Certified Ethical Hacking With Penetration Testing
CEHWPT

LABS Course

LAB2 LINUX Basic Commands

Prepared by Eng. Khaled Gamo

15-6-2019

LAB 2 LINUX Basic Commands

What is a command? A command is a software program that when executed on the CLI (command line interface), performs an action on the computer. When you type in a command, a process is run by the operating system that can read input, manipulate data and produce output. A command runs a process on the operating system, which then causes the computer to perform a job.

To execute a command, the first step is to type the name of the command. Click in the terminal on the right. Type `ls` and hit **Enter**. The result should resemble the example below:

```
sysadmin@localhost:~$ ls

Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Vi
deos
```

The name of the command is often based on what it does or what the developer who created the command thinks will best describe the command's function. For example, the `ls` command displays a *listing* of information about files. Associating the name of the command with something mnemonic for what it does may help you to remember commands more easily.

Consider This

Every part of the command is normally case-sensitive, so `LS` is incorrect and will fail, but `ls` is correct and will execute.

```
□□

sysadmin@localhost:~$ LS

-bash: LS: command not found
```

Most commands follow a simple pattern of syntax:

```
command [options…] [arguments…]
```

In other words, you type a command, followed by any *options* and/or *arguments* before pressing the **Enter** key. Typically *options* alter the behavior of the command and arguments are items or values for the command to act upon. Although there are some commands in Linux that aren't entirely consistent with this syntax, most commands use this syntax or something similar.

In the example above, the `ls` command was executed without any options or arguments, when this is the case, it's default behavior is to return a list of files contained within the current directory.

```
sysadmin@localhost:~$ ls

Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Vi
deos
```

```
command [options…] [arguments…]
```

An argument can be used to specify something for the command to act upon. The `ls` command can be given the name of a directory as an argument, and it will list the contents of that directory. In the next example, the `Documents` directory will be used as an argument:

```
sysadmin@localhost:~$ ls Documents
School            alpha-second.txt  food.txt     linux.txt     os.csv
Work              alpha-third.txt   hello.sh     longfile.txt  people.
csv
adjectives.txt    alpha.txt         hidden.txt   newhome.txt   profile
.txt
alpha-first.txt   animals.txt       letters.txt  numbers.txt   red.txt
```

The resulting output is a list of files contained with the `Documents` directory.

Because Linux is open source, there are some interesting secrets that have been added by developers. For example, the `aptitude` command is a package management tool available on some Linux distributions. This command will accept `moo` as an argument:

```
sysadmin@localhost:~$ aptitude moo
There are no Easter Eggs in this program.
sysadmin@localhost:~$ ls -l
total 32
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Desktop
drwxr-xr-x 4 sysadmin sysadmin 4096 Aug  4 20:58 Documents
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Downloads
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Music
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Pictures
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Public
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Templates
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Videos
```

Often the character is chosen to be mnemonic for its purpose, like choosing the letter *l* for *long* or *r* for *reverse*. By default the `ls` command prints the results in alphabetical order, so adding the `-r`option will print the results in reverse alphabetical order.

```
sysadmin@localhost:~$ ls -r
Videos  Templates  Public  Pictures  Music  Downloads  Documents  Des
ktop
```

Multiple options can be used at once, either given as separate options like `-l -r` or combined like `-lr`. The output of all of these examples would be the same:

```
ls -l -r
ls -rl
```

```
□□
ls -lr
```

As explained above `-l` gives a long listing format while `-r` reverses the listing. The result of using both options is a long listing given in reverse order:

```
sysadmin@localhost:~$ ls -l -r
total 32
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Videos
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Templates
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Public
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Pictures
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Music
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Downloads
drwxr-xr-x 4 sysadmin sysadmin 4096 Aug  4 20:58 Documents
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Desktop
sysadmin@localhost:~$ ls -rl
total 32
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Videos
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Templates
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Public
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Pictures
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Music
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Downloads
drwxr-xr-x 4 sysadmin sysadmin 4096 Aug  4 20:58 Documents
drwxr-xr-x 2 sysadmin sysadmin 4096 Aug  4 20:58 Desktop
```

Printing Working Directory

In order to discover where you are currently located within the filesystem, the `pwd` command can be used. The `pwd` command prints the working directory, your current location within the filesystem:

```
pwd [OPTIONS]
```

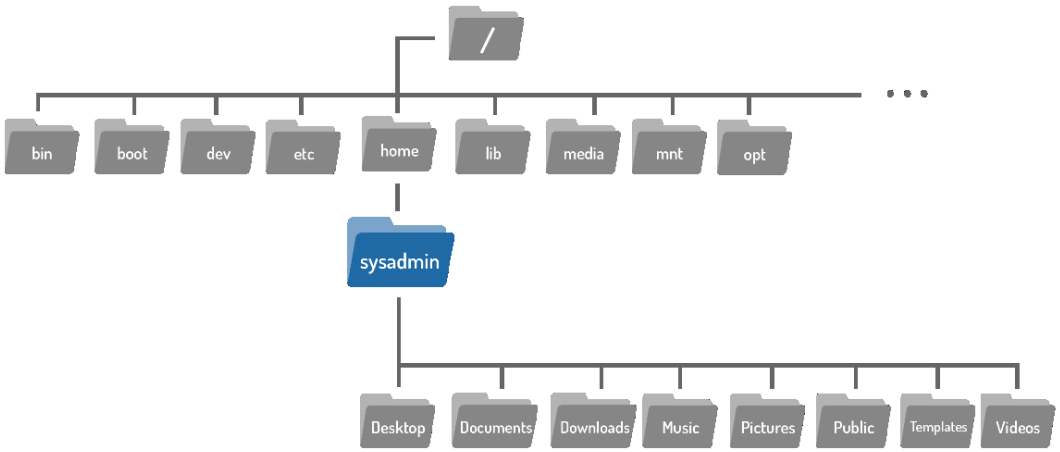
Consider This

Don't turn on your printer just yet! In the early days of computing the command line output would be sent to physical printers. This method was replaced by video displays which could display information more quickly. We still use the word *print* even though the output is just being displayed on your screen.

```
sysadmin@localhost:~$ pwd
```

```
/home/sysadmin
```

The output of the above command indicates that the user is currently in their home folder, shown in the filesystem below.



Consider This

Notice our virtual machines employ a prompt that displays the current working directory, emphasized with the color blue. In the first prompt above, the blue ~ is equivalent to `/home/sysadmin`, representing the user's home directory.

