard input coming from the keyboard, and both standard output and standard error going to the badstuff file. Now the subshell will handle the > operator. The stdout will be assigned the file goodstuff. The output is going to goodstuff, and the errors are going to badstuff. See Figure 13.4.

Figure 13.4. Separating stdout and stderr.



The noclobber Variable. The special TC shell built−in variable noclobber, when set, protects you from clobbering files with redirection. See Table 13.16.

Table 13.16. The noclobber Variable

noclobber Is Not SetFile ExistsFile Does Not Existcommand > filefile is overwritten.file is created.command >> filefile is appended to.file is created. noclobber Is Setcommand > fileError message.file is created.command >> fileFile is appended to.Error message. Overwriting noclobbercommand >! fileIf the noclobber variable is set, override its effects for this command and either open or truncate file, redirecting output of command to file.command >>! fileOverride noclobber variable; if file does not exist, it is created and output from command is appended to it.

Example 13.60

```
1   > cat filex
    abc
    123

2   > date > filex
3   > cat filex
    Tue Mar 18 11:51:04  PST 2001

4   > set noclobber
5   > date > filex
    filex: File exists.

6   > ls >! filex     # Override noclobber for this command only
    > cat filex
    abc
    ab1
    dir
    filex
    plan.c

7   > ls > filex
    filex:  File exists.

8   > date >> XXX
    XXX: No such file or directory.
```

```
9   > date >>! XXX        # Override noclobber for this command only

10  > unset noclobber     # Turn off noclobber permanently
```

EXPLANATION

1. The contents of filex are displayed on the screen.
2. The output of the date command is redirected to filex. The file is truncated and its original contents overwritten.
3. The contents of filex are displayed.
4. The noclobber variable is set.
5. Because filex already exists and noclobber is set, the shell reports that the file exists and will not allow it to be overwritten.
6. The output of ls is redirected to filex because the >! operator overrides the effects of noclobber.
7. The effects of the >! symbol were temporary. It does not turn off noclobber. It simply overrides noclobber for the command where it is implemented.
8. Attempting to redirect and append the output of the date command to a nonexistent file causes an error message when noclobber is set.
9. The noclobber variable is overridden with the exclamation mark attached to the >> redirection symbol.
10. The noclobber variable is unset.

13.7 Variables

Tcsh variables hold only strings or a set of strings. Some variables are built into the shell and can be set either by turning them on or off, such as the noclobber or filec variable. Others are assigned a string value, such as the path variable. You can create your own variables and assign them to strings or the output of commands. Variable names are case−sensitive and may contain up to 20 characters consisting of numbers, letters, and the underscore.

There are two types of variables: local and environment. The scope of a variable is its visibility. A local variable is visible to the shell where it is defined. The scope of environment variables is often called global. Their scope is for this shell and all processes spawned (started) from this shell. If a local variable is created with set −r, it will be read−only, meaning that it cannot be changed or unset.

The dollar sign ($) is a special metacharacter that, when preceding a variable name, tells the shell to extract the value of that variable. The echo command, when given the variable as an argument, will display the value of the variable after the shell has processed the command line and performed variable substitution.

The special notation $?, when prepended to the variable name, lets you know whether the variable has been set. If a one is returned, it means true, the variable has been set. If a zero is returned, it means false, the variable has not been set.

Example 13.61

```
1   > set autologout
2   > set history = 50
3   > set name = George
4   > set machine = 'uname −n'
5   > echo $?machine
     1
```

```
6    echo  $?blah
     0
```

EXPLANATION

1. Sets the tcsh built−in variable autologout variable to cause automatic logout after a specified time of inactivity has passed.
2. Sets the built−in variable history to 50 to control the number of events displayed.
3. Sets the user−defined variable name to George.
4. Sets the user−defined variable machine to the output of the UNIX command. The command is in backquotes, telling the shell to perform command substitution.
5. The $? is prepended to the variable name to test whether the variable has been set. Because the test yields a 1 (true), the variable has been set.
6. The $? yields 0 (false). The variable has not been set.

13.7.1 Printing the Values of Variables

The echo Command. The built−in echo command prints its arguments to standard output. The echo allows the use of numerous escape sequences, which are interpreted and displayed as tabs, newlines, form feed, etc. Table 13.17 lists the echo options and escape sequences.

The TC shell uses the style of both BSD and SVR4, but allows you to modify the behavior of the echo command by using the built−in echo_style variable; e.g., set echo_style=bsd. See Table 13.18. See the manual page for echo.

Table 13.17. echo Options and Escape Sequences

Option Meaning−nSuppresses newline at the end of a line of output. Escape Sequence\aAlert (bell).\bBackspace.\cPrint the line without a newline.\fForm feed.\nNewline.\rReturn.\tTab.\vVertical tab.\\Backslash.\nnnThe character whose ASCII code is nnn (octal).

Table 13.18. The echo_style Variable

bsdIf the first argument is −n, the newline is suppressed.sysvExpands escape sequences in echo strings.bothBoth −n and escape sequences are in effect (the default).noneRecognizes neither sysv or bsd.

Example 13.62

```
1   > echo The username is $LOGNAME.
    The username is ellie.

2   > echo "\t\tHello there\c"
                Hello there>

3   > echo −n "Hello there"
    Hello there$

4   > set echo_style=none

5   > echo  "\t\tHello there\c"
```

```
−n \t\tHello there\c
```

EXPLANATION

1. The echo command prints its arguments to the screen. Variable substitution is performed by the shell before the echo command is executed.
2. The echo command, by default, supports escape sequences similar to those of the C programming language and used in the SVR4 version of echo. The > is the shell prompt.
3. With the −n option, echo displays the string without the newline.
4. The echo_style variable is assigned the value none. Neither the BSD −n switch nor the SVR4 escape sequences are in effect.
5. With the new echo style, the string is displayed.

The printf Command. The GNU version of printf can be used to format printed output. It prints the formatted string in the same way as the C printf function. The format consists of a string that may contain formatting instructions to describe how the printed output will look. The formatting instructions are designated with a % followed by specifiers (diouxXfeEgGcs), where %f would represent a floating point number and %d would represent a whole (decimal) number.

To see a complete listing of printf specifiers and how to use them, type at the command line prompt: printf − −help. To see what version of printf you are using, type printf − −version. If using bash 2.x, the built−in printf command uses the same format as the executable version in /usr/bin.

FORMAT

```
printf format [argument...]
```

Example 13.63

```
printf "%10.2f%5d\n" 10.5  25
```

Table 13.19. Format Specifier for the printf Command

Format Specifier	Value
\"	Double quote.
\0NNN	An octal character in which NNN represents 0 to 3 digits.
\\	Backslash.
\a	Alert or beep.
\b	Backspace.
\c	Produce no further output.
\f	Form feed.
\n	Newline.
\r	Carriage return.
\t	Horizontal tab.
\v	Vertical tab.
\xNNN	Hexadecimal character in which NNN is 1 to 3 digits.
%%	Single %.
%b	ARGUMENT as a string with \ escapes interpreted.

Example 13.64

```
1   > printf −−version
    printf (GNU sh−utils) 1.16

2   > printf "The number is %.2f\n" 100
    The number is 100.00

3   > printf "%−20s%−15s%10.2f\n" "Jody" "Savage" 28
    Jody                Savage              28.00

4   > printf "|%−20s|%−15s|%10.2f|\n" "Jody" "Savage" 28
    |Jody                |Savage         |     28.00|

5   > printf "%s's average was %.1f%%.\n" "Jody" $(( (80+70+90)/3 ))
    Jody's average was 80.0%.
```

EXPLANATION

1. The GNU version of the printf command is printed. It is found in /usr/bin.

2. The argument 100 is printed as a floating point number with only two places to the right of the decimal point printing, designated by the format specification %.2f in the format string. Note that unlike C, there are no commas separating the arguments.

3,4. This time the format string specifies that three conversions will take place: the first one is %−20s (a left−justified, 20−character string), next is %−15s (a left−justified, 15−character string), and last %10.2f (a right−justified 10−character floating point number, one of those characters is the period and the last two characters are the two numbers to the right of the decimal point). Each argument is formatted in the order of the corresponding % signs, so that string Jody corresponds to first %, string Savage corresponds to the second %, and the number 28 to the last % sign. The vertical bars are used to demonstrate the width of the fields.

5. The printf command formats the string Jody and the result of the arithmetic expansion. (Refer to "Arithmetic Expansion".) Two percent (%%) signs are needed to print one percent sign (%).

Curly Braces and Variables. Curly braces insulate a variable from any characters that may follow it. They can be used to concatenate a string to the end of the variable.

Example 13.65

```
1   > set var = net
    > echo $var
    net

2   > echo $varwork
    varwork: Undefined variable.

3   > echo ${var}work
    network
```

EXPLANATION

1. The curly braces surrounding the variable name insulate the variable from characters that follow it.
2. A variable called varwork has not been defined. The shell prints an error message.
3. The curly braces shield the variable from characters appended to it. $var is expanded and the string work is appended.

13.7.2 Local Variables (Visibility and Naming)

Local variables are known only in the shell where they were created. If a local variable is set in the .tcshrc file, the variable will be reset every time a new TC shell is started. By convention, local variables are named with lowercase letters.

Setting Local Variables. If the string being assigned contains more than one word, it must be quoted; otherwise, only the first word will be assigned to the variable. It does not matter if there are spaces around the equal sign, but if there is a space on one side of the equal sign, there must be one on the other side.

Example 13.66

```
1   > set round = world
2   > set name = "Santa Claus"

3   > echo $round
     world

4   > echo $name
    Santa Claus

5   > tcsh            # Start a subshell
6   > echo $name
    name: Undefined variable.
```

EXPLANATION

1. The local variable round is assigned the value world.
2. The local variable name is assigned the value Santa Claus. The double quotes keep the shell from evaluating the whitespace between Santa and Claus.
3. The dollar sign prepended to the variable allows the shell to perform variable substitution, that is, to extract the value stored in the variable.
4. Variable substitution is performed.
5. A new TC shell (called a subshell) process is started.
6. In the subshell, the variable name has not been defined. It was defined in the parent shell as a local variable.

Read−Only Variables. Read−only variables are local variables that, once set, cannot be changed or unset or an error message will result. Environment variables cannot be made read−only.

Example 13.67

```
1   > set −r name = Tommy

2   > unset name
    unset: $name is read−only.

3   > set name = Danny
    set: $name is read−only
```

The set Command. The set command prints all local variables set for this shell.

Example 13.68

```
(The Command Line)
> set
addsuffix
argv          ()
cwd           /home/jody/meta
dirstack      /home/ellie/meta
echo_style both
edit
gid       501
```

```
group     ellie
history   500
home     /home/ellie
i        /etc/profile.d/mc.csh
owd      /home/ellie
noclobber
path  (/usr/sbin /sbin /usr/local/bin /bin  /usr/bin /usr/X11R6/bin )

prompt    [%n@%m  %c]#
prompt2   %R?
prompt3   CORRECT>%R  (y|n|e|a)?
savedirs
shell     /bin/tcsh
shlvl     2
status    0
tcsh      6.07.09
term      xterm
user      ellie
version tcsh 6.09.09 (Astron) 1998−08−16 (sparc−sun−solaris)
options 8b,nls,dl,al,rh,color
```

EXPLANATION

All of the local variables set for this shell are printed. Many of these variables, such as history, dirstack, and noclobber, are set in the .tcshrc file. Others, such as argv, cwd, shell, term, user, version, and status variables are preset, built−in variables.

Built−In Local Variables. The shell has a number of predefined variables with their own definitions. Some of the variables are either on or off. For example, if you set noclobber, the variable is on and effective, and when you unset noclobber, it is turned off. Some variables require a definition when set. Built−in variables are usually set in the .tcshrc file if they are to be effective for all interactive TC shells and tcsh scripts. Some of the built−in variables already discussed include noclobber, cdpath, history, rmstar, and noglob. For a complete list, see Table 13.24.

13.7.3 Environment Variables

Environment variables are often called global variables. They are defined in the shell where they were created and inherited by all shells spawned from that shell. Although environment variables are inherited by subshells, those defined in subshells are not passed back to parent shells. Inheritance is from parent to child, not the other way around (like real life). By convention, environment variables are named with capital letters.

Example 13.69

```
(The Command Line)
1   > setenv TERM wyse
2   > setenv PERSON "Joe Jr."
3   > echo $TERM
    wyse
4   > echo $PERSON
    Joe Jr.
5   > echo $$       # $$ evaluates to the PID of the current shell
    206

6   > tcsh              # Start a subshell
7   > echo $$
    211
8   > echo $PERSON
    Joe Jr.
```

```
9   > setenv PERSON "Nelly Nerd"
10  > echo $PERSON
      Nelly Nerd
11  > exit              # Exit the subshell

12  > echo $$
      206
13  > echo $PERSON      # Back in parent shell
      Joe Jr.
```

EXPLANATION

1. The shell environment variable TERM is set to a wyse terminal.
2. The user−defined variable PERSON is set to Joe Jr. The quotes are used to protect the space.
3. The dollar sign ($) prepended to the variable name allows the shell to evaluate the contents of the variable, called variable substitution.
4. The value of the environment variable PERSON is printed.
5. The $$ variable contains the PID of the current shell. The PID is 206.
6. The tcsh command starts a new TC shell, called a subshell.
7. The PID of the current shell is printed. Because this is a new TC shell, it has a different PID number. The PID is 211.
8. The environment variable PERSON was inherited by the new shell.
9. The PERSON variable is reset to Nelly Nerd. This variable will be inherited by any shells spawned from this shell.
10. The new value of the PERSON variable is printed.
11. This shell is exited.
12. The original shell is running; to attest to that, the PID 206 is printed. It is the same as it was before the subshell was started.
13. The PERSON variable contains its original value.

Displaying Environment Variables. The printenv (BSD) and env (SVR4) commands print all the environment variables set for this shell and its subshells. The setenv command prints variables and their values on both the UCB and SVR4 versions of TC shell.

Example 13.70

```
> env  or  printenv  or  setenv
USERNAME=root
COLORTERM=rxvt−xpm
HISTSIZE=1000
HOSTNAME=homebound
LOGNAME=ellie
HISTFILESIZE=1000
MAIL=/var/spool/mail/ellie
MACHTYPE=i386
COLORFGBG=0;default;15
TERM=xterm
HOSTTYPE=i386−unix
PATH=/usr/sbin:/sbin:/usr/local/bin:/bin:/usr/bin:/usr/X11R6/bin:/home/
ellie/bin;/root/bash−2.03/:/usr/X11R6/bin:/home/ellie/bin;/root/bash−
2.03/:/usr/X11R6/bin
HOME=/root
SHELL=/bin/bash
PS1=[\u@\h \W]\$
USER=ellie
```

```
VENDOR=intel
GROUP=ellie
HOSTDISPLAY=homebound:0.0
DISPLAY=:0.0
HOST=homebound
OSTYPE=unix
WINDOWID=37748738
PWD=/home/ellie
SHLVL=6
_=/usr/bin/env
```

EXPLANATION

The environment variables are set for this session and all processes that are started from this shell are displayed by using either one of the built−in commands: env or printenv. Many applications require the setting of environment variables. For example, the mail command has a MAIL variable set to the location of the user's mail spooler and the xterm program has a DISPLAY variable that determines which bit map display terminal to use. When any of these programs are executed, the values in their respective variables are passed on to them.

13.8 Arrays

13.8.1 What Is an Array?

In the TC shell, an array is simply a list of words, separated by spaces or tabs, and enclosed in parentheses. The elements of the array are numbered by subscripts starting at one. If there is not an array element for a subscript, the message Subscript out of range is displayed. Command substitution will also create an array. If the $# notation precedes an array name, the number of elements in the array is displayed.

Example 13.71

```
1   > set fruit = ( apples pears peaches plums )
2   > echo $fruit
     apples pears peaches plums

3   > echo $fruit[1]     # Subscripts start at 1
    apples

4   > echo $fruit[2-4]   # Prints the 2nd, 3rd, and 4th elements
    pears peaches plums

5   > echo $fruit[6]
    Subscript out of range.

6   > echo $fruit[*]     # Prints all elements of the array
    apples pears peaches plums

7   > echo $#fruit       # Prints the number of elements
    4

8   > echo $%fruit       # Prints the number of characters in the list
    23
9   > echo $fruit[$#fruit]       # Prints the last element
    plums

10  > set fruit[2] = bananas     # Reassigns the second element
    > echo $fruit
    apples bananas peaches plums
```

```
11  > set path = ( ~ /usr/bin /usr /usr/local/bin . )
    > echo $path
    /home/jody/ellie /usr/bin /usr /usr/local/bin .

12  > echo $path[1]
    /home/jody/ellie
```

EXPLANATION

1. The wordlist is enclosed within parentheses. Each word is separated by whitespace. The array is called fruit.
2. The words in the fruit array are printed.
3. The first element of the fruit array is printed. The subscripts start at one.
4. The second, third, and fourth elements of the wordlist are printed. The dash allows you to specify a range.
5. The array does not have six elements. The subscript is out of range.
6. All elements of the fruit array are printed.
7. The $# preceding the array is used to obtain the number of elements in the array. There are four elements in the fruit array.
8. The $% preceding a variable or an array prints the number of characters in the word(s).
9. Because the subscript $#fruit evaluates to the total number of elements in the array, if that value is used as an index value of the array, i.e., [$#fruit], the last element of the fruit array is printed.
10. The second element of the array is assigned a new value. The array is printed with its replaced value, bananas.
11. The path variable is a special TC shell array of directories used to search for commands. When you create an array, the individual elements of the path can be accessed or changed.
12. The first element of path is printed.