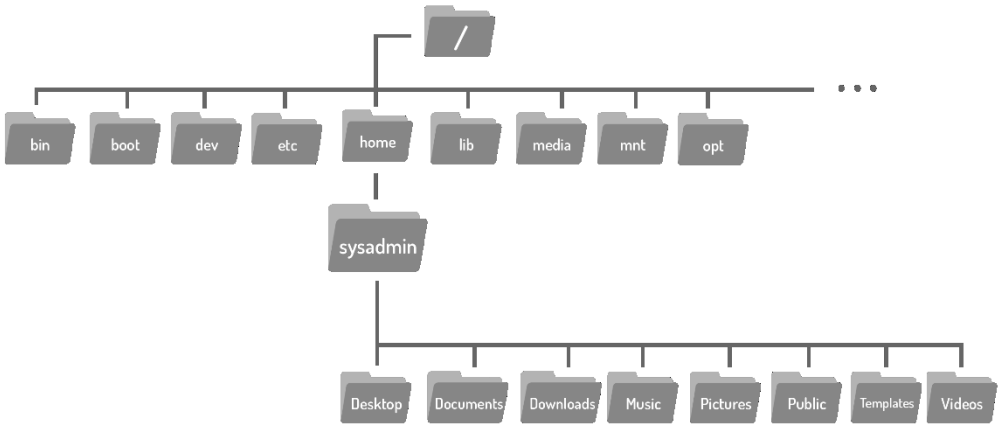
```
sysadmin@localhost:~$
```

After changing directories, the new location can also be confirmed in the new prompt, again shown in blue.

```
sysadmin@localhost:/etc/calendar$
```

Changing Directories

Files are used to store data such as text, graphics and programs. Directories are a type of file used to store other files, they provide a hierarchical organization structure. The image below shows an abbreviated version of the filesystem structure on the virtual machines.



When you start a fresh virtual machine, either by opening the course or after using the reset button, you are logged in as the `sysadmin` user in your home directory, highlighted below:

To navigate the filesystem structure, use the `cd` (change directory) command to change directories.

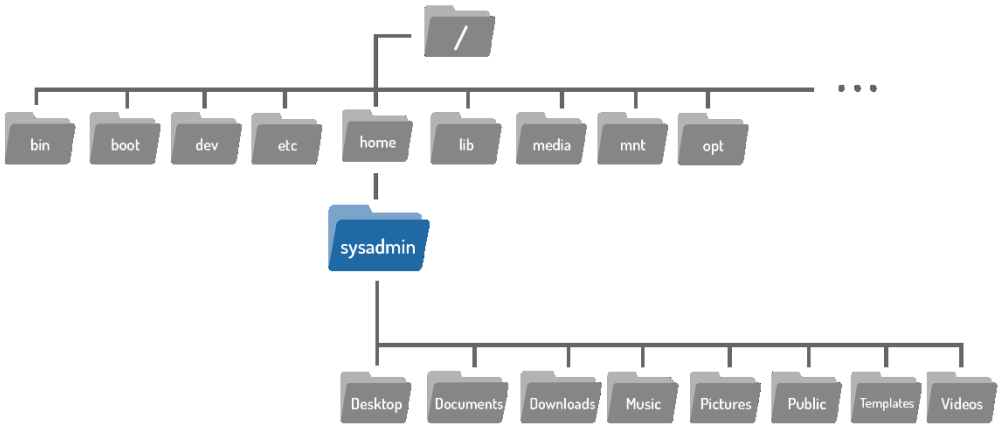
```
cd [options] [path]
```

If you look back at the graphic above, you will see the `Documents` directory is located within the `home` directory, where you are currently located. To move to the `Documents` directory, use it as argument to the `cd` command:

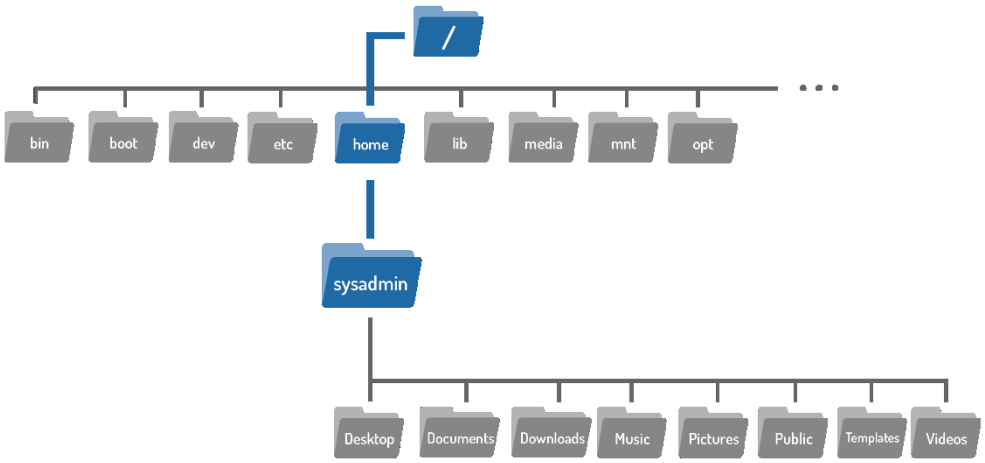
```
sysadmin@localhost:~$ cd Documents
sysadmin@localhost:~/Documents$
```

Directories are equivalent to folders on Windows and Mac OS. Like these more popular operating systems, a Linux directory structure has a top level. It is not called "My Computer", but rather the *root*directory and it is represented by the `/` character. To move to the root directory, use the `/` character as the argument to the `cd` command.

```
sysadmin@localhost:~$ cd /
```



The argument to the `cd` command is more than just the name of a directory, it is actually a *path*. A path is a list of directories separated by the `/` character. For example, `/home/sysadmin` is the path to your home directory:



If you think of the filesystem as a map, paths are the step-by-step directions; they can be used to indicate the location of any file within the filesystem. There are two types of paths: absolute and relative. Absolute paths start at the root of the filesystem, relative paths start from your current location.

Use this path as an argument to the `cd` command to move back into the home directory for the `sysadmin` user.

```
sysadmin@localhost:/$ cd /home/sysadmin
sysadmin@localhost:~$
```

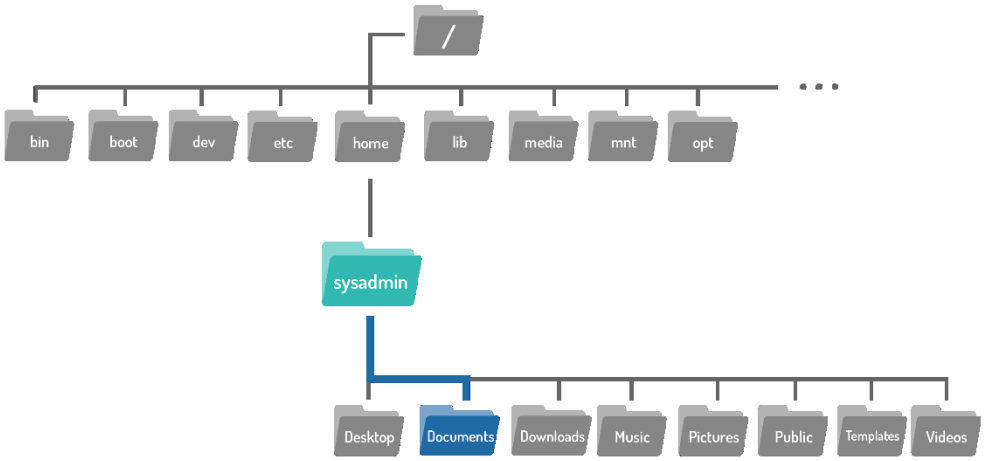
No output means the command succeeded. Go ahead and confirm this using the `pwd` command:

```
sysadmin@localhost:~$ pwd
/home/sysadmin
```

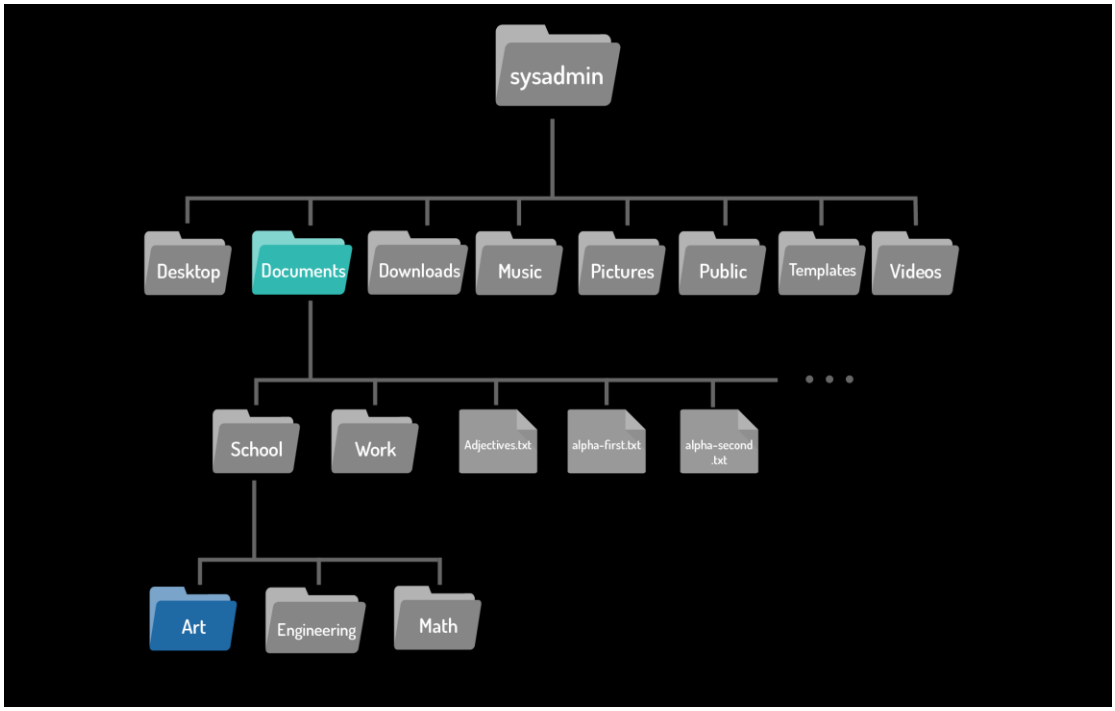
Relative Paths

A relative path gives directions to a file relative to your current location in the filesystem. Relative paths do not start with the `/` character, they start with the name of a directory. Take another look at the first `cd` command example. The argument is an example of the simplest relative path: the name of a directory in your current location.

```
sysadmin@localhost:~$ cd Documents
sysadmin@localhost:~/Documents$
```

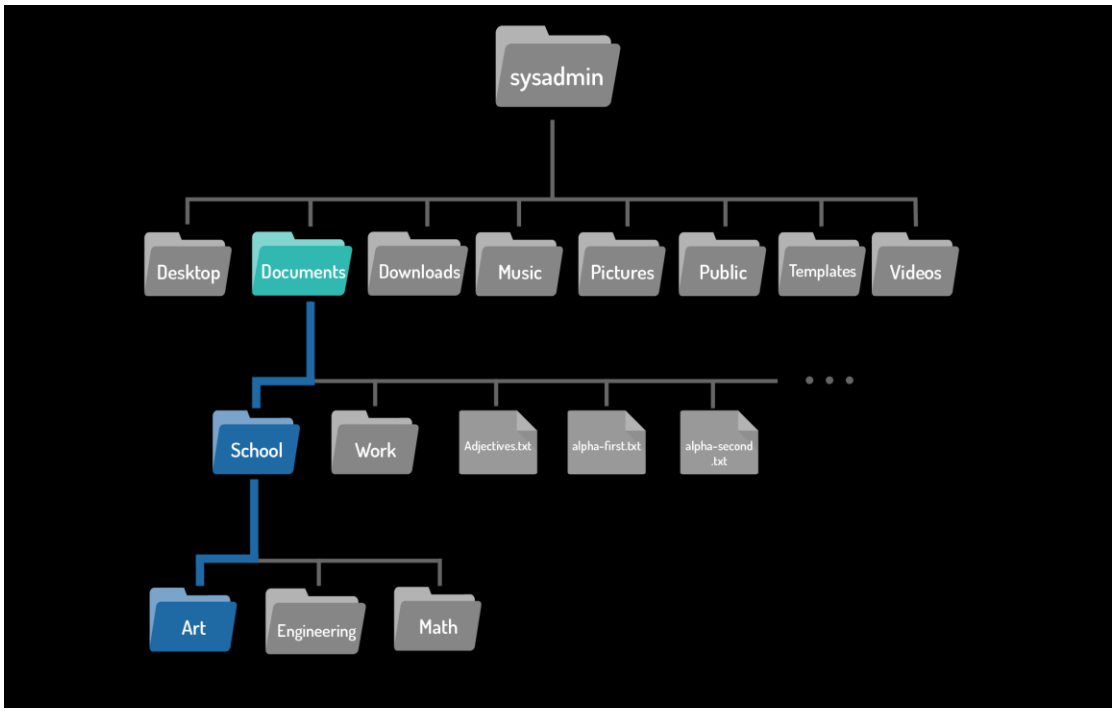


The image below shows a map of the files contained within the `sysadmin` directory. You are currently in the `Documents` directory and want to move to the `Art` directory:



A relative path begins in from with the current directory, however you don't include it in the path. The first step would be to move into the `School` directory, and then move into

the `Art` directory. Use the `/` character to separate the directory names and the result `School/Art` is a relative path from the `Documents` directory to the `Art` directory:

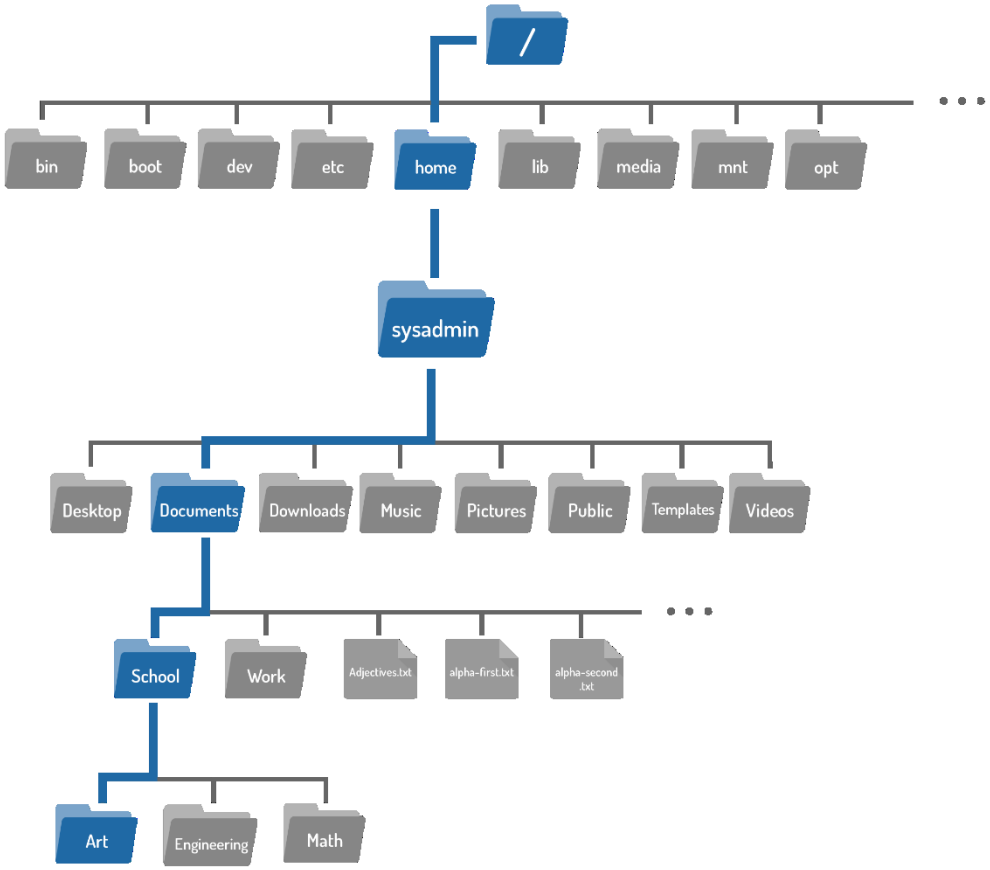


Use the relative path as an argument to the `cd` command to move into the `Art` directory.

```
sysadmin@localhost:~/Documents/$ cd School/Art
sysadmin@localhost:~/Documents/School/Art$
```

Use the `pwd` command to confirm the change:

```
sysadmin@localhost:~/Documents/School/Art$ pwd
/home/sysadmin/Documents/School/Art
```



Consider This

In the example above the `cd` command followed the `School/Art` path:

```
cd School/Art
```

A path can also be broken down into multiple `cd` commands. The following set of commands would achieve the same results:

```
cd School
cd Art
```

Shortcuts

The . . Characters

Regardless of which directory you are in, `. .` always represents one directory higher relative to the current directory, sometimes referred to as the parent directory. To move from the `Art` directory back to the `School` directory:

```
sysadmin@localhost:~/Documents/School/Art$ cd ..
sysadmin@localhost:~/Documents/School$
```

The ~ Character

The home directory of the current user is represented by the ~ character. As stated above, you always begin as the sysadmin user, whose home is located at /home/sysadmin. To return to your home directory at any time execute the following command:

```
sysadmin@localhost:~/Documents/School$ cd ~
```

Listing Files

The `ls` command is used to list the contents of a directory. You've already seen it used a few times before in examples, but this page will help ensure you are comfortable with its use.

```
ls [OPTIONS] [FILE]
```

By default, when the `ls` command is used with no options or arguments, it will list the files in the current directory:

```
sysadmin@localhost:~$ ls
Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Videos
```

To learn the details about a file, such as the type of file, the permissions, ownerships or the timestamp, perform a long listing using the `-l` option to the `ls` command. Below, a listing of the `/var/log` directory is used as an example, since it provides a variety of output:

```
sysadmin@localhost:~$ ls -l /var/log/
total 832
-rw-r--r-- 1 root   root  17869 Mar 14 17:48 alternatives.log
drwxr-x--- 2 root   adm    4096 Mar 14 17:48 apache2
drwxr-xr-x 2 root   root   4096 Mar 14 17:45 apt
-rw-r----- 1 syslog adm     380 Jul 28 03:45 auth.log
-rw-r--r-- 5 root   root  47816 Mar  2 23:10 bootstrap.log
-rw-rw---- 5 root   utmp      0 Mar  2 23:10 btmp
-rw-r----- 1 syslog adm     324 Jul 28 03:45 cron.log
-rw-r----- 1 root   adm   85083 Mar 14 17:48 dmesg
-rw-r--r-- 1 root   root 315196 Mar 14 17:48 dpkg.log
-rw-r--r-- 1 root   root  32064 Mar 14 17:48 faillog
drwxr-xr-x 2 root   root   4096 Jun 30 06:53 fsck
-rw-r----- 1 syslog adm     106 Jul 28 03:45 kern.log
-rw-rw-r-- 1 root   utmp 292584 Jul 28 03:45 lastlog
-rw-r----- 1 syslog adm   18703 Jul 28 03:46 syslog
drwxr-xr-x 2 root   root   4096 Apr 11  2014 upstart
```

```
-rw-rw-r-- 1 root   utmp    384 Jul 28 03:45 wtmp
```

Each line corresponds to a file contained within the directory. The information can be broken down into fields separated by spaces. The fields are as follows:

- **File Type**

```
- rw-r--r-- 1 root   root  17869 Mar 14 17:48 alternatives.log
d rwxr-x--- 2 root   adm    4096 Mar 14 17:48 apache2
```

The first field actually contains ten characters, where the first character indicates the type of file and the next nine specify permissions. The file types are:

Symbol	File Type	Description
d	directory	A file used to store other files.
-	regular file	Includes readable files, images files, binary files, and compressed files.
l	symbolic link	Points to another file.
s	socket	Allows for communication between processes.
p	pipe	Allows for communication between processes.
b	block file	Used to communicate with hardware.
c	character file	Used to communicate with hardware

- The first file `alternatives.log` is a regular file `-`, while the second file `apache2` is a directory `d`.

Permissions

```
d rwxr-xr-x 1 root root  0 Apr 11 21:58 upstart
```

Permissions indicate how certain users can access a file. Keep reading to learn more about permissions.

- **Hard Link Count**

```
-rw-r----- 1 syslog adm 23621 Aug 23 15:17 auth.log
```

This number indicates how many hard links point to this file. Hard links are beyond the scope of this module, but are covered in the NDG Linux Essentials course.

- **User Owner**

```
-rw-r----- 1 syslog adm 416 Aug 22 15:43 kern.log
```

User `syslog` owns this file. Every time a file is created, the ownership is automatically assigned to the user who created it.

- **Group Owner**

```
-rw-rw-r-- 1 root utmp 292584 Aug 20 18:44 lastlog
```

Indicates which group owns this file

- **File Size**

```
-rw-r----- 1 syslog adm 1087150 Aug 23 15:17 syslog.1
```

The size of the file in bytes. In the case of a directory, it might actually be a multiple of the block size used for the file system.