The shift Command and Arrays. If the built−in shift command takes an array name as its argument, it shifts off (to the left) the first element of the array. The length of the array is decreased by one. Without an argument, the shift command shifts off the first element of the built−in argv array.

Table 13.20. Variable Modifiers

Special Modifier ExampleWhat It Means$?$?varReturns 1 if var is set; 0 if not.$#$#varReturns the number of words in var.$%$%varReturns the number of characters in var.

Example 13.72

```
1   > set names = ( Mark Tom Liz Dan Jody )

2   > echo $names
    Mark Tom Liz Dan Jody

3   > echo $names[1]
    Mark

4   > shift  names

5   > echo $names
    Tom Liz Dan Jody
```

```
6    > echo $names[1]
     Tom

7    > set days = ( Monday Tuesday )

8    > shift days

9    > echo $days
     Tuesday

10   > shift days

11   > echo $days

12   > shift days
     shift: no more words.
```

EXPLANATION

1. The array is called names. It is assigned the list of words in parentheses. Each word is separated by whitespace.
2. The array is printed.
3. The first element of the array is printed.
4. The array is shifted to the left by one element. The word Mark is shifted off.
5. The array was decreased by one element after the shift.
6. The first element of the array, after the shift, is Tom.
7. An array called days is created. It has two elements, Monday and Tuesday.
8. The days array is shifted one to the left.
9. The array is printed. Tuesday is the only element left.
10. The days array is shifted again. The array is empty.
11. The days array is empty.
12. This time, attempting to shift causes the shell to send an error message indicating that it cannot shift elements from an empty array.

Creating an Array from a String. You may want to create a wordlist out of a quoted string. This is accomplished by placing the string variable within a set of parentheses.

Example 13.73

```
1    > set name = "Thomas Ben Savage"
     > echo $name[1]
     Thomas Ben Savage

2    > echo $name[2]
     Subscript out of range.

3    > set name = ( $name )

4    > echo $name[1] $name[2] $name[3]
     Thomas Ben Savage
```

EXPLANATION

1. The variable name is assigned the string Thomas Ben Savage.
2. When treated as an array, there is only one element, the entire string.

3. The variable is enclosed in parentheses, creating an array of words, called name.
4. The three elements of the new array are displayed.

13.9 Special Variables and Modifiers

Built into the TC shell are several variables consisting of one character. The $ preceding the character allows variable interpretation. See Table 13.21.

Table 13.21. Variables and Their Meanings

Variable	Example	Meaning
$?var	echo $?name	Returns 1 if variable has been set, 0 if not.
$#var	echo $#fruit	Prints the number of elements in an array.
$%var	echo $%name	Prints number of characters in a variable or array.
$$	echo $$	Prints the PID of the current shell.
$<	set name = $<	Accepts a line of input from user up to newline.
$?	echo $?	Same as $status. Contains the exit status of the last command.
$!	kill $!	Contains the process ID number of the last job put in the background.

Example 13.74

```
1   > set num
    > echo $?num
    1

2   > echo $path
    /home/jody/ellie  /usr /bin  /usr/local/bin
    > echo $#path
    3

3   > echo $$
    245

    > tcsh             # Start a subshell
    > echo $$
    248

4   > set name = $<
    Christy Campbell
    > echo $name
    Christy

5   > set name = "$<"
    Christy Campbell
    > echo $name
    Christy Campbell
```

EXPLANATION

1. The variable num is set to null. The $? preceding the variable evaluates to one if the variable has been set (either to null or some value), and to zero if the variable has not been set.
2. The path variable is printed. It is an array of three elements. The $# preceding the variable extracts and prints the number of elements in the array.
3. The $$ is the PID of the current process, in this case, the C shell.
4. The $< variable accepts a word of input from the user up to the first space or newline, whichever comes first, and stores the word in the name variable. The value of the name

variable is displayed.

5. The $< variable, when quoted (double quotes) accepts a line of input from the user up to, but not including, the newline, and stores the line in the name variable. The value of the name variable is displayed.

13.9.1 Pathname Variable Modifiers

If a pathname is assigned to a variable, it is possible to manipulate the pathname variable by appending special TC shell extensions to it. The pathname is divided into four parts: head, tail, root, and extension. See Table 13.22 for examples of pathname modifiers and what they do.

Table 13.22. Pathname Modifiers

`set pn = /home/ellie/prog/check.c` **Modifier Meaning Example Result**:rrootecho $pn:r/home/ellie/prog/check:hheadecho $pn:h/home/ellie/prog:ttailecho $pn:tcheck.c:eextensionecho $pn:ec:gglobalecho $p:gt(See Example 13.75)

Example 13.75

```
1   > set pathvar = /home/danny/program.c

2   > echo $pathvar:r
    /home/danny/program

3   > echo $pathvar:h
    /home/danny

4   > echo $pathvar:t
    program.c

5   > echo $pathvar:e
    c

6   > set pathvar = ( /home/* )
    echo $pathvar
    /home/jody /home/local /home/lost+found /home/perl /home/tmp

7   > echo $pathvar:gt
    jody  local  lost+found  perl tmp
```

EXPLANATION

1. The variable pathvar is set to /home/danny/program.c.
2. When :r is appended to the variable, the extension is removed when displayed.
3. When :h is appended to the variable, the head of the path is displayed; that is, the last element of the path is removed.
4. When :t is appended to the variable, the tail end of the path (the last element) is displayed.
5. When :e is appended to the variable, the extension is displayed.
6. The variable is set to /home/*. The asterisk expands to all the pathnames in the current directory starting in /home/.
7. When :gt is appended to the variable, the tail end of each (global) of the path elements is displayed.

13.9.2 Upper− and Lowercase Modifiers

A special history modifier can be used to change the case of letters in a variable.

Table 13.23. Case Modifiers

Modifier Effect:uUppercase the first lowercase letter in a word.:lLowercase the first uppercase letter in a word.:gApply a modifier once to each word.:aApply a modifier as many times as possible to a single word.

Example 13.76

```
1   > set name = nicky
    > echo $name:u
    Nicky

2   > set name = ( nicky jake )
    > echo $name:gu
    Nicky Jake

3   > echo $name:agu
    NICKY JAKE

4   > set name = ( TOMMY DANNY )
    > echo $name:agl
    tommy danny

5   > set name = "$name:agu
    > echo $name
    TOMMY DANNY
```

EXPLANATION

1. When :u is appended to the variable, the first letter in its value is uppercased.
2. When :gu is appended to the variable, the first letter in each word in the list of values is uppercased.
3. When :agu is appended to the variable, all letters in its value are uppercased.
4. When :agl is appended to the variable, all letters in its value are lowercased.
5. The variable is reset with all letters in its list uppercased.

13.10 Command Substitution

13.10.1 Backquotes

A string or variable can be assigned the output of a UNIX command by placing the command in backquotes. This is called command substitution. (On the keyboard, the backquotes are normally below the tilde character.) If the output of a command is assigned to a variable, it is stored as a wordlist or array. (See "Wordlists and Command Substitution" on page 919.)

Example 13.77

```
1   > echo The name of my machine is 'uname −n'.
    The name of my machine is stardust.

2   > echo The present working directory is 'pwd'.
    The present working directory is /home/stardust/john.
```

```
3   > set d = 'date'
    > echo $d
    Tue Mar 28 14:24:21 PDT 2001
```

EXPLANATION

1. The UNIX command uname −n is enclosed in backquotes. When the shell encounters the backquotes, it will execute the enclosed command, uname −n, and substitute the output of the command, stardust, into the string. When the echo command prints its arguments to standard output, the name of the machine will be one of its arguments.
2. The UNIX command pwd is executed by the shell and the output is substituted in place within the string.
3. The local variable d is assigned the output of the date command. The output is stored as a list of words (an array).

Wordlists and Command Substitution. When a command is enclosed in backquotes and assigned to a variable, the resulting value is an array (wordlist). Each element of the array can be accessed by appending a subscript to the array name. The subscripts start at one. If a subscript that is greater than the number of words in the array is used, the TC shell prints Subscript out of range. If the output of a command consists of more than one line, the newlines are stripped from each line and replaced with a single space.

After an array is created, the built−in shift command can be used to remove words starting at word number one. Once a word is shifted off, it cannot be retrieved.

Example 13.78

```
1   > set d = 'date'
    > echo $d
    Tue Mar 28 14:04:49 PST 2001

2   > echo $d[1–3]
    Tue Mar 28

3   > echo $d[6]
    2001

4   > echo $d[7]
    Subscript out of range.

5   > echo "The calendar for the month of March is 'cal 3 2000'"
    The calendar for month of March is March 2001 S M Tu W
    Th F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
    22 23 24 25 26 27 28 29 30 31
```

EXPLANATION

1. The variable d is assigned the output of the UNIX date command. The output is stored as an array. The value of the variable is displayed.
2. The first three elements of the array are displayed.
3. The sixth element of the array is displayed.
4. There are not seven elements in the array. The shell reports that the subscript is out of range.
5. The output spans more than one line. Each newline is replaced with a space. This may not

be the output you expected.

Example 13.79

```
1   > set machine = 'rusers | awk '/tom/{print $1}''

2   > echo $machine
    dumbo bambi dolphin

3   > echo $#machine
    3

4   > echo $machine[$#machine]
    dolphin

5   > echo $machine
    dumbo bambi dolphin

6   > shift $machine
    > echo $machine
    bambi dolphin

7   > echo $machine[1]
    bambi

8   > echo $#machine
    2
```

EXPLANATION

1. The output of the rusers command is piped to awk. If the regular expression tom is found, awk prints the first field. The first field, in this case, is the name of the machine(s) where user tom is logged on.
2. User tom is logged on three machines. The names of the machines are displayed.
3. The number of elements in the array is accessed by preceding the array name with $#. There are three elements in the array.
4. The last element of the array is displayed. The number of elements in the array ($#machine) is used as a subscript.
5. The array is displayed.
6. The shift command shifts the array to the left. The first element of the array is dropped and the subscripts are renumbered, starting at one.
7. The first element of the array after the shift is displayed.
8. After the shift, the length of the array has decreased by one.

13.11 Quoting

The TC shell has a whole set of metacharacters that have some special meaning. In fact, almost any character on your keyboard that is not a letter or a number has some special meaning for the shell. Here is a partial list:

```
* ? [ ] $ ~ ! ^ & { } ( ) > < | ; : %
```

The backslash and quotes are used to escape the interpretation of metacharacters by the shell. Whereas the backslash is used to escape a single character, the quotes can be used to protect a string of characters. There are some general rules for using quotes:

1. Quotes are paired and must be matched on a line. The backslash character can be used to escape a newline so that a quote can be matched on the next line.
2. Single quotes will protect double quotes, and double quotes will protect single quotes.
3. Single quotes protect all metacharacters from interpretation, with the exception of the history character (!).
4. Double quotes protect all metacharacters from interpretation, with the exception of the history character (!), the variable substitution character ($), and the backquotes (used for command substitution).

13.11.1 The Backslash

The backslash is used to quote a single character and is the only character that can be used to escape a history character sequence (such as !! or !string or !5). Often the backslash is used to escape the newline character. The special tcsh variable backslash_quote can be used for quoting quotes and backslashes, but will not work in csh scripts. (See Example 13.80.)

Example 13.80

```
1   > echo Who are you?
    echo: No match.

2   > echo Who are you\?
    Who are you?

3   > echo This is a very,very long line and this is where\
    ? I break the line.
    This is a very, very long line and this is where I break the
    line.

4   > echo "\abc"
    \abc
    > echo '\abc'
    \abc
    > echo \\abc
    \abc

5   > echo 'I can\'t help it!'
    Unmatched '.

6   > set backslash_quote
    > echo 'I can't help it!'
    I can't help it!
```

EXPLANATION

1. The question mark is used for filename expansion. It matches for a single character. The shell is looking for a file in the current directory that is spelled y−o−u, followed by a single character. Because there is not a file by that name in the directory, the shell complains that it could not find a match with No match.
2. The shell will not try to interpret the question mark because it is escaped with the backslash.
3. The string is continued to the next line by escaping the newline with a backslash. (The ? is the secondary prompt, prompt2.)
4. If the backslash is enclosed in either single or double quotes, it is printed. When not

enclosed in quotes, the backslash escapes itself.

5. When enclosed in single quotes the backslash is ignored as a quoting character; i.e., it will not protect the single apostrophe in can't. The shell sees three single quotes and reports an unmatched quote.
6. The tcsh variable backslash_quote, if set, causes backslashes to always quote backslashes, single quotes, and double quotes.

13.11.2 Single Quotes

Single quotes must be matched on the same line and will escape all metacharacters with the exception of the history (bang) character (!), which is not protected because the shell evaluates history before it does quotes (but not before backslashes).

Example 13.81

```
1   > echo 'I need $5.00'
    I need $5.00

2   > cp file1 file2
    > echo 'I need $500.00 now!!'
    echo 'I need $500.00 nowcp file1 file2'

3   > echo 'I need $500.00 now\!\!'
    I need $500.00 now!!

4   > echo 'This is going to be a long line so
    Unmatched '.

5   > echo 'This is going to be a long line so \
    ? I used the backslash to suppress the newline'
    This is going to be a long line so
    I used the backslash to suppress the newline
```

EXPLANATION

1. The string is enclosed in single quotes. All characters, except the history (bang) character (!), are protected from shell interpretation.
2. After you use the cp command, the echo program is executed. Because the !! was not protected from shell interpretation by using the backslash character, the last command on the history list is reexecuted and the cp command becomes part of the string.
3. By quoting the history characters (!!) with backslashes, they are protected from history substitution.
4. The quotes must be matched on the same line, or the shell reports Unmatched.
5. If the line is to be continued, the backslash character is used to escape the newline character. The quote is matched at the end of the next line. Even though the shell ignored the newline, the echo command did not. (The ? is the secondary prompt, prompt2.)

13.11.3 Double Quotes

Double quotes must be matched, will allow variable and command substitution, and hide everything else except the history (bang (!)). The backslash will not escape the dollar sign when enclosed in double quotes.

Example 13.82

```
1   > set name = Bob
    > echo "Hi $name"
    Hi Bob

2   > echo "I don't have time."
    I don't have time.

3   > echo "WOW!!"      # Watch the history metacharacter!
    echo "Wowecho "Wow!!""

4   > echo "WOW\!\!"
    Wow!!

5   > echo "I need \$5.00"
    I need \.00
```

EXPLANATION

1. The local variable name is assigned the value Bob. The double quotes allow the dollar sign to be used for variable substitution.
2. The single quote is protected within double quotes.
3. Double or single quotes will not protect the exclamation point from shell interpretation. The built−in history command is looking for the last command that began with a double quote and that event was not found.
4. The backslash is used to protect the exclamation point.
5. The backslash does not escape the dollar sign when used within double quotes.

13.11.4 Combining Double and Single Quotes

As long as the quoting rules are adhered to, double quotes and single quotes can be used in a variety of combinations in a single command.

Example 13.83

```
1   > set name = Tom

2   > echo "I can't give $name" ' $5.00\!\!'
    I can't give Tom $5.00!!

3   > echo She cried, \"Oh help me\!\!'" ', $name.
    She cried, "Oh help me!!", Tom.
```

EXPLANATION

1. The local variable name is assigned Tom.
2. The single quote in the word can't is protected when enclosed within double quotes. The shell would try to perform variable substitution if the dollar sign in $5.00 were within double quotes. Therefore, the string $5.00 is enclosed in single quotes so that the dollar sign will be a literal. The exclamation point is protected with a backslash because neither double nor single quotes can protect it from shell interpretation.
3. The first conversational quotes are protected by the backslash. The exclamation point is also protected with a backslash. The last conversational quotes are enclosed in a set of single quotes. Single quotes will protect double quotes.

13.11.5 Steps to Successful Quoting

In a more complex command, it is often difficult to match quotes properly unless you follow the steps listed here. (See Appendix C.)

1. Know the UNIX command and its syntax. Before variable substitution, hard code the values into the command line to see if you get the expected results.

   ```
   > awk −F: '/^Zippy Pinhead/{print "Phone is  " $2}' datafile
   Phone is 408−123−4563
   ```
2. If the UNIX command worked correctly, then plug in the variables. At this point, do not remove or change any quotes. Simply put the variables in place of the words they represent. In this example, replace Zippy Pinhead with $name.

   ```
   > set name = "Zippy Pinhead"
   > awk −F: '/^$name/{print "Phone is " $2}' datafile
   ```
3. Play the quoting game as follows: Starting at the left−hand side with the first single quote, insert a matching single quote just before the dollar sign in $name. Now you have a set of matched quotes.

   ```
   awk −F: '/^'$name/{print "Phone is " $2}' datafile
   ```

   Now, right after the last letter, e in $name, place another single quote. (Believe me, this works.) This quote matches the quote after the closing curly brace.