- **Timestamp**

```
drwxr-xr-x 1 root root 32 Jul 17 03:36 fsck
```

This indicates the time that the file's contents were last modified.

- **Filename**

```
-rw-r--r-- 1 root root 47816 Jul 17 03:36 bootstrap.log
```

The final field contains the name of the file or directory.

Consider This

In the case of symbolic links, the link name will be displayed along with an arrow and the pathname of the original file.

```
lrwxrwxrwx. 1 root root 22 Nov 6 2012 /etc/grub.conf -> ../boo
t/grub/grub.conf
```

Symbolic links are beyond the scope of this module, but are covered in greater detail in the NDG Linux Essentials course.

Sorting

By default the output of the `ls` command is sorted alphabetically by filename. It can sort by other methods as well.

Follow Along

The options in examples below will be combined with the `-l` option so the relevant details of the files are displayed. Notice fields corresponding to the search option.

The `-t` option will sort the files by timestamp:

```
sysadmin@localhost:~$ ls -lt /var/log
total 840
-rw-r----- 1 syslog adm   27014 Jul 28 00:10 syslog
-rw-r----- 1 syslog adm     380 Jul 27 23:10 auth.log
-rw-rw-r-- 1 root   utmp 292584 Jul 27 23:10 lastlog
-rw-rw-r-- 1 root   utmp    384 Jul 27 23:10 wtmp
-rw-r----- 1 syslog adm     324 Jul 27 23:10 cron.log
-rw-r----- 1 syslog adm     106 Jul 27 23:10 kern.log
drwxr-xr-x 2 root   root   4096 Jun 30 06:56 fsck
-rw-r--r-- 1 root   root  17869 Mar 14 17:48 alternatives.log
-rw-r----- 1 root   adm   85083 Mar 14 17:48 dmesg
-rw-r--r-- 1 root   root  32064 Mar 14 17:48 faillog
-rw-r--r-- 1 root   root 315196 Mar 14 17:48 dpkg.log
drwxr-x--- 2 root   adm    4096 Mar 14 17:48 apache2
drwxr-xr-x 2 root   root   4096 Mar 14 17:45 apt
-rw-r--r-- 5 root   root  47816 Mar  2 23:10 bootstrap.log
-rw-rw---- 5 root   utmp      0 Mar  2 23:10 btmp
drwxr-xr-x 2 root   root   4096 Apr 11  2014 upstart
```

The `-S` option will sort the files by file size:

```
sysadmin@localhost:~$ ls -l -S /var/log
total 840
-rw-r--r-- 1 root   root 315196 Mar 14 17:48 dpkg.log
-rw-rw-r-- 1 root   utmp 292584 Jul 27 23:10 lastlog
-rw-r----- 1 root   adm   85083 Mar 14 17:48 dmesg
-rw-r--r-- 5 root   root  47816 Mar  2 23:10 bootstrap.log
-rw-r--r-- 1 root   root  32064 Mar 14 17:48 faillog
-rw-r----- 1 syslog adm   27014 Jul 28 00:10 syslog
-rw-r--r-- 1 root   root  17869 Mar 14 17:48 alternatives.log
drwxr-x--- 2 root   adm    4096 Mar 14 17:48 apache2
drwxr-xr-x 2 root   root   4096 Mar 14 17:45 apt
drwxr-xr-x 2 root   root   4096 Jun 30 06:56 fsck
drwxr-xr-x 2 root   root   4096 Apr 11  2014 upstart
-rw-rw-r-- 1 root   utmp    384 Jul 27 23:10 wtmp
-rw-r----- 1 syslog adm     380 Jul 27 23:10 auth.log
-rw-r----- 1 syslog adm     324 Jul 27 23:10 cron.log
```

```
-rw-r----- 1 syslog adm     106 Jul 27 23:10 kern.log
-rw-rw---- 5 root   utmp      0 Mar  2 23:10 btmp
```

The `-r` option will reverse the order of any type of sort. Notice the difference when it is added to the previous example:

```
sysadmin@localhost:~$ ls -lSr /var/log
total 840
-rw-rw---- 5 root   utmp      0 Mar  2 23:10 btmp
-rw-r----- 1 syslog adm     106 Jul 27 23:10 kern.log
-rw-r----- 1 syslog adm     324 Jul 27 23:10 cron.log
-rw-r----- 1 syslog adm     380 Jul 27 23:10 auth.log
-rw-rw-r-- 1 root   utmp    384 Jul 27 23:10 wtmp
drwxr-xr-x 2 root   root   4096 Apr 11  2014 upstart
drwxr-xr-x 2 root   root   4096 Jun 30 06:56 fsck
drwxr-xr-x 2 root   root   4096 Mar 14 17:45 apt
drwxr-x--- 2 root   adm    4096 Mar 14 17:48 apache2
-rw-r--r-- 1 root   root  17869 Mar 14 17:48 alternatives.log
-rw-r----- 1 syslog adm   27014 Jul 28 00:10 syslog
-rw-r--r-- 1 root   root  32064 Mar 14 17:48 faillog
-rw-r--r-- 5 root   root  47816 Mar  2 23:10 bootstrap.log
-rw-r----- 1 root   adm   85083 Mar 14 17:48 dmesg
-rw-rw-r-- 1 root   utmp 292584 Jul 27 23:10 lastlog
-rw-r--r-- 1 root   root 315196 Mar 14 17:48 dpkg.log
```

The numbers in file size field switch from descending to ascending.

Used alone the `-r` option with list the files in reverse alphabetical order:

```
sysadmin@localhost:~$ ls -r /var/log
wtmp     lastlog   faillog   cron.log       auth.log  alternatives.lo
g
upstart  kern.log  dpkg.log  btmp           apt
syslog   fsck      dmesg     bootstrap.log  apache2
```

Administrative Access

There are many Linux commands which deal with sensitive information like passwords, system hardware, or otherwise operate under other exceptional circumstances. Preventing regular users from executing these commands helps to protect the system. Logging in as the root user provides administrative access, allowing for the execution of some of the privileged commands.

The `su` Command

```
su OPTIONS USERNAME
```

The `su` command allows you to temporarily act as a different user. It does this by creating a new shell. By default, if a user account is not specified, the `su` command will open a new shell as the root user, which provides administrative privileges.