   ```
   > awk −F: '/^'$name'/{print "Phone is  " $2}' datafile
   ```

   Count the number of single quotes, starting at the left−hand side. You have four, a nice even number. Everything within each set of single quotes is ignored by the shell. The quotes are matched as follows:

   ```
   > nawk -F: '$1 ~ /'$name'/{print $2}' filename
   ```
4. Last step: Double quote the variables. Surround each variable very snugly within a set of double quotes. The double quotes protect the whitespace in the expanded variable; for example, the space in Zippy Pinhead is protected.

   ```
   > nawk -F: '$1 ~ /'"$name"'/{print $2}' filename
   ```

13.11.6 Quoting Variables

The :x and :q modifiers are used when it's necessary to quote variables.

Quoting with the :q Modifier. The :q modifier is used to replace double quotes.

Example 13.84

```
1   > set name = "Daniel Savage"

2   > grep $name:q database
    same as
```

```
3   > grep "$name" database

4   > set food = "apple pie"

5   > set dessert = ( $food "ice cream")

6   > echo $#dessert
    3

7   > echo $dessert[1]
    apple

8   > echo $dessert[2]
    pie

9   > echo $dessert[3]
    ice cream

10  > set dessert = ($food:q "ice cream")

11  > echo $#dessert
    2

12  > echo $dessert[1]
    apple pie

13  > echo $dessert[2]
    ice cream
```

EXPLANATION

1. The variable is assigned the string Daniel Savage.
2. When :q is appended to the variable, the variable is quoted. This is the same as enclosing the variable in double quotes.
3. The double quotes surrounding the variable $name allow variable substitution to take place, but protect any whitespace characters. Without the double quotes, the grep program will search for Daniel in a file called Savage and a file called database.
4. The variable food is assigned the string apple pie.
5. The variable dessert is assigned an array (wordlist) consisting of apple pie and ice cream.
6. The number of elements in the dessert array is three. When the food variable was expanded, the quotes were removed. There are three elements, apple, pie, and ice cream.
7. The first element of the array is printed. The variable expands to separated words if not quoted.
8. The second element of the array is printed.
9. Since "ice cream" is quoted, it is treated as one word.
10. The dessert array is assigned apple pie and ice cream. The :q can be used to quote the variable in the same way double quotes quote the variable; i.e., $food:q is the same as "$food".
11. The array consists of two strings, apple pie and ice cream.
12. The first element of the array, apple pie, is printed.
13. The second element of the array, ice cream, is printed.

Quoting with the :x Modifier. If you are creating an array and any of the words in the list contain metacharacters, :x prevents the shell from interpreting the metacharacters when performing variable substitution.

Example 13.85

```
1   > set  things = "*.c  a??  file[1−5]"
    > echo $#things
    1

2   > set newthings = ( $things )
    set: No match

3   > set newthings = ( $things:x )

4   > echo $#newthings
    3

5   > echo "$newthings[1] $newthings[2] $newthings[3] "
    *.c  a??   file[1−5]

6   >  grep $newthings[2]:q filex
```

EXPLANATION

1. The variable things is assigned a string. Each string contains a wildcard. The number of elements in the variable is one, one string.
2. When attempting to create an array out of the string things, the TC shell tries to expand the wildcard characters to perform filename substitution within things and produces a No match.
3. The :x extension prevents the shell from expanding the wildcards in the things variable.
4. The array newthings consists of three elements.
5. To print the elements of the array, they must be quoted or, again, the shell will try to expand the wildcards.
6. The :q quotes the variable just as though the variable were surrounded by double quotes. The grep program will print any lines containing the pattern a?? in file filex.

13.12 Built−In Commands

Rather than residing on disk like UNIX executable commands, built−in commands are part of the TC shell's internal code and are executed from within the shell. If a built−in command occurs as any component of a pipeline except the last, it is executed in a subshell. The tcsh command, aptly called builtins, lists all the built−in commands:

Example 13.86

```
1  > builtins
:          @          alias      alloc     bg         bindkey    break
breaksw    builtins   case       cd        chdir      complete   continue
default    dirs       echo       echotc    else       end        endif
endsw      eval       exec       exit      fg         filetest   foreach
glob       goto       hashstat   history   hup        if         jobs
kill       limit      log        login     logout     ls−F       nice
nohup      notify     onintr     popd      printenv   pushd      rehash
repeat     sched      set        setenv    settc      setty      shift
source     stop       suspend    switch    telltc     time       umask
unalias    uncomplete unhash     unlimit   unset      unsetenv   wait
where      which      while
```

See Table 13.24 for a list of built−in commands.

Table 13.24. Built−In Commands and Their Meanings

Built−In Command Meaning:Interprets null command, but performs no action.alias [name [wordlist]]A nickname for a command. Without arguments, prints all aliases; with a name, prints the name for the alias; with a name and wordlist, sets the alias.allocDisplays amount of dynamic memory acquired, broken down into used and free memory. Varies across systems.

bg [%job]

%job &

Runs the current or specified jobs in the background.

A synonym for the bg built−in command.

bindkey [−l|−d|−e|−v|−u] (+)

bindkey [−a] [−b] [−k] [−r] [− −] key

Without options, the first form lists all bound keys and the editor command to which each is bound, the second form lists the editor command to which key is bound, and the third form binds the editor command command to key. Options include:bindkey [−a] [−b] [−k] [−c|−s] [− −] key command−lLists all editor commands and a short description of each. −dBinds all keys to the standard bindings for the default editor. −eBinds all keys to the standard GNU emacs−like bindings. −vBinds all keys to the standard vi−like bindings. −aLists or changes key−bindings in the alternative key map. This is the key map used in vi command mode. −bThis key is interpreted as a control character written as ^character (e.g., ^A) or C−character (e.g., C−A), a meta− character written M−character (e.g., M−A), a function key written F−string (e.g., F−string), or an extended prefix key written X−character (e.g., X−A). −kThis key is interpreted as a symbolic arrow key name, which may be one of down, up, left, or right. −rRemoves key's binding. Be careful: bindkey−r does not bind key to self−insert−command (q.v.), it unbinds key completely. −cThis command is interpreted as a built−in or external command, instead of an editor command. −sThis command is taken as a literal string and treated as terminal input when key is typed. Bound keys in commands are themselves reinterpreted, and this continues for 10 levels of interpretation. − −−Forces a break from option processing, so the next word is taken as a key even if it begins with a hyphen (−). −u

(or any invalid option) Prints a usage message. This key may be a single character or a string. If a command is bound to a string, the first character of the string is bound to sequence−lead−in and the entire string is bound to the command.

Control characters in key can be literal (they can be typed by preceding them with the editor command quoted−insert, normally bound to ^V) or written caret−character style, e.g., ^A. Delete is written ^? (caret−question mark). Key and command can contain backslashed escape sequences (in the style of System V echo) as follows:

\a Bell\f Form feed\t Horizontal tab\b Backspace \n Newline\v Vertical tab\e Escape\r Carriage return \nnn The ASCII character corresponding to the octal number nnn. \ nullifies the special meaning of the following character, if it has any, notably backslash (\) and caret (^).breakBreaks out of the innermost foreach or while loop.breakswBreaks from a switch, resuming after the endsw.builtinsPrints the names of all built−in commands.byeA synonym for the logout built−in command. Available only if the shell was so compiled; see the version shell variable.case label:A label in a switch statement.cd [dir]Changes the shell's working directory to dir. If no argument is given, changes to the home directory of the user.cd [−p] [−l] [−n|−v] [name]

If a directory name is given, changes the shell's working directory to name. If not, changes to home. If name is − it is interpreted as the previous working directory.

−p, prints the final directory stack, just like dirs.

−l, −n, and −v flags have the same effect on cd as on dirs, and they imply −p.

chdirA synonym for the cd built−in command.

complete [command [word/pattern/list[:select]/[[suffix]/] …]]

Without arguments, lists all completions. With command, lists completions for command. With command and word etc., defines completions. (See "Programming Completions" on page 866.)continueContinues execution of the nearest enclosing while or foreach.default:Labels the default case in a switch statement. The default should come after all case labels.

dirs [−l] [−n|−v]

dirs −S|−L [filename]

dirs −c

The first form prints the directory stack. The top of the stack is at the left and the first directory in the stack is the current directory. −l, ~ or ~name in the output is expanded explicitly to home or the pathname of the home directory for user name.

(+) −n, entries are wrapped before they reach the edge of the screen.

(+) −v, entries are printed one per line preceded by their stack postions.

−S, the second form saves the directory stack to filename as a series of cd and pushd commands.

−L, the shell source's filename, which is presumably a directory stack file saved.

In either case, dirsfile is used if filename is not given and ~/.cshdirs is used if dirsfile is unset.

With −c, form clears the directory stack.

echo [−n] listWrites the words in list to the shell's standard output, separated by SPACE characters. The output is terminated with a NEWLINE unless the −n option is used.echo [−n] word …Writes each word to the shell's standard output, separated by spaces and terminated with a newline. The echo_style shell variable may be set to emulate (or not) the flags and escape sequences of the BSD and/or System V versions of echo.echotc [−sv] arg …Exercises the terminal capabilities in args. For example, echotc home sends the cursor to the home position. If arg is baud, cols, lines, meta, or tabs, prints the value of that capability. With −s, nonexistent capabilities return the empty string rather than causing an error. With −v, messages are verbose.else if (expr2) thenSee "The if/else if Statements" on page 401.

else

end

endif

endsw

See the description of the foreach, if, switch, and while statements below.endExecutes the commands between the while and the matching end while expr evaluates nonzero. while and end must appear alone on their input lines. break and continue may be used to terminate or continue the loop prematurely. If the input is a terminal, the user is prompted the first time through the loop as with foreach.eval arg …Treats the arguments as input to the shell and executes the resulting command(s) in the context of the current shell. This is usually used to execute commands generated as the result of command or variable substitution, since parsing occurs before these substitutions.eval commandRuns command as standard input to the shell and executes the resulting commands. This is usually used to execute commands generated as the result of command or variable substitution, since parsing occurs before these substitutions (e.g., eval tset −s options).exec commandExecutes command in place of the current shell, which terminates.exit [(expr)]Exits the shell, either with the value of the status variable or with the value specified by expr.

fg [% job]

%job

Brings the current or specified job into the foreground.

A synonym for the fg built−in command.

filetest −op file …Applies op (which is a file inquiry operator) to each file and returns the results as a space−separated list.

foreach name (wordlist)

…

end

See "The foreach Loop" on page 412.foreach var (wordlist)See "The foreach Loop" on page 412.getspathPrints the system execution path. (TCF only) (tcsh only)getxversPrints the experimental version prefix. (TCF only) (tcsh only)glob wordlistPerforms filename expansion on wordlist. Like echo, but no escapes (\) are recognized. Words are delimited by null characters in the output.goto labelSee "The goto" on page 405.goto word word is filename and command−substituted to yield a string of the form label. The shell rewinds its input as much as possible, searches for a line of the form label:, possibly preceded by blanks or tabs, and continues execution after that line.hashstatPrints a statistics line indicating how effective the internal hash table has been at locating commands (and avoiding execs). An exec is attempted for each component of the path where the hash function indicates a possible hit, and in each component that does not begin with a backslash.

history [−hTr] [n] history −S|−L|−M [filename] history −c

The first form prints the history event list. If n is given, only the n most recent events are printed or saved. With −h, the history list is printed without leading numbers. If −T is specified, timestamps are printed in comment form. (This can be used to produce files suitable for loading with history −L or source −h.)

With −r, the order of printing is most recent first rather than oldest first. (See "History".) With −c, clears the history list.

hup [command]With command, runs command such that it will exit on a hangup signal and arranges for the shell to send it a hangup signal when the shell exits. Note that commands may set their own response to hangups, overriding hup. Without an argument (allowed only in a shell script), causes the shell to exit on a hangup for the remainder of the script.if (expr) commandIf expr evaluates true, then command is executed. Variable substitution on command happens early, at the same time it does for the rest of the if command. Command must be a simple command, not an alias, a pipeline, a command list or a parenthesized command list, but it may have arguments. Input/output redirection occurs even if expr is false and command is thus not executed; this is a bug.

if (expr) then

…

else if (expr2) then

…

else

…

endif

If the specified expr is true then the commands to the first else are executed; otherwise if expr2 is true then the commands to the second else are executed, etc. Any number of else if pairs are possible; only one endif is needed. The else part is likewise optional. (The words else and endif must appear at the beginning of input lines; the if must appear alone on its input line or after an else.)inlib shared−library …Adds each shared−library to the current environment. There is no way to remove a shared library. (Domain/OS only)jobs [−l]

Lists the active jobs under job control.

With −l, lists IDs in addition to the normal information.

kill [−sig] [pid] [%job] …

kill −l

Sends the TERM (terminate) signal, by default or by the signal specified, to the specified ID, the job indicated, or the current job. Signals are given either by number or name. There is no default. Typing kill does not send a signal to the current job. If the signal being sent is TERM (terminate) or HUP (hangup), then the job or process is sent a CONT (continue) signal as well. With −l, lists the signal names that can be sent.limit [−h] [resource [max−use]]Limits the consumption by the current process or any process it spawns, each not to exceed max−use on the specified resource. If max−use is omitted, print the current limit; if resource is omitted, display all limits. With −h, uses hard limits instead of the current limits. Hard limits impose a ceiling on the values of the current limits. Only the superuser may raise the hard limits. Resource is one of: cputime, maximum CPU seconds per process; filesize, largest single file allowed; datasize, maximum data size (including stack) for the process; stacksize, maximum stack size for the process; coredump, maximum size of a core dump; and descriptors, maximum value for a file descriptor.logPrints the watch shell variable and reports on each user indicated in watch who is logged in, regardless of when they last logged in. See also watchlog.loginTerminates a login shell, replacing it with an instance of /bin/login.login [username|−p]Terminates a login shell and invokes login. The .logout file is not processed. If username is omitted, login prompts for the name of a user. With −p, preserves the current environment (variables).logoutTerminates a login shell.ls −F [−switch …] [file …]Lists files like ls −F, but much faster. It identifies each type of special file in the listing with a special character: /Directory *Executable #Block device |Named pipe (systems with named pipes only) =Socket (systems with sockets only) +Hidden directory (AIX only) or context−dependent (HP/UX only) @Symbolic link (systems with symbolic links only) :Network special (HP/UX only) If the listlinks shell variable is set, symbolic links are identified in more detail (only, of course, on systems which have them): @Symbolic link to a nondirectory >Symbolic link to a directory &Symbolic link to nowhere The ls −F built−in can list files using different colors depending on the filetype or extension.

migrate [−site] pid|%jobid …

migrate −site

The first form migrates the process or job to the site specified or the default site determined by the system path. The second form is equivalent to migrate −site $$. It migrates the current process to the specified site. Migrating the shell itself can cause unexpected behavior, since the shell does not like to lose its tty. (TCF only)@ @ name = expr @ name[index] = expr @ name++|− − @ name[index]++|− −The first form prints the values of all shell variables. The second form assigns the value of expr to name. The third form assigns the value of expr to the indexth component of name; both name and its indexth component must already exist. The fourth and fifth forms increment (++) or decrement (− −) name or its indexth component.newgrp [−] groupEquivalent to exec newgrp. Available only if the shell was so compiled; see the version shell variable.nice [+number][command]Sets the scheduling priority for the shell to number, or, without number, to 4. With command, runs command at the appropriate priority. The greater the number, the less CPU the process gets. The superuser may specify negative priority by using nice −number …. Command is always executed in a subshell, and the restrictions placed on commands in simple if statements apply.nohup [command]Runs command with HUPs (hangups) ignored. With no arguments, ignores HUPs throughout the remainder of a script.

notify [%job]

Notifies the user asynchronously when the status of the current or of a specified job changes.onintr [− | label]Controls the action of the shell on interrupts. With no arguments, onintr restores the default action of the shell on interrupts. (The shell terminates shell scripts and returns to the terminal command input level.) With the minus sign argument, the shell ignores all interrupts. With a label argument, the shell executes a goto label when an interrupt is received or a child process terminates because it was interrupted.popd [+n]Pops the directory stack and cd to the new top directory. The elements of the directory stack are numbered from zero, starting at the top. With +n, discard the nth entry in the stack.printenv [name]Prints the names and values of all environment variables or, with name, the value of the environment variable name.pushd [+n | dir]Pushes a directory onto the directory stack. With no arguments, exchanges the top two elements. With +n, rotates the nth entry to the top of the stack and cd to it. With dir, pushes the current working directory onto the stack and changes to dir.rehashRecomputes the internal hash table of the contents of directories listed in the path variable to account for new commands added.repeat count commandRepeats command count times.rootnode //nodenameChanges the rootnode to //nodename, so that / will be interpreted as //nodename. (Domain/OS only)

sched

sched [+]hh:mm command

sched −n

The first form prints the scheduled−event list. The sched shell variable may be set to define the format in which the scheduled−event list is printed. The second form adds command to the scheduled−event list.

set

set name …

set name=word …

set [−r] [−f|−l] name=(wordlist) … (+)

set name[index]=word …

set −r

set −r name …

set −r name=word …

The first form of the command prints the value of all shell variables. Variables which contain more than a single word print as a parenthesized word list. The second form sets name to the null string. The third form sets name to the single word. The fourth form sets name to the list of words in wordlist. In all cases the value is command and filename expanded. If −r is specified, the value is set read−only. If −f or −l are specified, set only unique words keeping their order. −f prefers the first occurrence of a word, and −l the last occurrence of the word. The fifth form sets the index'th component of name to word; this component must already exist. The sixth form lists the names (only) of all shell variables which are read−only (tcsh only). The seventh form makes name read−only, whether or not it has a value (tcsh only). The eighth form is the same as the third form, but makes name read−only at the same time (tcsh only).set [var [= value]]See "Variables".setenv [VAR [word]]See "Variables". The most commonly used environment variables, USER, TERM, and PATH, are automatically imported to and exported from the csh variables user, term, and path; there is no need to use setenv for these. In addition, the shell sets the PWD environment variable from the csh variable cwd whenever the latter changes.setenv [name [value]]Without arguments, prints the names and values of all environment variables. Given name, sets the environment variable name to value or, without value, to the null string.setpath pathEquivalent to setpath. (Mach only)setspath LOCAL|site|cpu …Sets the system execution path. (TCF only)settc cap valueTells the shell to believe that the terminal capability cap has the value value. No sanity checking is done. Concept terminal users may have to settc xn no to get proper wrapping at the rightmost column.setty [−d|−q|−x] [−a] [[+|−]mode]Controls which tty modes the shell does not allow to change. −d, −q, or −x tells setty to act on the edit, quote, or execute set of tty modes, respectively; without −d, −q, or −x, execute is used. Without other arguments, setty lists the modes in the chosen set which are fixed on (+mode) or off (−mode). The available modes, and thus the display, vary from system to system. With −a, lists all tty modes in the chosen set whether or not they are fixed. With +mode, −mode, or mode, fixes mode on or off or removes control from mode in the chosen set. For example, setty +echok echoe fixes echok mode on and allows commands to turn echoe mode on or off, both when the shell is executing commands.setxvers [string]Sets the experimental version prefix to string, or removes it if string is omitted. (TCF only)shift [variable]The components of argv, or variable, if supplied, are shifted to the left, discarding the first component. It is an error for variable not to be set, or to have a null value.source [−h] nameReads commands from name. Source commands may be nested, but if they are nested too deeply, the shell may run out of file descriptors. An error in a sourced file at any level terminates all nested source commands. Used commonly to reexecute the .login or .cshrc files to ensure variable settings are handled within the current shell, i.e., shell does not create a child shell (fork). With −h, places commands from the filename on the history list without executing them.stop [%job] …Stops the current or specified background job.suspendStops the shell in its tracks, much as if it had been sent a stop signal with ^Z. This is most often used to stop shells started by su.switch (string)See "The switch Command" on page 409.telltcLists the values of all terminal capabilities.time [command]With no argument, prints a summary of time used by this shell and its children. With an optional command, executes command and print a summary of the time it uses.umask [value]Displays the file creation mask. With value, sets the file creation mask. Value, given in octal, is xored with the permissions of 666 for files and 777 for directories to arrive at the permissions for new files. Permissions cannot be added via umask.unalias patternRemoves all aliases whose names match pattern. unalias * thus removes all aliases. It is not an error for nothing to be unaliased.uncomplete patternRemoves all completions whose names match pattern. uncomplete * thus removes all completions.unhashDisables the internal hash table.universe universeSets the universe to universe. (Masscomp/RTU only)unlimit [−h] [resource]Removes the limitation on resource or, if no resource is specified, all resource limitations. With −h, the corresponding hard limits are removed. Only the superuser may do this.unsetenv patternRemoves all environment variables whose names match pattern. unsetenv * thus removes all environment variables; this is a bad idea. If there is no pattern to be unsetenved, no error will result from this built−in.unsetenv variableRemoves variable from the environment. Pattern matching, as with unset, is not performed.

@ [var =expr]

@ [var[n] =expr]

With no arguments, displays the values for all shell variables. With arguments, the variable var, or the nth word in the value of var, is set to the value that expr evaluates to.ver [systype [command]]Without arguments, prints SYSTYPE. With systype, sets SYSTYPE to systype. With systype and command, executes command under systype. systype may be bsd4.3 or sys5.3. (Domain/OS only)waitWaits for background jobs to finish (or for an interrupt) before prompting.warp universeSets the universe to universe. (Convex/OS only)watchlogAn alternate name for the log built−in command (q.v.). Available only if the shell was so compiled; see the version shell variable.where commandReports all known instances of command, including aliases, built−ins, and executables in path.which commandDisplays the command that will be executed by the shell after substitutions, path searching, etc. The built−in command is just like which, but it correctly reports tcsh aliases and built−ins and is 10 to 100 times faster.while (expr)See "The while Loop" on page 415.

13.12.1 Special Aliases

If set, each of the TC shell aliases executes automatically at the indicated time. They are all initially undefined.

beepcmd	Runs when the shell wants to ring the terminal bell.
cwdcmd	Runs after every change of working directory.
periodic	Runs every tperiod minutes; e.g., > set tperiod = 30 > alias periodic date
precmd	Runs just before each prompt is printed; e.g., alias precmd date.

13.12.2 Special Built−In Shell Variables

The built−in shell variables have special meaning to the shell and are used to modify and control the way many of the shell commmands behave. They are local variables and therefore most of them are set in the .tcshrc file if they are to be passed on to and affect child TC shells.

When the shell starts up, it automatically sets the following variables: addsuffix, argv, autologout, command, echo_style, edit, gid, group, home, loginsh, oid, path, prompt, prompt2, prompt3, shell, shlvl, tcsh, term, tty, uid, user, and version. Unless the user decides to change them, these variables will remain fixed. The shell also keeps track of and changes special variables that may need periodic updates, such as, cwd, dirstack, owd, and status, and when the user logs out, the shell sets the logout variable.

Some of the local variables have a corresponding environment variable of the same name. If one of the environment or local variables are affected by a change in the user's environment, the shell will synchronize the local and environment variables[10] so that their values always match. Examples of cross−matched variables are afuser, group, home, path, shlvl, term, and user. (Although cwd and PWD have the same meaning, they are not cross−matched. Even though the syntax is different for the path and PATH variables, they are automatically crossed−matched if either one is changed.)

Table 13.25. Special Shell Variables[23]

Variable EffectaddsufixFor filename completion, adds slashes at the end of directories and space to the end of normal files if they are matched. Set by default.afsuserIf set, autologout's autolock feature uses its value instead of the local username for kerberos authentication.ampmIf set, all times are shown in 12−hour AM/PM format.argvAn array of command line arguments to the shell; also represented as $1, $2, etc.autocorrectInvokes the spell checker before each attempt at filename, command, or variable completion.autoexpandIf set, the expand−history editor command is invoked automatically before each completion attempt.autolistIf set, possibilities are listed after an ambiguous completion. If set to ambiguous, possibilities are listed only when no new characters are added by completion.autologoutIts argument is the number of minutes of inactivity before automatic logout; the second optional argument is the number of minutes before automatic locking causes the screen to lock. backslash_quoteIf set, a backslash will always quote itself, a single quote, or a double quote.cdpathA list of directories in which cd should search for subdirectories if they aren't found in the current directory.colorEnables color display for the built−in command, ls −F and passes − −color=auto to ls.completeIf set to enhance, completion ignores case, considers periods, hyphens, and underscores to be word separators, and hyphens and underscores to be equivalent.correctIf set to cmd, commands are automatically spelling−corrected. If set to complete, commands are automatically completed. If set to all, the entire command line is corrected.cwdThe full pathname of the current working directory.dextractIf set, pushd +n extracts the nth directory from the directory stack rather than rotating it to the top.dirsfileThe default location in which dirs −S and dirs −L look for a history file. If unset, ~/.cshdirs is used.dirstackA list of all directories on the directory stack.duniqueWill not allow pushd to keep duplicate directory entries on the stack.echoIf set, each command with its arguments is echoed just before it is executed. Set by the −x command line option.echo−styleSets the style for echo. If set to bsd will not echo a newline if the first argument is −n; if set to sysv, recognizes backslashed escape sequences in echo strings; if set to both, recognizes both the −n flag and backslashed escape sequences; the default, and if set to none, recognizes neither.editSets the command−line editor for interactive shells; set by default.ellipsisIf set, the %c/%. and %C prompt sequences (see the "The Shell Prompts") indicate skipped directories with an ellipsis (…) instead of /<skipped>.fignoreLists filename suffixes to be ignored by completion.filecIn tcsh, completion is always used and this variable is ignored. If set in csh, filename completion is used.gidThe user's read group ID number.groupThe user's group name.histcharsA string value determining the characters used in history substitution. The first character of its value is used as the history substitution character to replace the default character, !. The second character of its value replaces the character ^ in quick substitutions.histdupControls handling of duplicate entries in the history list. Can be set to all (removes all duplicates) , prev (removes the current command if it duplicates the previous command), or erase (inserts the current event for an older duplicate event).histfileThe default location in which history −S and history −L look for a history file. If unset, ~/.history is used.histlitEnters events on the history list literally; i.e., unexpanded by history substitution.historyThe first word indicates the number of history events to save. The optional second word (+) indicates the format in which history is printed.homeThe home directory of the user; same as ~.ignoreeofIf logging out by pressing Control−D, prints Use exit to leave tcsh. Prevents inadvertently logging out.implicitcdIf set, the shell treats a directory name typed as a command as though it were a request to change to that directory and changes to it.inputmodeIf set to insert or overwrite, puts the editor into that input mode at the beginning of each line.listflagsIf set to x, a, or A, or any combination (e.g., xA), values are used as flags to ls −F, making it act like ls −xF, ls −Fa, ls −FA, or any combination of those flags.listjobsIf set, all jobs are listed when a job is suspended. If set to long, the listing is in long format.listlinksIf set, the ls −F built−in command shows the type of file to which each symbolic link points.listmaxThe maximum number of items that the list−choices editor command will list without asking first.listmaxrowsThe maximum number of rows of items which the list−choices editor command will list without asking first.loginshSet by the shell if it is a login shell. Setting or unsetting it within a shell has no effect. See also shlvl later in this table.logoutSet by the shell to normal before a normal logout, automatic before an automatic logout, and hangup if the shell was killed by a hangup signal.mailThe names of the files or directories to check for incoming mail. After 10 minutes if new mail has come in, will printYou have new mail.matchbeepIf set to never, completion never beeps; if set to nomatch, completion beeps only when there is no match; and when set to ambiguous, beeps when there are multiple matches.nobeepDisables all beeping.noclobberSafeguards against the accidental removal of existing files when redirection is used; e.g., ls > file.noglobIf set, inhibits filename and directory stack substitutions when using wildcards.nokanjiIf set and the shell supports Kanji (see the version shell variable), it is disabled so that the Meta key can be used.nonomatchIf set, a filename substitution or directory stack substitution that does not match any existing files is left untouched rather than causing an error.nostatA list of directories (or glob patterns that match directories) that should not be stated during a completion operation. This is usually used to exclude directories which take too much time tostat.notifyIf set, the shell announces job completions asynchronously instead of waiting until just before the prompt appears.oidThe user's real organization ID. (Domain/OS only)owdThe old or previous working directory.pathA list of directories in which to look for executable commands. path is set by the shell at startup from the PATH environment variable or, if PATH does not exist, to a system−dependent default something like /usr/local/bin /usr/bsd/bin /usr/bin. printexitvalueIf set and an interactive program exits with a nonzero status, the shell prints Exit status.promptThe string printed before reading each command from the terminal; may include special formatting sequences (See "The Shell Prompts").prompt2The string with which to prompt in while and foreach loops and after lines ending in \. The same format sequences may be used as in prompt; note the variable meaning of %R. Set by default to %R? in interactive shells.prompt3The string with which to prompt when confirming automatic spelling correction. The same format sequences may be used as in prompt; note the variable meaning of %R. Set by default to CORRECT>%R (y|n|e|a)? in interactive shells.promptcharsIf set (to a two−character string), the %# formatting sequence in the prompt shell variable is replaced with the first character for normal users and the second character for the superuser.pushtohomeIf set, pushd without arguments does pushd ~, like cd.pushdsilentIf set, pushd and popd do not print the directory stack.recexactIf set, completion completes on an exact match even if a longer match is possible. recognize_only_executablesIf set, command listing displays only files in the path that are executable.rmstarIf set, the user is prompted before rm [23] is executed.rpromptThe string to print on the right−hand side of the screen (after the command input) when the prompt is being displayed on the left. It recognises the same formatting characters as prompt. It will automatically disappear and reappear as necessary, to ensure that command input isn't obscured, and will only appear if the prompt, command input, and itself will fit together on the first line. If edit isn't set, then rprompt will be printed after the prompt and before the command input.savedirsIf set, the shell does dirs −S before exiting.savehistIf set, the shell does history −S before exiting. If the first word is set to a number, at most that many lines are saved. (The number must be less than or equal to history.) If the second word is set to merge, the history list is merged with the existing history file instead of replacing it (if there is one) and sorted by timestamp and the most recent events are retained.schedThe format in which the sched built−in command prints scheduled events; if not given, %h\t%T\t%R\n is used. The format sequences are described above under prompt; note the variable meaning of %R.shellThe file in which the shell resides. This is used in forking shells to interpret files that have execute bits set, but that are not executable by the system. (See the description of built−in and nonbuilt−in command execution.) Initialized to the (system−dependent) home of the shell.shlvlThe number of nested shells. Reset to 1 in login shells. See also loginsh.statusThe status returned by the last command. If it terminated abnormally, then 0200 is added to the status. Built−in commands that fail return exit status 1, all other built−in commands return status 0.symlinksCan be set to several different values to control symbolic link (symlink) resolution. (See tcsh man page for examples.)tcshThe version number of the shell in the format R.VV.PP, where R is the major release number, VV the current version, and PP the patch level.termThe terminal type. Usually set in ~/.login as described under "Startup".timeIf set to a number, then the time built−in executes automatically after each command which takes more than that many CPU seconds. If there is a second word, it is used as a format string for the output of the time built−in. The following sequences may be used in the format string: %UThe time the process spent in user mode in CPU seconds. %SThe time the process spent in kernel mode in CPU seconds. %EThe elapsed (wall clock) time in seconds. %PThe CPU percentage computed as (%U + %S) / %E. %WNumber of times the process was swapped. %XThe average amount in (shared) text space used in KB. %DThe average amount in (unshared) data/stack space used in KB. %KThe total space used (%X + %D) in KB. %MThe maximum memory the process had in use at any time in KB. %FThe number of major page faults (page needed to be brought from disk). %RThe number of minor page faults. %IThe number of input operations. %OThe number of output operations. %rThe number of socket messages received. %sThe number of socket messages sent. %kThe number of signals received. %wThe number of voluntary context switches (waits). %cThe number of involuntary context switches. Only the first four sequences are supported on systems without BSD resource limit functions. The default time format is %Uu %Ss %E %P %X+%Dk %I+%Oio %Fpf+%Ww for systems that support resource usage reporting and %Uu %Ss %E %P for systems that do not. Under Sequent's DYNIX/ptx, %X, %D, %K, %r, and %s are not available, but the following additional sequences are: %YThe number of system calls performed. %ZThe number of pages that are zero−filled on demand. %iThe number of times a process' resident set size was increased by the kernel. %dThe number of times a process' resident set size was decreased by the kernel. %lThe number of read system calls performed. %mThe number of write system calls performed. %pThe number of reads from raw disk devices. %qThe number of writes to raw disk devices. The default time format is %Uu %Ss $E %P %I+%Oio %Fpf+%Ww. Note that the CPU percentage can be higher than 100 percent on multiprocessors.tperiodThe period, in minutes, between executions of the periodic special alias.ttyThe name of the tty, or empty if not attached to one.uidThe user's real user ID.userThe user's login name.verboseIf set, causes the words of each command to be printed, after history substitution (if any). Set by the −v command line option.versionThe version ID stamp. It contains the shell's version number (see tcsh), origin, release date, vendor, operating system, etc.

[23] Adapted from the tcsh manual pages.

Shell Command Line Switches. The TC shell can take a number of command line switches (also called flag arguments) to control or modify its behavior. The command line switches are listed in Table 13.26.

Table 13.26. Shell Command Line Switches[*]

Switch Meaning−Specifies the shell is a login shell.−bForces a "break" from option processing. Any shell arguments thereafter, will not be treated as options. The remaining arguments will not be interpreted as shell options. Must include this option if shell is set−user−ID.−cIf a single argument follows the −c, commands are read from the argument (a filename). Remaining arguments are placed in the argv shell variable.−dThe shell loads the directory stack from ~/.cshdirs.−Dname[=value]Sets the environment variable name to value.−eThe shell exits if any invoked command terminates abnormally or yields a nonzero exit status.−fCalled the fast startup because the shell ignores ~/.tcshrc when starting a new TC shell.−FThe shell uses fork instead of vfork to spawn processes. (Convex/OS only)−iThe shell is interactive and prompts input, even if it appears to not be a terminal. This option isn't necessary if input and output are connected to a terminal.−lThe shell is a login shell if −l is the only flag specified.−mThe shell loads ~/.tcshrc even if it does not belong to the effective user.−nUsed for debugging scripts. The shell parses commands but does not execute them.−qThe shell accepts the SIGQUIT signal and behaves when it is used under a debugger. Job control is disabled.−sCommand input is taken from the standard input.−tThe shell reads and executes a single line of input. A backslash (\) may be used to escape the newline at the end of this line and continue on to another line.−vSets the verbose shell variable so that command input is echoed after history substitution. Used to debug shell scripts.−xSets the echo shell variable so that commands are echoed before execution and after history and variable substitution. Used to debug shell scripts.−VSets the verbose shell variable before executing the ~/.tcshrc file.−XSets the echo shell variable before executing the ~/.tcshrc file.