Follow Along

Utilizing the login shell option is recommended, as the login shell fully configures the new shell with the settings of the new user. This option can be specified one of three ways:

```
su -

su -l

su --login
```

After executing the `su` command, a password is required. On our virtual machines, the password for both the `root` and `sysadmin` accounts is `netlab123`. If you ever forget, it is displayed every time a new virtual machine is started. As a security measure, the password will not be visible as it is typed.

```
sysadmin@localhost:~$ su  -

Password:

root@localhost:~#
```

Note the command prompt has changed to reflect that you are now logged in as the `root` user. To logout and return to the `sysadmin` account, use the `exit` command. Note the prompt changes back:

```
root@localhost:~# exit

exit

sysadmin@localhost:~$
```

To avoid executing any sensitive commands, we've configure the Steam Locomotive command, the `sl` command, to require administrative access. If the command is executed as `sysadmin`, it fails:

```
sysadmin@localhost:~$ sl

sl: Permission denied
```

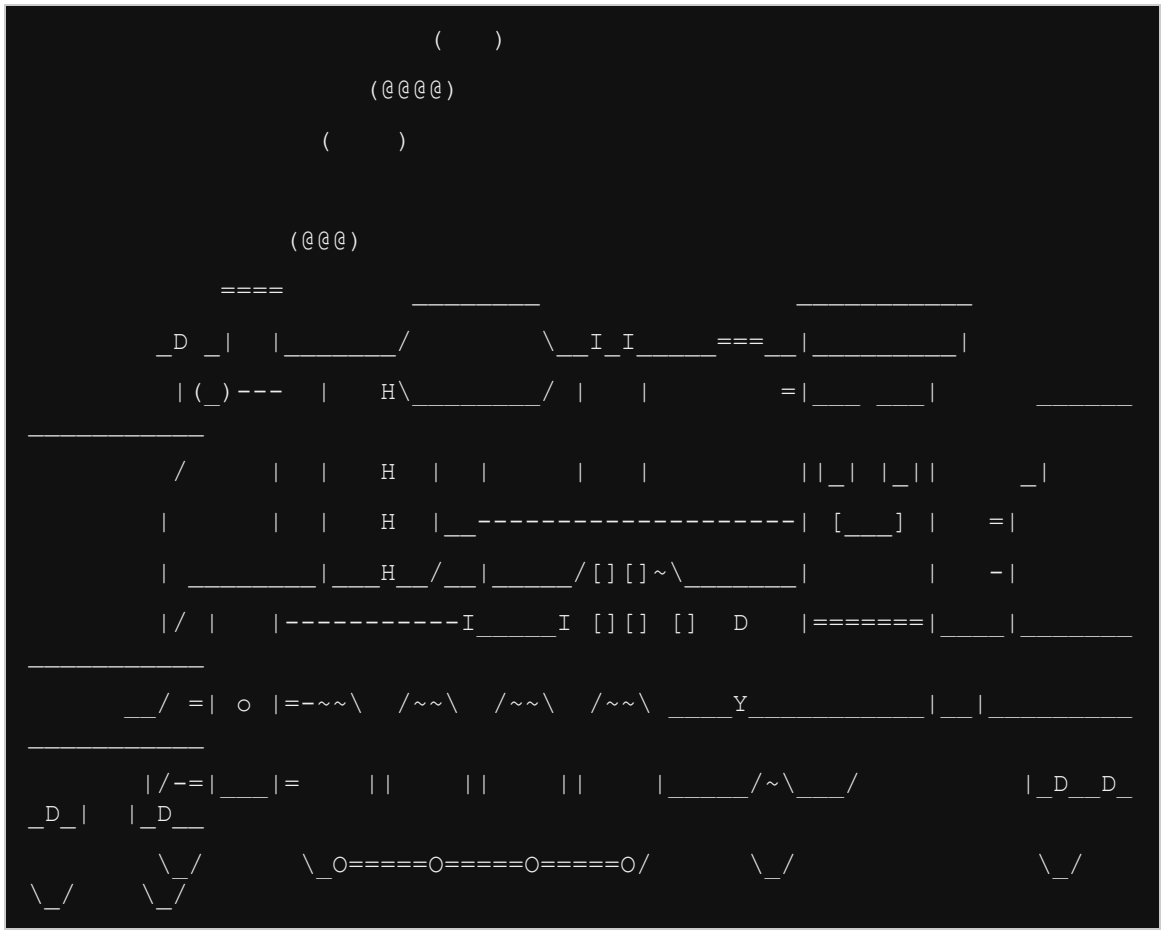
Use the `su` command to switch to the root account and execute the `sl` command with administrative access:

```
sysadmin@localhost:~$ su  -

Password:

root@localhost:~# sl

                                (@@) (  ) (@)  ( )  @@    ()    @     O
@
```



Use the `exit` command again to return to the `sysadmin` account.

```
root@localhost:~# exit
exit
sysadmin@localhost:~$
```

The `sudo` Command

```
sudo [OPTIONS] COMMAND
```

The `sudo` command allows a user to execute a command as another user without creating a new shell. Instead, to execute a command with administrative privileges, use it as an argument to the `sudo` command. Like the `su` command, the `sudo` command assumes by default the `root` user account should be used to execute commands.

Consider This

The `sudo` command can be used to switch to other user accounts as well. To specify a different user account use the `-u` option.

Execute the `sl` command as the root user by putting `sudo` in front of it:

```
sysadmin@localhost:~$  sudo sl
Password:
```

Note

Remember the password is `netlab123`. The prompt for the password will not appear again as long as the user continues to execute `sudo` commands less than five minutes apart.

Once the command has completed notice the prompt has *not* changed, you are still logged in as `sysadmin`. The sudo command only provides administrative access for the execution of the specified command. This is an advantage as it reduces the risk that a user accidentally executes a command as root. The intention to execute a command is clear; the command is executed as root if prefixed with the `sudo` command. Otherwise, the command is executed as a regular user.

Permissions

Permissions determine the ways different users can interact with a file or directory. When listing a file with the `ls -l` command, the output includes permission information. For the example we will use a script called `hello.sh` located in the `Documents` directory:

Follow Along

Use the following command to switch to the `Documents` directory:

```
sysadmin@localhost:~$ cd ~/Documents
sysadmin@localhost:~/Documents$ ls -l hello.sh
-rw-rw-r-- 1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
```

Below is a review of the fields relevant to permissions.

File Type Field

```
-rw-rw-r-- 1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
```

The first character of this output indicates the type of a file. Recall if the first character is a – this is a regular file. If the character was a `d`, it would be a directory.

Permissions Field

```
- rw-rw-r--  1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
```

After the file type character, the permissions are displayed. The permissions are broken into three sets of three characters:

- Owner

  ```
  - rw- rw-r-- 1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
  ```

  The first set is for the user who owns the file. If your current account is the user owner of the file, then the first set of the three permissions will apply and the other permissions have no effect.

  The user who owns the file, and who these permissions apply to, can be determined by the *user owner* field:

```
-rw-rw-r-- 1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
```

- Group

```
-rw-rw-r-- 1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
```

The second set is for the group that owns the file. If your current account *is not* the user owner of the file and you *are* a member of the group that owns the file, then the group permissions will apply and the other permissions have no effect.

The group for this file can be determined by the *group owner* field:

```
-rw-rw-r-- 1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
```

- Other

```
-rw-rw-r-- 1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
```

The last set is for everyone else, any one who that first two sets of permissions do not apply to. If you are not the user who owns the file or a member of the group that owns the file, the third set of permissions applies to you.

Permission Types

There are three different permissions that can be placed on a file or directory: read, write, and execute. The manner in which these permissions apply differs for files and directories, as shown in the chart below:

Permission	Effects on File	Effects on Directory
read (`r`)	Allows for file contents to be read or copied.	Without execute permission on the directory, allows for a non-detailed listing of files. With execute permission, `ls -l` can provide a detailed listing.
write (`w`)	Allows for contents to be modified or overwritten. Allows for files to be added or removed from a directory.	For this permission to work, the directory must also have execute permission.
execute (`x`)	Allows for a file to be run as a process, although script files require read permission, as well.	Allows a user to change to the directory if parent directories have write permission as well.

Consider This

Understanding which permissions apply is an important skill set in Linux. For example, consider the following set of permissions:

```
-r--rw-rwx. 1 sysadmin staff 999 Apr  10  2013 /home/sysadmin/test
```

In this scenario, the user `sysadmin` ends up having less access to this file than members of the `staff` group or everyone else. The user `sysadmin` only has the permissions of `r--`. It doesn't matter if `sysadmin` is a member of the `staff` group; once user ownership has been established, only the user owner's permissions apply.

Changing File Permissions

The `chmod` command is used to change the permissions of a file or directory. Only the root user or the user who owns the file is able to change the permissions of a file.

Consider This

Why is the command named `chmod` instead of `chperm`? Permissions used to be referred to as *modes of access*, so the command `chmod` really means *change the modes of access*.

There are two techniques of changing permissions with the `chmod` command: *symbolic* and *octal*. The symbolic method is good for changing one set of permissions at a time. The octal or numeric method requires knowledge of the octal value of each of the permissions and requires all three sets of permissions (user, group, other) to be specified every time. For the sake of simplicity, only the symbolic method will be covered, to learn more about the octal method check out NDG Linux Essentials!

Follow Along

Use the following command to switch to the `Documents` directory:

```
sysadmin@localhost:~$ cd ~/Documents
```

The Symbolic Method

```
chmod [<SET><ACTION><PERMISSIONS>]... FILE
```

To use the symbolic method of `chmod` first indicate which *set* of permissions is being changed:

```
chmod [ <SET> <ACTION><PERMISSIONS>]... FILE
```

Symbol	Meaning
u	User: The user who owns the file.
g	Group: The group who owns the file.
o	Others: Anyone other than the user owner or member of the group owner.

Symbol	Meaning
a	All: Refers to the user, group and others.

Next, specify an action symbol:

```
chmod [<SET><ACTION><PERMISSIONS>]... FILE
```

Symbol	Meaning
+	Add the permission, if necessary
=	Specify the exact permission
-	Remove the permission, if necessary

After an action symbol, specify one or more permissions to be acted upon.

```
chmod [<SET><ACTION><PERMISSIONS>]... FILE
```

Symbol	Meaning
r	read
w	write
x	execute

Finally, a space and the pathnames for the files to assign those permissions.

```
chmod [<SET><ACTION><PERMISSIONS>]... FILE
```

The file `hello.sh` used in the examples on the previous page is a script. A script is a file that can be executed, similar to a command:

```
sysadmin@localhost:~/Documents$ ls -l hello.sh
□□
-rw-rw-r-- 1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
```

However currently, the execute permission is not set for any of the permission groups:

```
-rw-rw-r-- 1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
```

Attempting to execute this script using the following syntax fails:

```
sysadmin@localhost:~/Documents$ ./hello.sh
-bash: ./hello.sh: Permission denied
```

Since the system is currently logged in as the `sysadmin` user, and `sysadmin` is the owner of this file, giving the user owner the execute permission should allow you to execute this script. Using the `chmod` command with the `u` character to represent the user owner permission set, the `+` character to indicate a permission is being added, and the `x` character to represent the execute permission, the command should be executed as follows:

```
sysadmin@localhost:~/Documents$ chmod u+x hello.sh
```

No output indicates the command succeeded. Confirm by checking the permissions using the `ls -l`command:

```
sysadmin@localhost:~/Documents$ ls -l hello.sh
-rwxrw-r-- 1 root sysadmin 112 Aug  1 03:48 hello.sh
```

The user owner now has the execute permission listed:

```
-rwxrw-r-- 1 sysadmin sysadmin 21 Aug  1 02:35 hello.sh
```

Finally, attempt to execute the script again. Use the command syntax shown below:

```
./hello.sh
sysadmin@localhost:~/Documents$ ./hello.sh
 _______________
( Hello World! )
 ---------------
        \
         \
           <(^)
            ( )
```

Consider This

Notice that to execute the script in the previous example, a `./` character combination was placed before the script name.

```
./hello.sh
```

This indicates the "command" should be run from the current directory.

Changing File Ownership

Initially, the owner of a file is the user who creates it. The `chown` command is used to change the ownership of files and directories. Changing the user owner require administrative access, a regular user cannot use this command to change the user owner of a file, even to give the ownership of one of their own files to another user. However, the `chown` command also permits changing group ownership, which can be accomplished by either root or the owner of the file.

To change the user owner of a file, the following syntax can be used. The first argument `[OWNER]` specifies which user is to be the new owner. The second argument `FILE` specifies of which file the ownership is changing.

```
chown [OPTIONS] [OWNER] FILE
```

Follow Along

Use the following command to switch to the `Documents` directory:

```
sysadmin@localhost:~$ cd ~/Documents
```

Currently all the files in the `Documents` directory are owned by the `sysadmin` user. This can be verified by using the `ls -l` command. Recall the third column indicates the user owner.

```
sysadmin@localhost:~/Documents$ ls -l
total 148
drwxrwxr-x 2 sysadmin sysadmin  4096 Aug  1 03:40 School
drwxrwxr-x 2 sysadmin sysadmin  4096 Aug  1 03:40 Work
-rw-r--r-- 1 sysadmin sysadmin    39 Mar 14 17:48 adjectives.txt
-rw-r--r-- 1 sysadmin sysadmin    90 Mar 14 17:48 alpha-first.txt
-rw-r--r-- 1 sysadmin sysadmin    89 Mar 14 17:48 alpha-first.txt.ori
ginal
-rw-r--r-- 1 sysadmin sysadmin   106 Mar 14 17:48 alpha-second.txt
-rw-r--r-- 1 sysadmin sysadmin   195 Mar 14 17:48 alpha-third.txt
-rw-r--r-- 1 sysadmin sysadmin   390 Mar 14 17:48 alpha.txt
-rw-r--r-- 1 sysadmin sysadmin    42 Mar 14 17:48 animals.txt
-rw-r--r-- 1 sysadmin sysadmin    14 Mar 14 17:48 food.txt
-rwxrw-r-- 1 sysadmin sysadmin   112 Aug  1 03:48 hello.sh
-rw-r--r-- 1 sysadmin sysadmin    67 Mar 14 17:48 hidden.txt
-rw-r--r-- 1 sysadmin sysadmin    10 Mar 14 17:48 letters.txt
-rw-r--r-- 1 sysadmin sysadmin    83 Mar 14 17:48 linux.txt
-rw-r--r-- 1 sysadmin sysadmin 66540 Mar 14 17:48 longfile.txt
-rw-r--r-- 1 sysadmin sysadmin   235 Mar 14 17:48 newhome.txt
-rw-r--r-- 1 sysadmin sysadmin    10 Mar 14 17:48 numbers.txt
-rw-r--r-- 1 sysadmin sysadmin    77 Mar 14 17:48 os.csv
-rw-r--r-- 1 sysadmin sysadmin    59 Mar 14 17:48 people.csv
-rw-r--r-- 1 sysadmin sysadmin   110 Mar 14 17:48 profile.txt
```

```
-rw-r--r-- 1 sysadmin sysadmin    51 Mar 14 17:48 red.txt
```