[*] Adapted from the tcsh manual pages.

TC SHELL LAB EXERCISES

Lab 57: Getting Started

1: What does the init process do?

2: What is the function of the login process?

3: How do you know what shell you are using?

4: How can you change your login shell?

5: Explain the difference between the .tcshrc, .cshrc, and .login files. Which one is executed first?

6: Edit your .tcshrc file as follows:

a. Create three of your own aliases.
b. Reset your prompt with the host machine name, time, and username.
c. Set the following variables and put a comment after each variable explaining what it does.

7: Type the following:

```
source .tcshrc
```

What does the source command do?

8: Edit your .login file as follows:

a. Welcome the user.
b. Add your home directory to the path if it is not there.
c. Source the login file.

9: What is the difference between path and PATH?

Lab 58: History

1: In what file are history events stored when you log out? What variable controls the number of history events to be displayed? What is the purpose of the savehist variable?

2: Print your history list in reverse.

3: Print your history list without line numbers.

4: Type the following commands:

a. ls −a
b. date '+%T'
c. cal 2000
d. cat /etc/passwd
e. cd

5: Type history. What is the output?

a. How do you reexecute the last command?
b. Now type echo a b c.

Use the history command to reexecute the echo command with only its last argument, c.

6: Use history to print and execute the last command in your history list that started with the letter d.

7: Execute the last command that started with c.

8: Execute the echo command and the last argument from the previous command.

9: Use the history substitution command to replace the T in the date command with an H.

10: How do you use the bindkey command to start the vi editor for command line editing?

11: How do you list the editor commands and what they do?

12: How do you see how the editing keys are actually bound?

13: Describe what the fignore variable does.

Lab 59: Shell Metacharacters

1: Type at the prompt:

```
touch ab abc a1 a2 a3 all a12 ba ba.1 ba.2 filex filey AbC ABC
ABc2 abc
```

2: Write and test the command that will do the following:

a. List all files starting with a.
b. List all files ending in at least one digit.
c. List all files not starting with an a or A.
d. List all files ending in a period, followed by a digit.
e. List all files containing just two letters.
f. List three−character files where all letters are uppercase.
g. List files ending in 11 or 12.
h. List files ending in x or y.
i. List all files ending in a digit, an uppercase letter, or a lowercase letter.
j. List all files containing a b.
k. Remove two−character files starting with a.

Lab 60: Redirection

1: What are the names of the three file streams associated with your terminal?

2: What is a file descriptor?

3: What command would you use to do the following:

a. Redirect the output of the ls command to a file called lsfile?
b. Redirect and append the output of the date command to lsfile?
c. Redirect the output of the who command to lsfile? What happened?

4: What happens when you type cp all by itself?

a. How do you save the error message from the above example to a file?

5: Use the find command to find all files, starting from the parent directory, and of type directory. Save the standard output in a file called found and any errors in a file called found.errs.

6: What is noclobber? How do you override it?

7: Take the output of three commands and redirect the output to a file called gottemall.

8: Use a pipe(s) with the ps and wc commands to find out how many processes you are currently running.

Lab 61: Variables and Arrays

1: What is the difference between a local variable and an environment variable?

2: How do you list all local variables? Environmental variables?

3: In what initialization file would you store local variables? Why?

4: Create an array called fruit. Put five kinds of fruit in the array.

a. Print the array.
b. Print the last element of the array.
c. Print the number of elements in the array.
d. Remove the first element from the array.
e. If you store an item that isn't fruit in the array, is it OK?

5: Describe the difference between a wordlist and a string.

[1] The T in tcsh has origins dating back to the TENEX and TOP−10s operating systems used by DEC for its PDP−10 computer. These systems had a form of command completion for the monitor. The creator of the tcsh admired features of these systems, and hence, added the T to the C shell.

[2] See tutorial at www.tac.nyc.ny.us/mirrors/tcsh−book.

[3] The order in which these files are read can be changed when tcsh is compiled.

[4] Do not confuse the search path variable with the cdpath variable set in the cshrc file.

[5] On machines without vfork(2), prints the number and size of hash buckets.

[6] The length of the command line can be 256 characters or more.

[7] The name of the .history file can be changed by assigning the new name to the histfile shell variable.

[8] The tcsh \1 man page warns that spelling correction is not guaranteed to work the way you may intend and is provided as an experimental feature.

[9] The tcsh man page says that a command in the scheduled−event list is executed just before the first prompt is printed after the time when the command is scheduled. If it so happens that the exact time when the command is to be run is missed, an overdue command will execute at the next prompt.

[10] This is true unless the variable is a read−only variable, and then there will be no synchronization.

CONTENTS

Appendix A. Useful UNIX Utilities for Shell Programmers

at—at, batch—execute commands at a later time

at [–csm] [–f script] [–qqueue] time [date] [+ increment]
at –l [job...]
at –r job...
batch

at and batch read commands from standard input to be executed at a later time. at allows you to specify when the commands should be executed, while jobs queued with batch will execute when system load level permits. Executes commands read from stdin or a file at some later time. Unless redirected, the output is mailed to the user.

Example A.1

```
1   at 6:30am Dec 12 < program
2   at noon tomorrow < program
3   at 1945 pm August 9 < program
4   at now + 3 hours < program
5   at 8:30am Jan 4 < program
6   at −r 83883555320.a
```

EXPLANATION

1. At 6:30 in the morning on December 12th, start the job.
2. At noon tomorrow start the job.
3. At 7:45 in the evening on August 9th, start the job.
4. In three hours start the job.
5. At 8:30 in the morning of January 4th, start the job.
6. Removes previously scheduled job 83883555320.a.

awk—pattern scanning and processing language

awk [–fprogram–file] [–Fc] [prog] [parameters]
[filename...]

awk scans each input filename for lines that match any of a set of patterns specified in prog.

Example A.2

```
1   awk '{print $1, $2}' file
2   awk '/John/{print $3, $4}' file
3   awk −F: '{print $3}' /etc/passwd
4   date | awk '{print $6}'
```

EXPLANATION

1. Prints the first two fields of file where fields are separated by whitespace.
2. Prints fields 3 and 4 if the pattern John is found.
3. Using a colon as the field separator, prints the third field of the /etc/passwd file.
4. Sends the output of the date command to awk and prints the sixth field.

banner—make posters

banner prints its arguments (each up to 10 characters long) in large letters on the standard output.

Example A.3

```
banner Happy Birthday
```

EXPLANATION

Displays in banner format the string Happy Birthday.

basename—with a directory name delivers portions of the pathname

basename string [suffix]
dirname string

basename deletes any prefix ending in / (forward slash) and the suffix (if present in string) from string, and prints the result on the standard output.

Example A.4

```
1   basename /usr/local/bin
2   scriptname="'basename $0'"
```

EXPLANATION

1. Strips off the prefix /usr/local/ and displays bin.
2. Assigns just the name of the script, $0, to the variable scriptname

bc—processes precision arithmetic

bc [–c] [–l] [filename...]

bc is an interactive processor for a language that resembles C but provides unlimited precision arithmetic. It takes input from any files given, then reads the standard input.

Example A.5

```
1   bc << EOF
    scale=3
    4.5 + 5.6 / 3
    EOF
    Output : 6.366
    -----------------------------
2   bc
    ibase=2
    5
    101 (Output)
    20
    10100 (Output
    ^D
```

EXPLANATION

1. This is a here document. From the first EOF to the last EOF input is given to the bc command. The scale specifies the number of digits to the right of the decimal point. The result of the calculation is displayed on the screen.
2. The number base is two. The number is converted to binary (AT&T only).

bdiff—compares two big files

bdiff compares two files that are too large for diff.

cal—displays a calendar

cal [[month] year]

cal prints a calendar for the specified year. If a month is also specified, a calendar just for that month is printed. If neither is specified, a calendar for the present month is printed.

Example A.6

```
1   cal 1997
2   cal 5 1978
```

EXPLANATION

1. Prints the calendar year 1997.
2. Prints the month of May for 1978.

cat—concatenates and displays files

cat [–bnsuvet] filename...

cat reads each filename in sequence and writes it on the standard output. If no input file is given, or if the argument – is encountered, cat reads from the standard input file.

Example A.7

```
1   cat /etc/passwd
2   cat -n file1 file2 >> file3
```

EXPLANATION

1. Displays the contents of the /etc/passwd file.
2. Concatenates file1 and file2 and appends output to file3. The –n switch causes each line to be numbered.

chmod—change the permissions mode of a file

chmod [–fR] mode filename...
chmod [ugoa]{ + | – | = }[rwxlsStTugo] filename...

chmod changes or assigns the mode of a file. The mode of a file specifies its permissions and other attributes. The mode may be absolute or symbolic.

Example A.8

```
1   chmod +x script.file
2   chmod u+x,g-x file
3   chmod 755 *
```

EXPLANATION

1. Turns on execute permission for user, group, and others on script.file.
2. Turns on execute permission for user, and removes it from group on file.

3. Turns on read, write, and execute for the user, read and execute for the group, and read and execute for others on all files in the current working directory. The value is octal (111 101 101).

```
rwxxr-xr-x
```

chown—changes owner of file

chown [–fhR] owner filename ...

chown changes the owner of the files to owner. The owner may be either a decimal user ID or a login name found in /etc/passwd file. Only the owner of a file (or the superuser) may change the owner of that file.

Example A.9

```
1   chown john filex
2   chown −R ellie ellie
```

EXPLANATION

1. Changes the user ID of filex to john.
2. Recursively changes the ownership to ellie for all files in ellie directory.

clear—clears the terminal screen

cmp—compares two files

cmp [–l] [–s] filename1 filename2

The two files are compared. cmp makes no comment if the files are the same; if they differ, it announces the byte and line numbers at which the first difference occurred.

Example A.10

```
cmp file.new file.old
```

EXPLANATION

If the files differ, the character number and the line number are displayed.

compress—compress, uncompress, zcat compress, uncompress files, or display expanded files

compress [–cfv] [–b bits] [filename...]
uncompress [–cv] [filename...]

zcat [filename...]

compress reduces the size of the named files using adaptive Lempel−Ziv coding. Whenever possible, each file is replaced by one with a .Z extension. The ownership modes, access time, and modification time will stay the same. If no files are specified, the standard input is compressed to the standard output.

Example A.11

```
1   compress −v book
    book:Compression:35.07% −− replaced with book.Z
2   ls
    book.Z
```

EXPLANATION

1. Compresses the book into a file called book.Z and displays the percentage that the file was compressed and its new name.

cp—copies files

cp [–i] [–p] [–r] [filename ...] target

The cp command copies filename to another target, which is either a file or directory. The filename and target cannot have the same name. If the target is not a directory, only one file may be specified before it; if it is a directory, more than one file may be specified. If target does not exist, cp creates a file named target. If target exists and is not a directory, its contents are overwritten. If target is a directory, the file(s) are copied to that directory.

Example A.12

```
1   cp file1 file2
2   cp chapter1 book
3   cp −r desktop /usr/bin/tester
```

EXPLANATION

1. Copies the contents of file1 to file2.
2. Copies the contents of chapter1 to the book directory. In the book directory, chapter1 has its original name.
3. Recursively copies the entire desktop directory into /usr/bin/tester.

cpio—copy file archives in and out

cpio –i [bBcdfkmrsStuvV6] [–C bufsize] [–E filename]
 [–H header] [–I filename [–M message]] [–R id]
 [pattern ...]
cpio –o [aABcLvV] [–C bufsize] [–H header]

[–O filename [–M message]]
cpio –p [adlLmuvV] [–R id] directory

Copies file archives according to the modifiers given, usually for backup to a tape or directory.

Example A.13

```
find . −depth −print | cpio −pdmv /home/john/tmp
```

EXPLANATION

Starting at the current directory, find descends the directory hierarchy, printing each entries of the directory even if the directory does not have write permission, and sends the filenames to cpio to be copied into the john/tmp directory in the /home partition.

cron—the clock daemon

cron executes commands at specified dates and times. Regularly scheduled jobs can be specified in the /etc/crontab file. In order to use cron, one of the following must be true: (1) you are superuser; (2) you are regular user, but your user ID is listed in the /etc/cron.allow file; (3) you are regular user, but your system contains a file /etc/cron.deny, which is empty.

crypt—encodes or decodes a file

crypt [password]

crypt encrypts and decrypts the contents of a file. The password is a key that selects a type of transformation.

cut—removes selected fields or characters from each line of a file

cut –clist [filename ...]
cut –flist [–dc] [–s] [filename ...]

The cut command cuts out columns or characters from a line of a file; if no files are given, uses standard input. The –d option specifies the field delimiter. The default delimiter is a tab.

Example A.14

```
1   cut −d: −f1,3 /etc/passwd
2   cut −d: −f1−5 /etc/passwd
3   cut −c1−3,8−12 /etc/passwd
4   date | cut −c1−3
```

EXPLANATION

1. Using the colon as a field delimiter, displays fields 1 and 3 of the /etc/passwd file.
2. Using the colon as a field separator, displays fields 1 through 5 of the etc/passwd file.
3. Cuts and displays characters 1 through 3 and 8 through 12 of each line from the /etc/passwd file.
4. Sends the output of the date command as input to cut. The first three characters are printed.

date—displays the date and time or sets the date

[–u] [–a [–] sss.fff] [yymmddhhmm [.ss]]
[+format]

Without arguments, the date command displays the date and time. If the command line argument starts with a plus sign, the rest of the argument is used to format the output. If a percent sign is used, the next character is a formatting character to extract a particular part of the date, such as just the year or weekday. To set the date. the command line argument is expressed in digits representing the year, month, day, hours, and minutes.

Example A.15

```
1   date +%T
2   date +20%y
3   date "+It is now %m/%d /%y"
```

EXPLANATION

1. Displays the time as 20:25:51
2. Displays 2096.
3. Displays It is now 07/25/96.

diff—compares two files for differences diff [–bitw] [–c | –Cn

Compares two files and displays the differences on a line−by−line basis. Also displays commands that you would use with the ed editor to make changes.

Example A.16

```
diff file1 file2
1c1
< hello there
---
> Hello there.
2a3
> I'm fine.
```

EXPLANATION

Shows how each line of file1 and file2 differs. The first file is represented by the < symbol, and the second file by the > symbol. Each line is preceded by an ed command indicating the editing command that would be used to make the files the same.

du—summarizes disk usage

du [–arskod] [name ...]

The du command reports the number of 512−byte blocks contained in all files and (recursively) directories within each directory and file specified.

Example A.17

```
1   du −s /desktop
2   du −a
```

EXPLANATION

1. Displays a summary of the block usage for all the files in /desktop and its subdirectories.
2. Displays block usage for each file in this directory and subdirectories.

echo—echoes arguments

echo [argument] ...
echo [–n] [argument]

echo writes its arguments separated by blanks and terminated by a newline on the standard output.

System V echo options:
\b backspace
\c suppress newline
\f form feed
\n newline
\r return
\t tab
\v vertical tab
\\ backslash
\0n n is a 1, 2, or 3, octal value

egrep—searches a file for a pattern using full regular expressions

egrep [–bchilnsv] [–e special–expression][–f filename]
[strings] [filename ...]

egrep (expression grep) searches files for a pattern of characters and prints all lines that contain that pattern. egrep uses full regular expressions (expressions with string values that use the full set of alphanumeric and special characters) to match the patterns.

Example A.18

```
1   egrep 'Tom|John' datafile
2   egrep '^ [A–Z]+' file
```

> **EXPLANATION**
>
> 1. Display all lines in datafile containing the pattern either Tom or John.
> 2. Display al lines starting with one or more uppercase letters.

expr—evaluates arguments as an expression

expr arguments

The arguments are taken as an expression. After evaluation, the result is written to the standard output. The terms of the expression must be separated by blanks. Characters special to the shell must be escaped. Used in Bourne shell scripts for performing simple arithmetic operations.

Example A.19

```
1   expr 5 + 4
2   expr 5 \* 3
3   num=0
    num='expr $num + 1'
```

> **EXPLANATION**
>
> 1. Prints the sum of 5 + 4
> 2. Prints of result of 5 * 3. The asterisk is protected from shell expansion.
> 3. After assigning 0 to variable num, the expr command adds 1 to num and result is assigned to num.

fgrep—search a file for a character string

fgrep [–bchilnsvx] [–e special string]
[–f filename] [strings] [filename ...]

fgrep (fast grep) searches files for a character string and prints all lines that contain that string. fgrep is different from grep and egrep because it interprets regular expression metacharacters as literals.

Example A.20

```
1   fgrep '***' *
2   fgrep '[ ] * ? $' filex
```

EXPLANATION

1. Displays any line containing three asterisks from each file in the present directory. All characters are treated as themselves; i.e., metacharacters are not special.
2. Displays any lines in filex containing the string enclosed in quotes.

file—determines the type of a file by looking at its contents

file [[–f ffile] [–cl] [–m mfile] filename...

file performs a series of tests on each filename in an attempt to determine what it contains. If the contents of the file appear to be ASCII text, file examines the first 512 bytes and tries to guess its language.

Example A.21

```
1   file bin/ls
    /bin/ls:sparc pure dynamically linked executable
2   file go
    go:    executable shell script
3   file junk
    junk:  English text
```

EXPLANATION

1. ls is a binary file dynamically linked when executed.
2. go is an executable shell script.
3. junk is a file containing ASCII text.

find—finds files

find path–name–list expression

find recursively descends the directory hierarchy for each pathname in the pathname list (i.e., one or more pathnames) seeking files that match options. First argument is the path where the search starts. The rest of the arguments specify some criteria by which to find the files, such as name, size, owner, permissions, etc. Check the UNIX manual pages for different syntax.

Example A.22

```
1   find . −name \*.c −print
2   find .. −type f −print
3   find . −type d −print
4   find / −size 0 − exec rm "{}" \;
5   find ~ −perm 644 −print
6   find . −type f −size +500c −atime +21 −ok rm −f "{}" \;
7   find . −name core −print 2> /dev/null (Bourne and Korn Shells)
    ( find . −name core −print > /dev/tty ) >& /dev/null ( C shell)
8   find / −user ellie xdev −print
9   find ~ −atime +31 −exec mv {} /old/{} \; −print
```

EXPLANATION

1. Starting at the present working directory (dot), finds all files ending in .c and prints the full pathname of the file.
2. Starting at the parent directory (dot dot), finds all files of type file; i.e., files that are not directories.
3. Starting at the present directory (dot), finds all directory files.
4. Starting at the root directory, finds all files of size zero and removes them. The {} are used as a place holder for the name of each file as it is found.
5. Starting at the user's home directory ~ (Korn and C shells), finds all files that have permissions 644 (read and write for the owner, and read permission for the group and others).
6. Starting at the present working directory, finds files that are over 500 bytes and have not been accessed in the last 21 days and asks if it is okay to remove them.
7. Starting at the present working directory, finds and displays all files named core and sends errors to /dev/null, the UNIX bit bucket.
8. Prints all files on the root partition that belong to user ellie.
9. Moves files that are older than 31 days into a directory, /old, and prints the files as it moves them.

finger—displays information about local and remote users

finger [–bfhilmpqsw] [username...]
finger [–l] username@hostname...

By default, the finger command displays information about each logged−in user, including login name, full name, terminal name (prepended with a * if write permission is denied), idle time, login time, and location if known.

fmt—simple text formatters

fmt [–c] [–s] [–w width | –width] [inputfile...]

fmt is a simple text formatter that fills and joins lines to produce output lines of (up to) the number of characters specified in the –w width option. The default width is 72. fmt concatenates the input files listed as arguments. If none are given, fmt formats text from the standard input.

Example A.23

```
fmt −c −w45 letter
```

EXPLANATION

Formats letter. The –c switch preserves the indentation of the first two lines within the paragraph and aligns the left margin of each subsequent line with that of the second line. The –w switch fills the output line of up to 45 columns.

fold—folds long lines

fold [–w width | –width] [filename ...]

Fold the contents of the specified filenames, or the standard input if no files are specified, breaking the lines to have maximum width. The default for width is 80. Width should be a multiple of 8 if tabs are present, or the tabs should be expanded.

ftp—file transfer program

ftp [–dgintv] [hostname]

The ftp command is the user interface to the Internet standard File Transfer Protocol (FTP). ftp transfers files to and from a remote network site. The file transfer program is not limited to UNIX machines.

Example A.24

```
1   ftp ftp.uu.net
2   ftp −n 127.150.28.56
```

EXPLANATION

1. ftp to the machine ftp.uu.net, a large repository run by the UUNET service that handles e−mail and net news for UNIX systems.
2. Opens a connection to the machine at 127.45.4.1 and does not attempt to auto−login.

getopt(s)—parses command line options

The getopts command supersedes getopt. getopts is used to break up options in command lines for easy parsing by shell procedures and to check for legal options.

grep—searches a file for a pattern

grep [–bchilnsvw] limited–regular–expression
[filename ...]

grep searches files for a pattern and prints all lines that contain that pattern. Uses regular expressions metacharacters to match the patterns. egrep has an extended set of metacharacters.

Example A.25

```
1   grep Tom file1 file2 file3
2   grep –in '^tom savage' *
```

EXPLANATION

1. Grep displays all lines in file1, file2, and file3 that contain the pattern Tom.
2. Grep displays all lines with line numbers from the files in the current working directory that contain tom savage if tom savage is at the beginning of the line, ignoring case.

groups—prints group membership of user

groups [user...]

The command groups prints on standard output the groups to which you or the optionally specified user belong.

id—prints the username, user ID, group name and group ID

/usr/bin/id [–a]

id displays your user ID, username, group ID, and group name. If your real ID and your effective ID's do not match, both are printed.

jsh—the standard, job control shell

jsh [–acefhiknprstuvx] [argument...]

The command jsh is an interface to the standard Bourne shell which provides all of the functionality of the Bourne shell and enables job control.

line—reads one line

line copies one line (up to a newline) from the standard input and writes it on the standard output. It returns an exit code of one on EOF and always prints at least a newline. It is often used within shell files to read from the user's terminal.

logname—gets the name of the user running the process

lp—sends output to a printer (AT&T)

lp [–cmsw] [–ddest] [–number] [–ooption] [–ttitle] filename ...
cancel [ids] [printers]

lp, cancel sends or cancels requests to a lineprinter.

Example A.26

```
1   lp –n5 filea fileb
2   lp –dShakespeare filex
```

> **EXPLANATION**
>
> 1. Send five copies of filea and fileb to the printer.
> 2. Specify Shakespeare as the printer where filex will be printed.

lpr—sends output to a printer (UCB)

lpr [–Pprinter] [–#copies] [–Cclass] [–Jjob]
[–Ttitle] [–i [indent]] [–1234font] [–wcols]
[–r] [–m] [–h] [–s] [–filter–option]
[filename ...]

lpr creates a printer job in a spooling area for subsequent printing as facilities become available. Each printer job consists of a control job and one or more data files.

Example A.27

```
1   lpr –#5 filea fileb
2   lpr –PShakespeare filex
```

> **EXPLANATION**
>
> 1. Send five copies of filea and fileb to the printer.
> 2. Specify Shakespeare as the printer where filex will be printed.

lpstat—print information about the status of the LP print service (AT&T)

lpq—print information about the status of the printer (UCB)

ls—lists contents of directory

ls [–abcCdfFgilLmnopqrRstux1] [names]

For each directory argument, ls lists the contents of the directory; for each file argument, ls repeats its name and any other information requested. The output is sorted alphabetically by default. When no argument is given, the current directory is listed.

Example A.28

```
1   ls -alF
2   ls -d a*
3   ls -i
```

EXPLANATION

1. The –a lists invisible files (those files beginning with a dot), the –l is a long listing showing attributes of the file, the –F puts a slash at the end of directory filenames, a * at the end of executable scriptnames, and an @ symbol at the end of symbolically linked files.
2. If the argument to the –d switch is a directory, only the name of the directory is displayed, not its contents.
3. The –i switch causes each filename to be preceded by its inode number.

mail—mail, rmail—read mail or send mail to users

Sending mail
 mail [–tw] [–m message_type] recipient...
 rmail [–tw] [–m message_type] recipient...
Reading mail
 mail [–ehpPqr] [–f filename]
Forwarding mail
 mail –F recipient...
Debugging
 mail [–x debug_level] [other_mail_options] recipient...
 mail [–T mailsurr_file] recipient...

A recipient is usually a username recognized by login. When recipients are named, mail assumes a message is being sent. It reads from the standard input up to an end−of−file (Ctrl−D), or if reading from a terminal, until it reads a line consisting of just a period. When either of those indicators is received, mail adds the letter to the mailfile for each recipient.

mailx—interactive message processing system

mailx [–deHiInNUvV] [–f [filename|+folder]]
[–T filename] [–u user] [recipient...]
mailx [–dFinUv] [–h number] [–r address][–s subject] recipient...

The mail utilities listed above provide an interactive interface for sending, receiving, and manipulating mail messages. Basic Networking Utilities must be installed for some of the features to work. Incoming mail is stored in a file called mailbox, and after it is read, is sent to a file called mbox.

make—maintains, updates, and regenerates groups of related programs and files

make [–f makefile] ... [–d] [–dd] [–D]
[–DD] [–e] [–i] [–k] [–n] [–p] [–P]
[–q] [–r] [–s] [–S] [–t] [target ...]
[macro=value ...]

make updates files according to commands listed in a description file, and if the target file is newer than the dependency file of the same name, make will update the target file.

mesg—permits or denies messages resulting from the write command

mesg [–n] [–y]

mesg with argument –n forbids messages via write by revoking nonuser write permission on the user's terminal. mesg with argument –y reinstates permission. All by itself, mesg reports the current state without changing it.

mkdir—creates a directory

mkdir [–p] dirname ...

more—browse or page through a text file

more [–cdflrsuw] [–lines] [+linenumber] [+/pattern]
[filename ...]
page [–cdflrsuw] [–lines] [+linenumber] [+/pattern]
[filename ...]

more is a filter that displays the contents of a text file on the terminal, one screenful at a time. It normally pauses after each screenful, and prints —More— at the bottom of the screen.

mv—move or rename files

mv [–f] [–i] filename1 [filename2 ...] target

The mv command moves a source filename to a target filename. The filename and the target may not have the same name. If target is not a directory, only one file may be specified before it; if it is a directory, more than one file may be specified. If target does not exist, mv creates a file named target. If target exists and is not a directory, its contents are overwritten. If target is a directory the file(s) are moved to that directory.

Example A.29

```
1   mv file1 newname
2   mv –i test1 test2 train
```

EXPLANATION

1. Renames file1 to newname. If newname exists its contents are overwritten.
2. Moves files test1 and test2 to the train directory. The –i switch is for interactive mode, meaning it asks before moving the files.

nawk—pattern scanning and processing language

nawk [–F re] [–v var=value] ['prog'] [filename ...]
nawk [–F re] [–v var=value] [–f progfile][filename ...]

nawk scans each input filename for lines that match any of a set of patterns. The command string must be enclosed in single quotes (') to protect it from the shell. Awk programs consist of a set of pattern/action statements used to filter specific information from a file, pipe, or stdin.

newgrp—log in to a new group

newgrp [–] [group]

newgrp logs a user into a new group by changing a user's real and effective group ID. The user remains logged in and the current directory is unchanged. The execution of newgrp always replaces the current shell with a new shell, even if the command terminates with an error (unknown group).

news—prints news items

news [–a] [–n] [–s] [items]

news is used to keep the user informed of current events. By convention, these events are described by files in the directory /var/news. When invoked without arguments, news prints the contents of all current files in /var/news, most recent first, with each preceded by an appropriate header.

nice—runs a command at low priority

nice [–increment] command [arguments]

/usr/bin/nice executes a command with a lower CPU scheduling priority. The invoking process (generally the user's shell) must be in the time−sharing scheduling class. The command is executed in the time−sharing class. An increment of 10 is the default. The increment value must be in a range between 1 and 19, unless you are the superuser. Also a csh built−in.

nohup—makes commands immune to hangups and quits

/usr/bin/nohup command [arguments]

There are three distinct versions of nohup. nohup is built in to the C shell and is an executable program available in /usr/bin/nohup when using the Bourne shell. The Bourne shell version of nohup executes commands such that they are immune to HUP (hangup) and TERM (terminate) signals. If the standard output is a terminal, it is redirected to the file nohup.out. The standard error is redirected to follow the standard output. The priority is incremented by five. nohup should be invoked from the shell with & in order to prevent it from responding to interrupts or input from the next user.

Example A.30

```
nohup lookup &
```

> # EXPLANATION
>
> The lookup program will run in the background and continue to run until it has completed, even if a the user logs off. Any output generated goes to a file in the current directory called nohup.out.

od—octal dump

od [–bcCDdFfOoSsvXx] [filename] [[+] offset [.] [b]]

od displays filename in one or more formats, as selected by the first argument. If the first argument is missing, –o is default; e.g., the file can be displayed in bytes octal, ASCII, decimal, hex, etc.

pack—pack, pcat, unpack—compresses and expands files

pack [–] [–f] name ...
pcat name ...
unpack name ...

pack compresses files. Wherever possible (and useful), each input file name is replaced by a packed file name.z with the same access modes, access and modified dates, and owner as those of name. Typically, text files are reduced to 60–75% of their original size. pcat does for packed files what cat does for ordinary files, except that pcat cannot be used as a filter. The specified files are unpacked and written to the standard output. Thus, to view a packed file named name.z, use pcat name.z or just pcat name. Unpack expands files created by pack.

passwd—changes the login password and password attributes

passwd [name]
passwd [–d | –l] [–f] [–n min] [–w warn][–x max] name
passwd –s [–a]
passwd –s [name]

The passwd command changes the password or lists password attributes associated with the user's login name. Additionally, privileged users may use passwd to install or change passwords and attributes associated with any login name.

paste—merges same lines of several files or subsequent lines of one file

paste filename1 filename2...
paste –d list filename1 filename2...
paste –s [–d list] filename1 filename2...

paste concatenates corresponding lines of the given input files filename1, filename2, etc. It treats each file as a column or columns of a table and pastes them together horizontally (see cut).

Example A.31

```
1   ls | paste – – –
2   paste –s –d"\t\n" testfile1 testfile2
3   paste file1 file2
```

EXPLANATION

1. Files are listed in three columns and glued together with a Tab.
2. Combines a pair of lines into a single line using a Tab and newline as the delimiter, i.e.,

the first pair of lines are glued with a Tab; the next pair are glued by a newline, the next pair by a Tab, etc. The –s switch causes subsequent lines from testfile1 to be pasted first and then subsequent lines from testfile2.

3. A line from file1 is pasted to a line from file2, glued together by a Tab so that the file lines appear as two columns.

pcat—(see pack)

pg—displays files a page at a time

pg [–number] [–p string] [–cefnrs] [+linenumber]
 [+/pattern/] [filename ...]

The pg command is a filter that allows you to page through filenames one screenful at a time on a terminal. If no filename is specified or if it encounters the file name –, pg reads from standard input. Each screenful is followed by a prompt. If the user types a Return, another page is displayed. It allows you to back up and review something that has already passed. (See more.)

pr—prints files

pr [[–columns] [–wwidth] [–a]] [–eck] [–ick] [–drtfp]
  [+page] [–nck] [–ooffset] [–llength] [–sseparator]
  [– hheader] [–F] [filename ...]
pr [[–m] [–wwidth]] [–eck] [–ick] [–drtfp] [+page] [–nck]
  [–ooffset] [–llength] [–sseparator] [–hheader] [–F]
  [filename1 filename2 ...]

The pr command formats and prints the contents of a file according to different format options. By default, the listing is sent to stdout and is separated into pages, each headed by the page number, the date and time that the file was last modified, and the name of the file. If no options are specified, the default file format is 66 lines with a five−line header and five−line trailer.

Example A.32

```
pr −2dh "TITLE" file1 file2
```

EXPLANATION

Prints two columns double sided with header "TITLE" for file1 and file2.

ps—reports process status

ps [–acdefjl] [–g grplist] [–p proclist]
 [–s sidlist] [–t term] [–u uidlist]

ps prints information about active processes. Without options, ps prints information about processes associated with the controlling terminal. The output contains only the process ID, terminal identifier, cumulative execution time, and the command name. Otherwise, the information that is displayed is controlled by the options. The ps options are not the same for AT&T and Berkeley type versions of UNIX.

Example A.33

```
1   ps –aux | grep '^linda'      #  ucb
2   ps –ef | grep '^ *linda'     # at&t
```

EXPLANATION

1. Prints all processes running and pipes the output to the grep program, and printing only those processes owned by user linda, where linda is at the beginning of each line. (UCB version).
2. Same as the first example, only the AT&T version.

pwd—displays the present working directory name

rcp—remote file copy

rcp [–p] filename1 filename2
rcp [–pr] filename...directory

The rcp command copies files between machines in the following form:

remothostname:path
user@hostname:file
user@hostname.domainname:file

Example A.34

```
1   rcp dolphin:filename /tmp/newfilename
2   rcp filename broncos:newfilename
```

EXPLANATION

1. Copy filename from remote machine dolphin to /tmp/newfilename on this machine.
2. Copy filename from this machine to remote machine broncos and name it newfilename.

rlogin—remote login

rlogin [–L] [–8] [–ec] [–l username] hostname rlogin establishes a remote login session from your terminal to the remote machine named hostname. Hostnames are listed in the host's database, which may be contained in the /etc/hosts file, the Network Information Service (NIS) hosts map, the Internet domain name server, or a combination of these. Each host has one official name (the first name in the database entry), and optionally one or more nicknames. Either official hostnames or nicknames may be specified in hostname. A list of trusted hostnames can be stored in the machine's file /etc/hosts.equiv.

rm—removes files from directories

rm [–f] [–i] filename...
rm –r [–f] [–i] dirname...[filename...]

rm removes the entries for one or more files from a directory if the file has write permission. If filename is a symbolic link, the link will be removed, but the file or directory to which it refers will not be deleted. A user does not need write permission on a symbolic link to remove it, provided they have write permissions in the directory.

Example A.35

```
1   rm file1 file2
2   rm -i *
3   rm -rf dir
```

EXPLANATION

1. Removes file1 and file2 from the directory.
2. Removes all files in the present working directory, but asks first if it is okay.
3. Recursively removes all files and directories below dir and ignores error messages.

rmdir—removes a directory

rmdir [–p] [–s] dirname...

Removes a directory if it is empty. With –p, parent directories are also removed.

rsh—starts a remote shell

rsh [–n] [–l username] hostname command
rsh hostname [–n] [–l username] command

rsh connects to the specified hostname and executes the specified command. rsh copies its standard input to the remote command, the standard output of the remote command to its standard output, and the standard error of the remote command to its standard error. Interrupt, quit, and terminate signals are propagated to the remote command; rsh normally terminates when the remote command does. If a command is not given, then rsh logs you on to the remote host using rlogin.

Example A.36

```
1   rsh bluebird ps −ef
2   rsh −l john owl ls; echo $PATH;cat .profile
```

EXPLANATION

1. Connect to machine bluebird and display all processes running on that machine.
2. Go to the remote machine owl as user john and execute all three commands.

ruptime—shows the host status of local machines

ruptime [–alrtu]

ruptime gives a status line like uptime for each machine on the local network; these are formed from packets broadcast by each host on the network once a minute. Machines for which no status report has been received for five minutes are shown as being down. Normally, the listing is sorted by host name, but this order can be changed by specifying one of ruptime's options.

rwho—who is logged in on local machines

rwho [–a]

The rwho command produces output similar to who, but for all machines on your network. However, it does not work through gateways and host must have the directory /var/spool/rwho as well as the rwho daemon running. If no report has been received from a machine for five minutes, rwho assumes the machine is down, and does not report users last known to be logged into that machine. If a user has not typed to the system for a minute or more, rwho reports this idle time. If a user has not typed to the system for an hour or more, the user is omitted from the output of rwho, unless the –a flag is given.

script—creates a typescript of a terminal session

script [–a] [filename]

script makes a typescript of everything printed on your terminal. The typescript is written to a filename. If no filename is given, the typescript is saved in the file called typescript. The script ends when the shell exits or when Ctrl−D is typed.

Example A.37

```
1   script
2   script myfile
```

EXPLANATION

1. Starts up a script session in a new shell. Everything displayed on the terminal is stored in a file called typescript. Must press ^d or exit to end the session.
2. Starts up a script session in a new shell, storing everything displayed on the terminal in myfile. Must press ^d or exit to end the session.

sed—streamlined editor

sed [–n] [–e script] [–f sfilename] [filename ...]

sed copies the named filename (standard input default) to the standard output, edited according to a script of command. Does not change the original file.

Example A.38

```
1   sed 's/Elizabeth/Lizzy/g' file
2   sed '/Dork/d' file
3   sed −n '15,20p' file
```

EXPLANATION

1. Substitute all occurrences of Elizabeth with Lizzy in file and display on the terminal screen.
2. Remove all lines containing Dork and print the remaining lines on the screen.
3. Print only lines 15 through 20.

size—prints section sizes in bytes of object files

size [–f] [–F] [–n] [–o] [–V] [–x] filename...

The size command produces segment or section size information in bytes for each loaded section in ELF or COFF object files. size prints out the size of the text, data, and bss (uninitialized data) segments (or sections) and their total.

sleep—suspends execution for some number of seconds

sleep time

sleep suspends execution for time seconds. It is used to execute a command after a certain amount of time.

Example A.39

```
1   (sleep 105; command)&
2   (In Script)
    while true
    do
       command
       sleep 60
    done
```

EXPLANATION

1. After 105 seconds, command is executed. Prompt returns immediately.
2. Enters loop; executes command and sleeps for a minute before entering the loop again.

sort—sort and/or merge files

sort [–cmu] [–ooutput] [–T directory] [–ykmem]
[–dfiMnr] [–btx] [+pos1 [–pos2]] [filename...]

The sort command sorts (ASCII) lines of all the named files together and writes the result on the standard output. Comparisons are based on one or more sort keys extracted from each line of input. By default, there is one sort key, the entire input line, and ordering is lexicographic by bytes in machine collating sequence.

Example A.40

```
1   sort filename
2   sort –u filename
3   sort –r filename
4   sort +1 –2 filename
5   sort –2n filename
6   sort –t: +2n –3 filename
7   sort –f filename
8   sort –b +1 filename
```

EXPLANATION

1. Sorts the lines alphabetically.
2. Sorts out duplicate entries.
3. Sorts in reverse.
4. Sorts starting on field 1 (fields are separated by whitespace and start at field 0), stopping at field 2 rather than sorting to the end of the line.
5. Sorts the third field numerically.
6. Sorts numercially starting at field 2 and stopping at field 3, with the colon designated as the field separator (–t:).
7. Sorts folding in upper and lowercase letters.
8. Sorts starting at field 1, removing leading blanks.

spell—finds spelling errors

spell [–blvx] [–d hlist] [–s hstop] [+local_file] [filename]...

spell collects words from the named filenames and looks them up in a spelling list. Words that neither occur among nor are derivable from (by applying certain inflections, prefixes, and/or suffixes) words in the spelling list are printed on the standard output. If no filenames are named, words are collected from the standard input.

split—splits a file into pieces

split [–n] [filename [name]]

split reads filename and writes it in n line pieces into a set of output files. The first output file is named with aa appended, and so on lexicographically, up to zz (a maximum of 676 files). The maximum length of name is 2 characters less than the maximum filename length allowed by the filesystem. See statvfs. If no output name is given, x is used as the default (output files will be called xaa, xab, and so forth).

Example A.41

```
1   split −500 filea
2   split −1000 fileb out
```

> # EXPLANATION
>
> 1. Splits filea into 500 line files. Files are named xaa, xab, xac, etc.
> 2. Splits fileb into 1000 line files named out.aa, out.ab, etc.

strings—finds any printable strings in an object or binary file

strings [–a] [–o] [–number] [filename...]

The strings command looks for ASCII strings in a binary file. A string is any sequence of four or more printing characters ending with a newline or a null character. strings is useful for identifying random object files and many other things.

Example A.42

```
strings /bin/nawk | head −2
```

> # EXPLANATION
>
> Prints any ASCII text in the first two lines of the binary executable /bin/nawk.

stty—sets the options for a terminal

stty [–a] [–g] [modes]

stty sets certain terminal I/O options for the device that is the current standard input; without arguments, it reports the settings of certain options.

Example A.43

```
1   stty erase <Press backspace key> or ^h
2   stty −echo; read secretword; stty echo
3   stty −a (AT&T) or stty −everything (BSD)
```

EXPLANATION

1. Sets the backspace key to erase.
2. Turns off echoing; waits for user input; turns echoing back on.
3. Lists all possible options to stty.

su—become superuser or another user

su [–] [username [arg ...]]

su allows one to become another user without logging off. The default username is root (superuser). To use su, the appropriate password must be supplied (unless the invoker is already root). If the password is correct, su creates a new shell process that has the real and effective user ID, group IDs, and supplementary group list set to those of the specified username. The new shell will be the shell specified in the shell field of username's password file entry. If no shell is specified, sh (Bourne shell) is used. To return to normal user ID privileges, type Ctrl−D to exit the new shell. The – option specifies a complete login.

sum—calculates a checksum for a file

sync—updates the superblock and sends changed blocks to disk

tabs—set tab stops on a terminal

tail—displays the tail end of a file.

tail +[–number [lbc] [f] [filename]
tail +[–number [l] [rf] [filename]

When a plus sign precedes the number, tail displays blocks, characters, or lines counting from the beginning of the file. If a hyphen precedes the number, tail counts from the end of the file.

Example A.44

```
1   tail +50 filex
2   tail −20 filex
3   tail filex
```

EXPLANATION

1. Displays contents of filex starting at line 50.
2. Displays the last 20 lines of filex.
3. Displays the last 10 lines of filex.

talk—allows you to talk to another user

talk username [ttyname]

talk is a visual communications program that copies lines from your terminal to that of another user.

Example A.45

```
talk joe@cowboys
```

EXPLANATION

Opens a request to talk to user joe on a machine called cowboys.

tar—stores and retrieves files from an archive file, normally a tape device

tar [–] c|r|t|u|x [bBefFhilmopvwX0134778] [tarfile]
[blocksize] [exclude–file] [–I include–file]
filename1 filename2 … –C directory filenameN …

Example A.46

```
1   tar cvf /dev/diskette
2   tar tvf /dev/fd0
3   tar xvf /dev/fd0
```

EXPLANATION

1. Sends all files under the present working directory to tape at device /dev/diskette, and prints the files that are being sent.
2. Displays the table of contents of what is on tape device /dev/fd0.
3. Extracts all files from tape and prints which files were extracted.

tee—replicates the standard output

tee [–ai] [filename]

tee copies the standard input to the standard output and one or more files, as in ls|tee outfile. Output goes to screen and to outfile.

Example A.47

```
date | tee nowfile
```

EXPLANATION

The output of the date command is displayed on the screen and also stored in nowfile.

telnet—communicates with a remote host

Example A.48

```
telnet necom.com
```

EXPLANATION

Opens a session with the remote host necom.com

test—evaluates an expression

test evaluates an expression and returns an exit status indicating that the expression is either true (zero) or false (not zero). Used primarily by Bourne and Korn shell for string, numeric, and file testing. The C shell has most of the tests built−in.

Example A.49

```
1   test 5 gt 6
2   echo $? ( Bourne and Korn Shells)
    (Output is 1, meaning the result of the test is not true.)
```

EXPLANATION

1. The test command performs an integer test to see if 5 is greater than 6.
2. The $? variable contains the exit status of the last command. If a nonzero status is reported, the test results are not true; if the return status is zero, the the test result is true.

time—displays a summary of time used by this shell and its children

timex—times a command; reports process data and system activity

timex [–o] [–p [–fhkmrt]] [–s] command

The given command is executed; the elapsed time, user time, and system time spent in execution are reported in seconds. Optionally, process accounting data for the command and all its children can be listed or summarized, and total system activity during the execution interval can be reported. The output of timex is written on standard error.

touch—updates access time and/or modification time of a file

touch [–amc] [mmddhhmm [yy]] filename...

touch causes the access and modification times of each argument to be updated. The filename is created if it does not exist. If no time is specified the current time is used.

Example A.50

```
touch a b c
```

> **EXPLANATION**
>
> Three files, a, b, and c are created. If any of them already exist, the modification time−stamp on the files is updated.

tput—initializes a terminal or queries the terminfo database

tput [–Ttype] capname [parms...]
tput [–Ttype] init
tput [–Ttype] reset
tput [–Ttype] longname
tput –S <<

tput uses the terminfo database to make the values of terminal−dependent capabilities and information available to the shell (see sh), to initialize or reset the terminal, or return the long name of the requested terminal type.

Example A.51

```
1   tput longname
2   bold='tput smso'
    unbold='tput rmso'
    echo "${bold}Enter your id: ${offbold}\c"
```

EXPLANATION

1. Displays a long name for the terminal from the terminfo database.
2. Sets the shell variable bold to turn on the highlighting of displayed text. Then sets the shell variable unbold to return to normal text display. The line Enter your id: is highlighted in black with white letters. Further text is displayed normally.

tr—translates characters

tr [–cds] [string1 [string2]]

tr copies the standard input to the standard output with substitution or deletion of selected characters. Input characters found in string1 are mapped into the corresponding characters of string2. The forward slash can be used with an octal digit to represent the ASCII code. When string2 (with any repetitions of characters) contains fewer characters than string1, characters in string1 with no corresponding character in string2 are not translated. Octal values for characters may be used when preceded with a backslash:

\11 Tab
\12 Newline
\042 Single quote
\047 Double quote

Example A.52

```
1   tr 'A' 'B' < filex
2   tr '[A–Z]' [a–z]' < filex
3   tr –d ' ' < filex
4   tr –s '\11' '\11' < filex
5   tr –s ':' ' ' < filex
6   tr '\047' '\042'
```

EXPLANATION

1. Translates As to Bs in filex.
2. Translates all uppercase letters to lowercase letters.
3. Deletes all spaces from filex.
4. Replaces (squeezes) multiple tabs with single tabs in filex.
5. Squeezes multiple colons into single spaces in filex.
6. Translates double quotes to single quotes in text coming from standard input.

true—provide successful exit status

true does nothing, successfully, meaning that it always returns a zero exit status, indicating success. Used in Bourne and Korn shell programs as a command to start an infinite loop.

while true

do
 command
done

tsort —topological sort

/usr/ccs/bin/tsort [filename]

The tsort command produces, on the standard output, an ordered list of items consistent with a partial ordering of items mentioned in the input filename. If no filename is specified, the standard input is understood. The input consists of pairs of items (nonempty strings) separated by blanks. Pairs of different items indicate ordering. Pairs of identical items indicate presence, but not ordering.

tty—gets the name of the terminal

tty [–l] [–s]

tty prints the path name of the user's terminal.

umask—sets file−creation mode mask for permissions

umask [ooo]

The user file−creation mode mask is set to 000. The three octal digits refer to read/write/execute permissions for owner, group, and other, respectively. The value of each specified digit is subtracted from the corresponding "digit" specified by the system for the creation of a file. For example, umask 022 removes write permission for group and other (files normally created with mode 777 become mode 755; files created with mode 666 become mode 644). If 000 is omitted, the current value of the mask is printed. umask is recognized and executed by the shell.

Example A.53

```
1   umask
2   umask 027
```

EXPLANATION

1. Displays the current file permission mask.
2. The directory permissions, 777, minus the umask 027 is 750. The file permissions, 666, minus the umask 027 is 640. When created, directories and files will be assigned the permissions created by umask.

uname—prints name of current machine

uname [–amnprsv]
uname [–S system_name]

uname prints information about the current system on the standard output. If no options are specified, uname prints the current operating system's name. The options print selected information returned by uname and/or sysinfo.

Example A.54

```
1   uname -n
2   uname -a
```

EXPLANATION

1. Prints the name of the host machine.
2. Prints the machine hardware name, network nodename, operating system release number, the operating system name, and the operating system version—same as –m, –n, –r, –s, and –v.

uncompress—restores files to their original state after they have been compressed using the compress command

uncompress [–cFv] [file . . .]

Example A.55

```
uncompress file.Z
```

EXPLANATION

Restore file.Z back to its original state; i.e., what it was before being compressed.

uniq—reports on duplicate lines in a file

uniq [[–u] [–d] [–c] [+n] [–n]] [input [output]]

uniq reads the input file, comparing adjacent lines. In the normal case, the second and succeeding copies of repeated lines are removed; the remainder is written on the output file. Input and output should always be different.

Example A.56

```
1   uniq file1 file2
2   uniq −d −2 file3
```

EXPLANATION

1. Removes duplicate adjacent lines from file1 and puts output in file2.
2. Displays the duplicate lines where the duplicate starts at third field.

units—converts quantities expressed in standard scales to other scales

units converts quantities expressed in various standard scales to their equivalents in other scales. It works interactively in this fashion:

You have: inch
You want: cm
 * 2.540000e+00
 / 3.937008e–01

unpack—expands files created by pack

unpack expands files created by pack. For each filename specified in the command, a search is made for a file called name.z (or just name, if name ends in .z). If this file appears to be a packed file, it is replaced by its expanded version. The new file has the .z suffix stripped from its name, and has the same access modes, access and modification dates, and owner as those of the packed file.

uucp—copy files to another system, UNIX−to−UNIX system copy

uucp [–c | –C] [–d | –f] [–ggrade] [–j] [–m] [–nuser] [–r] [–sfile] [–
xdebug_level]
 source–file destination–file

uucp copies files named by the source−file arguments to the destination−file argument.

uuencode—uuencode, uudecode—encode a binary file into ASCII text in order to send it through e−mail, or convert it back into its original form

uuencode [source–file] file–label
uudecode [encoded–file]

uuencode converts a binary file into an ASCII−encoded representation that can be sent using mail. The label argument specifies the output filename to use when decoding. If no file is given, stdin is encoded. uudecode reads an encoded file, strips off any leading and trailing lines added by mailer programs, and recreates the original binary data with the filename and the mode and owner specified in the header. The encoded file is an ordinary ASCII text file; it can be edited by any text editor. But it is best only to change the mode or file−label in the header to avoid corrupting the decoded binary.

Example A.57

```
1   uuencode mybinfile decodedname > uumybinfile.tosend
2   uudecode uumybinfile.tosend
```

EXPLANATION

1. The first argument, mybinfile, is the existing file to be encoded. The second argument is the name to be used for the uudecoded file, after mailing the file, and uumybinfile.tosend is the file that is sent through the mail.
2. This decodes the uuencoded file and creates a filename as given as the second argument to uuencode.

wc—counts lines, words, and characters

wc [–lwc] [filename ...]

wc counts lines, words, and characters in a file or in the standard input if no filename is given. A word is a string of characters delimited by a space, tab, or newline.

Example A.58

```
1   wc filex
2   who | wc −l
3   wc −l filex
```

EXPLANATION

1. Prints the number of lines, words, and characters in filex.
2. The output of the who command is piped to wc, displaying the number of lines counted.
3. Prints the number of lines in filex.

what—extracts SCCS version information from a file by printing information found after the @(#) pattern

what [–s] filename

what searches each filename for the occurrence of the pattern @(#), which the SCCS get command substitutes for the %Z% keyword, and prints what follows up to a " >, newline, \, or null character.

which—locates a command and displays its pathname or alias (UCB)

which [filename]

which takes a list of names and looks for the files that would be executed had the names been given as commands. Each argument is expanded if it is aliased, and searched for along the user's path. Both aliases and path are taken from the user's .cshrc file. Only .cshrc file is used.

whereis—locates the binary, source, and manual page files for a command (UCB)

whereis [–bmsu] [–BMS directory ... –f] filename

who—displays who is logged on the system

write—writes a message to another user

write username [ttyname]

write copies lines from your terminal to another user's terminal.

xargs—constructs an argument list(s) and executes a command

xargs [flags] [command [initial–arguments]]

xargs allows you to transfer contents of files into a command line and dynamically build command lines.

Example A.59

```
1   ls $1 | xargs −i −t mv $1/{} $2/{}
2   ls | xargs −p −l rm −rf
```

EXPLANATION

1. Moves all files from directory $1 to directory $2, and echos each mv command just before executing.
2. Prompts (−p) the user which files are to be removed one at a time and removes each one.

zcat—uncompress a compressed file to standard output. Same as uncompress –c

zcat [file . . .]

Example A.60

```
zcat book.doc.Z | more
```

EXPLANATION

Uncompresses book.doc.Z and pipes the output to more.

CONTENTS

Appendix B. Comparison of the Shells

B.1 The Shells Compared

Feature	Bourne	C	TC	Korn	Bash
Aliases	no	yes	yes	yes	yes
Advanced Pattern Matching	no	no	no	yes	yes
Command Line Editing	no	no	yes	yes[a]	yes
Directory Stacks (pushd, popd)	no	yes	yes	no	yes
Filename Completion	no	yes[a]	yes	yes	yes
Functions	yes	no	no	yes	yes
History	no	yes	yes	yes	yes
Job Control	no	yes	yes	yes	yes
Key Binding	no	no	yes	no	yes
Prompt Formatting	no	no	yes	no	yes
Spelling Correction	no	no	yes[a]	no	yes[b]

[a] not a default setting; must be set by the user.

[b] cdspel is a shopt option set to correct minor spelling errors in directory names when cd is used.

B.2 tcsh versus csh

The TC shell (tcsh) is an enhanced version of the Berkeley C shell (csh). Listed here are some of the new features.

- An enhanced history mechanism
- A built−in command line editor (emacs or vi) for editing the command line
- Formatting the prompts
- A spelling correction facility and special prompts for spelling correction and looping
- Enhanced and programmed word completion for completing commands, filenames, variables, usernames, etc.
- Ability to create and modify key bindings
- Automatic, periodic, and timed events (scheduled events, special aliases, automatic logout, terminal locking, etc.)
- New built−in commands (hup, ls –F, newgrp, printenv, which, where, etc.)
- New built−in variables (gid, loginsh, oid, shlvl, tty, uid, version, HOST, REMOTEHOST, VENDOR, OSTYPE, MACHTYPE)
- Read−only variables
- Better bug reporting facility

B.3 bash versus sh

The Bourne Again (bash) shell has the following features not found in the traditional Bourne shell (sh).

- Formatting the prompts
- History (csh style)
- Aliases
- A built−in command line editor (emacs or vi) for editing the command line
- Directory manipulation with pushd and popd
- Csh−type job control to stop or run jobs in the background, bring them to the foreground, etc. with command such as bg, fg, Ctrl−Z, etc.
- Tilde, brace, and parameter expansion
- Key bindings to customize key sequences
- Advanced pattern matching
- Arrays
- The select loop (from Korn shell)
- Many new built−in commands

Feature	csh/tcsh	Bourne	Bash	
Variables:				
Assigning values to local variables	`set x = 5`	`x=5`	`x=5`	`x=5`
Assigning variable attributes			`declare` or `typeset`	`type`
Assigning values to environment variables	`setenv NAME Bob`	`NAME='Bob';` `export NAME`	`export NAME='Bob'`	`expo`
Read−Only Variables:				

Accessing variables	`echo $NAME`
	`set var = net`
	`echo ${var}work`
	`network`
		`echo $NAME`
		`var=net`
		`echo ${var}work`
		`network`
			`echo $NAME`
			`var=net`
			`echo ${var}work`
			`network`
				`echo`
				`var=n`
				`print`
				`netwo`

Number of characters	`echo $%var` (tcsh only)	N/A	`${#var}`	`${#v`
Special Variables:				
PID of the process	`$$`	`$$`	`$$`	`$$`
Exit status	`$status, $?`	`$?`	`$?`	`$?`
Last background job	`$!` (tcsh only)	`$!`	`$!`	`$!`
Arrays:				

Assigning arrays	`set x = ( a b c )`	N/A	`y[0]='a'; y[2]='b';`
			`y[2]='c'`
			`fruit=(apples pears`
			`peaches plums)`
				`y[0]=`
				`y[`
				`set −`
				`pe`

Accessing array elements	`echo $x[1] $x[2]`	N/A	`echo ${y[0]} ${y[1]}`	`prin`
All elements	`echo $x or $x[*]`	N/A	`echo ${y[*]}, ${fruit[0]}`	`prin ${fr`
No. of elements	`echo $#x`	N/A	`echo $y{#[*]}`	`prin`
Command Substitution:				
Assigning output of command to variable	``set d = `date` ``	``d=`date` ``	``d=$(date) or d=`date` ``	`d=$(`

Accessing values	`echo $d`
	`echo $d[1], $d[2], ...`
	`echo $#d`
		`echo $d`	`echo $d`	`prin`

Command Line Arguments (Positional Parameters):				

Accessing	`$argv[1], $argv[2]`
	`or`
	`$1, $2 ...`
		`$1, $2 ... $9`	`$1, $2, ... ${10}` …	`$1,`

Setting positional parameters	N/A	`set a b c`
		``set `date` ``
		`echo $1 $2 ...`
			`set a b c`
			``set `date` or set $(date)``
			`echo $1 $2 ...`
				`set a`
				``set ` ``
				`print`

No. of command line arguments	`$#argv` `$# (tcsh)`	`$#`	`$#`	`$#`
No. of characters in $arg[number]	`$%1, $%2, (tcsh)`	N/A	N/A	N/A
Metacharacters for Filename Expansion:				
Matches for:				
Single character	`?`	`?`	`?`	`?`
Zero or more characters	`*`	`*`	`*`	`*`
One character from a set	`[abc]`	`[abc]`	`[abc]`	`[abc`
One character from a range of characters in a set	`[a-c]`	`[a-c]`	`[a-c]`	`[a-c`
One character not in the set	`N/A (csh)` `[^abc] (tcsh)`	`[!abc]`	`[!abc]`	`[!ab`
? matches zero or one occurrences of any pattern in the			`abc?(2|9)1`	`abc?`

parentheses. The vertical bar represents an or condition; e.g., either 2 or 9. Matches abc21, abc91, or abc1.				
Filenames not matching a pattern	`^pattern` (tcsh)			
I/O Redirection and Pipes:				
Command output redirected to a file	`cmd > file`	`cmd > file`	`cmd > file`	`cmd`
Command output redirected and appended to a file	`cmd >> file`	`cmd >> file`	`cmd >> file`	`cmd`
Command input redirected from a file	`cmd < file`	`cmd < file`	`cmd < file`	`cmd`
Command errors redirected to a file	`(cmd > /dev/tty)>&errors`	`cmd 2>errors`	`cmd 2> file`	`cmd`
Output and errors redirected to a file	`cmd >& file`	`cmd > file 2>&1`	`cmd >& file` or `cmd &> file` or `cmd > file 2>&1`	`cmd`
Assign output and ignore noclobber	`cmd >| file`	N/A	`cmd >| file`	`cmd`

here document	`cmd << EOF`
	`input`
	`EOF`
		`cmd << EOF`
		`input`
		`EOF`
			`cmd << EOF`
			`input`
			`EOF`
				`cmd <`
				`input`
				`EOF`

Pipe output of one command to input of another command	`cmd | cmd`	`cmd | cmd`	`cmd | cmd`	`cmd`
Pipe output and error to a command	`cmd |& cmd`	N/A	N/A	(See c

Coprocess	N/A	N/A	N/A	comm
Conditional statement	`cmd && cmd` `cmd || cmd`	`cmd && cmd` `cmd || cmd`	`cmd && cmd` `cmd || cmd`	`cmd &` `cmd |`
Reading from the Keyboard:				

Read a line of input and store into variable(s)	`set var = $<`
	`set var = 'line'`
		`read var`
		`read var1 var2...`
			`read var`
			`read var1 var2...`
			`read`
			`read -p prompt`
			`read -a arrayname`
				`read`
				`read`
				`read`
				`read`

Arithmetic:				
Perform calculation	`@ var = 5 + 1`	``var=`expr 5 + 1` ``	`(( var = 5 + 1 ))` `let var=5+1`	`(( va` `let v`
Tilde Expansion:				
Represent home directory of user	`~username`	N/A	`~username`	`~use`
Represent home directory	`~`	N/A	`~`	`~`
Represent present working directory	N/A	N/A	`~+`	`~+`
Represent previous working directory	N/A	N/A	`~-`	`~-`
Aliases:				
Create an alias	`alias m more`	N/A	`alias m=more`	`alia`
List aliases	`alias`		`alias, alias -p`	`alia`
Remove an alias	`unalias m`	N/A	`unalias m`	`unal`
History:				
Set history	`set history = 25`	N/A	`automatic or HISTSIZE=25`	`auto`
Display numbered history list	`history`		`history, fc -l`	`hist`
Display portion of list selected by number	`history 5`		`history 5`	`histo` `histo`

Reexecute a command	`!! (last command)`
	`!5 (5th command)`
	`!v (last command starting with v)`
			`!! (last command)`
			`!5 (5th command)`
			`!v (last command starting with v)`
				`r (la`
				`r5 (5`
				`r v (`
				`w`

	N/A (csh)	N/A	`set -o vi`	`set -`

Set interactive editor	bindkey –v or bindkey –e (tcsh)		set –o emacs	set –
Signals:				
Command	onintr	trap	trap	trap
Initialization Files:				
Executed at login	.login	profile	bash_profile	prof
Executed every time the shell is invoked	.cshrc	N/A	BASH_ENV=.bashrc (or other filename) (bash 2.x) ENV=.bashrc	ENV=
Functions:				
Define a function	N/A	fun() { commands; }	function fun { commands; }	func }
Call a function	N/A	fun fun param1 param2 ...	fun fun param1 param2 ...	fun fun p
Programming Constructs:				

if conditional	if (expression)
	then
	    commands
	endif
	if { (command) }
	then
	    commands
	endif
		if [expression]
		then
		    commands
		fi
		if command
		then
		    commands
		fi
			if [[string expression]]
			then
			    commands
			fi
			if ((numeric expression))
			then
			    commands
			fi
				if [[
				then
				
				fi
				if ((
				then
				
				fi

if/else conditional	if (expression)
	then
	    commands
	else
	    commands
	endif
		if command
		then
		    commands
		else
		    …
		fi
			if command
			then
			    commands
			else
			    …
			fi
				if co
				then
				
				else
				
				fi

if/else/elseif conditional	if (expression) then
	    commands
	else if (expression) then
	    commands
	else
	    commands
	endif
		if command
		then
		    commands
		elif command
		then
		    commands
		else
		    commands
		fi
			if command
			then
			    commands
			elif command
			then
			    commands
			else
			    commands
			fi
				if co
				then
				
				elif
				then
				
				else
				
				fi

goto	goto label ... label:	N/A	N/A	N/A

switch and case	switch ("$value")
	case pattern1:
	    commands
	    breaksw
	case pattern2:
	    commands
	    breaksw
	default:
	    commands
	    breaksw
	endsw
		case "$value" in
		pattern1) commands
		    ;;
		pattern2) commands
		    ;;
		*) commands
		    ;;
		esac
			case "$value" in
			pattern1) commands
			    ;;
			pattern2) commands
			    ;;
			*) commands
			    ;;
			esac
				case
				patte
				
				patte
				
				*) co
				
				esac

Loops:				

while loops	`while (expression)`
	`     commands`
	`end`
		`while command`
		`do`
		`     command`
		`done`
			`while command`
			`do`
			`     command`
			`done`
				`while`
				`do`
				
				`done`

for/foreach	`foreach var (wordlist)`
	`     commands`
	`end`
		`for var in wordlist`
		`do`
		`     commands`
		`done`
			`for var in wordlist`
			`do`
			`     commands`
			`done`
				`for v`
				`do`
				
				`done`

until		`until command`
		`do`
		`     commands`
		`done`
			`until command`
			`do`
			`     commands`
			`done`
				`until`
				`do`
				
				`done`

repeat	`repeat 3 "echo hello"`
	`hello`
	`hello`
	`hello`
		N/A	N/A	N/A

select	N/A	N/A	`PS3="Please select a menu item"`
			`select var in wordlist`
			`do`
			`     commands`
			`done`
				`PS3="`
				`selec`
				`do`
				
				`done`

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Appendix C. Steps for Using Quoting Correctly

C.1 Backslash

1. Precedes a character and escapes that character.
2. Same as putting single quotes around one character.

C.2 Single Quotes

1. Must be matched.
2. Protect all metacharacters from interpretation except the following:

   a. Itself.
   b. Exclamation point (csh only).
   c. Backslash.

Examples

C Shell	Bourne Shell	Korn Shell
`echo '$><%^&*'`	`echo '$*&!><?'`	`echo '$*&!><?'`
`echo 'I need $5.00\!'`	`echo 'I need \$5.00!'`	`echo 'I need \$5.00!'`
`ho 'She cried, "Help"'`	`echo 'She cried, "Help"'`	`echo 'She cried, "Help"'`
`echo '\\\\'`	`echo '\\\\'`	`print '\\\\'`
`\\\\`	`\\`	`\\`

C.3 Double Quotes

1. Must be matched.
2. Protect all metacharacters from interpretation except the following:

   a. Itself.
   b. Exclamation point (csh only).
   c. $ used for variable substitution.
   d. `' '` Backquotes for command substitution.

Examples:

C Shell	Bourne Shell	Korn Shell
`echo "Hello $LOGNAME\!"`	`echo "Hello $LOGNAME!"`	`print "Hello $LOGNAME!"`
`echo "I don't care"`	`echo "I don't care"`	

		print "I don't care"
echo "The date is 'date'"	echo "The date is 'date'"	print "The date is $(date)"
echo "\\\\"	echo "\\\\"	print "\\\\"
\\\\	\	\

C.4 Combining Quotes

The end result is to be able to embed the shell variable in the awk command line and have the shell expand the variable without interfering with nawk's field designators, $1 and $2.

C.5 Setting the Shell Variable

name="Jacob Savage"   (Bourne and Korn Shell)
set name = "Jacob Savage" (C Shell)

(The line from the datafile)
Jacob Savage:408−298−7732:934 La Barbara Dr. , San Jose, CA:02/27/78:500000

(The nawk command line)
nawk −F: '$1 ~ /^' "$name" '/{print $2}' datafile

(Output)
408−298−7732

Step1:

Test your knowledge of the UNIX command at the command line before plugging in any shell variables.

nawk −F: '$1 ~ /^Jacob Savage/{print $2}' filename

(Output)
408−298−7732

Step 2:

Plug in the shell variable without changing anything else. Leave all quotes as they were.

nawk −F: '$1 ~ /^$name/{print $2}' datafile

Starting at the left−hand side of the awk command leave the first quote as is; right before the shell dollar sign in $name, place another single quote. Now the first quote is matched and all text within these two quotes is protected from shell interference. The variable is exposed. Now put another single quote right after the e in $name. This starts another matched set of single quotes ending after awk's closing curly brace. Everything within this set of quotes is also protected from shell interpretation.

```
nawk -F: '$1 ~ /^'$name'/{print $2}' datafile
```

Step 3:

Enclose the shell variable in a set of double quotes. This allows the variable to be expanded but the value of the variable will be treated as single string if it contains whitespace. The whitespace must be protected so that the command line is parsed properly.

```
nawk -F: '$1 ~ /^' "$name" '/{print $2}'  datafile
```

Count the number of quotes. There should be an even number of single quotes and an even number of double quotes.

Example:

oldname="Ellie Main"
newname="Eleanor Quigley"

1. Make sure the command works.

   nawk −F: '/^Ellie Main/{$1="Eleanor Quigley"; print $0}' datafile
2. Plug in the variables.

   nawk −F: '/^$oldname/{$1="$newname"; print $0}' datafile
3. Play the quoting game. Starting at the first single quote at the left, move across the line until you come to the variable $oldname and place another single quote just before the dollar sign. Put another single quote right after the last letter in the variable name.

   Now move to the right and place another single quote right before the dollar sign in $newname. Put another single quote after the last character in $newname.

```
nawk -F: '/^'$oldname'/{$1=" '$newname' "; print $0}' datafile
```

4. Count the number of single quotes. If the number of single quotes is an even number, each quote has a matching quote. If not, you have forgotten a step.
5. Enclose each of the shell variables in double quotes. The double quotes are placed snugly around the shell variable.

```
nawk -F: '/^' "$oldname"'/{$1=" ' "$newname" ' "; print $0}' datafile
```

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