To switch the owner of the `hello.sh` script to the `root` user, use `root` as the first argument and `hello.sh` as the second argument. Don't forget to use the `sudo` command in order to gain the necessary administrative privileges. Use password `netlab123` when prompted:

```
sysadmin@localhost:~/Documents$ sudo chown root hello.sh
[sudo] password for sysadmin:
```

Confirm the user owner has changed by executing the `ls -l` command. Use the filename as an argument to limit the output:

```
sysadmin@localhost:~/Documents$ ls -l hello.sh
-rwxrw-r-- 1 root sysadmin 112 Aug  1 03:48 hello.sh
```

The user owner field is now `root` indicating the change was successful.

Consider This

Try executing the `hello.sh` script again. It fails! Why?

```
sysadmin@localhost:~/Documents$ ./hello.sh
□□
-bash: ./hello.sh: Permission denied
```

Only the user owner has the execute permission, and now the `root` user is the user owner. This file now requires administrative access to execute. Use the `sudo` command to execute the script as the `root` user.

```
sysadmin@localhost:~/Documents$ sudo ./hello.sh
[sudo] password for sysadmin:
 _______________
( Hello World! )
 ---------------
        \
         \
           <(^)
            ( )
```

Moving Files

The `mv` command is used to move a file from one location in the filesystem to another.

```
mv SOURCE DESTINATION
```

The `mv` command requires at least two arguments. The first argument is the source, a path to the file to be moved. The second argument is the destination, a path to where the

file will be moved to. The files to be copied are sometimes referred to as the source and the place to where the copies are placed in is called the destination.

Follow Along

Use the following command to switch to the `Documents` directory:

```
sysadmin@localhost:~$ cd ~/Documents
```

To move the `people.csv` file into the `Work` directory, use the filename as the source, and the directory name as the destination:

```
sysadmin@localhost:~/Documents$ mv people.csv Work
```

If a file is moved from one directory to another and without specifying a new name for the file, it will retain its original name. The move above can be confirmed using the `ls` command on the `Work`directory:

```
sysadmin@localhost:~/Documents$ ls Work
people.csv
```

The `mv` command is able to move multiple files, as long as the final argument provided to the command the destination. For example, to move three files into the `School` directory:

```
sysadmin@localhost:~/Documents$ mv numbers.txt food.txt alpha.txt Sch
ool
sysadmin@localhost:~/Documents$ ls School
Art  Engineering  Math  alpha.txt  food.txt  numbers.txt
```

Moving a file within the same directory is an effective way to rename it. For example, in the following example the `animals.txt` file is given a new name of `zoo.txt`:

```
mv animals.txt zoo.txt
sysadmin@localhost:~/Documents$ ls
School            alpha-second.txt  hidden.txt    newhome.txt
Work              alpha-third.txt   letters.txt   os.csv
adjectives.txt    animals.txt       linux.txt     profile.txt
alpha-first.txt   hello.sh          longfile.txt  red.txt
sysadmin@localhost:~/Documents$ mv animals.txt zoo.txt
sysadmin@localhost:~/Documents$ ls
School            alpha-second.txt  letters.txt   os.csv
Work              alpha-third.txt   linux.txt     profile.txt
adjectives.txt    hello.sh          longfile.txt  red.txt
alpha-first.txt   hidden.txt        newhome.txt   zoo.txt
```

Consider This

Permissions can have an impact on file management commands, such as the `mv` command. Moving a file requires write and execute permissions on both the origin and destination directories.

Copying Files

Creating copies of files can be useful for numerous reasons:

- If a copy of a file is created before changes are made, then it is possible to revert back to the original.
- It can be used to transfer a file to removable media devices.
- A copy of an existing document can be used as a template for a new document.

```
cp [OPTIONS] SOURCE DESTINATION
```

Follow Along

Use the following command to switch to the `Documents` directory:

```
sysadmin@localhost:~$ cd ~/Documents
```

The `cp` command is used to copy files. Similar to the `mv` command it requires at least two arguments: a source and a destination. For example, to copy the `/etc/passwd` file to the current directory, use the following command:

```
sysadmin@localhost:~/Documents$ cp /etc/passwd .
```

Note

The second argument is the `.` character. Recall from the Changing Directories section that is a shortcut which represents the current directory.

The result of executing the previous command would create a copy of the contents of the `/etc/passwd` file in the `Documents` directory, since that is our current directory. This can be confirmed using the `ls` command:

```
sysadmin@localhost:~/Documents$ ls
School            alpha-second.txt  letters.txt   os.csv       zoo.txt
Work              alpha-third.txt   linux.txt     passwd
adjectives.txt    hello.sh          longfile.txt  profile.txt
alpha-first.txt   hidden.txt        newhome.txt   red.txt
□□
```

Consider This

Permissions can have an impact on file management commands, such as the `cp` command. In order to copy a file, it is necessary to have execute permission to access the directory where the file is located and the read permission for the file being copied.

It is also necessary to have write and execute permission on the directory the file is being copied to. Typically, there are two places where you should always have write and execute permission on the directory: your home directory and the `/tmp` directory.

Copying Files

The `dd` command is a utility for copying files or entire partitions at the bit level.

```
dd [OPTIONS] OPERAND
```

This command has several useful features, including:

- It can be used to clone or delete (wipe) entire disks or partitions.
- It can be used to copy raw data to removable devices, such as USB drives and CDROMs.
- It can backup and restore the MBR (Master Boot Record).
- It can be used to create a file of a specific size that is filled with binary zeros, which can then be used as a swap file (virtual memory).

Let's examine the following example, the `dd` command creates a file named `/tmp/swapex` with 50 blocks of zeros that are one megabyte in size:

```
sysadmin@localhost:~$ dd if=/dev/zero of=/tmp/swapex bs=1M count=50
50+0 records in
50+0 records out
52428800 bytes (52 MB) copied, 0.825745 s, 635 MB/s
```

The `dd` command uses special arguments to specify how it will work. The following illustrates some of the more commonly used arguments:

Argument	Description
`if`	Input File: The input file to be read from. `dd if=/dev/zero of=/tmp/swapex bs=1M count=50` The example reads from the `/dev/zero`file, a special file containing an unlimited number of zeros.
`of`	Output File: The output file to be written. `dd if=/dev/zero of=/tmp/swapex bs=1M count=50`
`bs`	Block Size: The block size to be used. By default, the value is considered to be in bytes. Use the following suffixes to specify other units: `K`, `M`, `G`, and `T` for kilobytes, megabytes, gigabytes and terabytes respectively. `dd if=/dev/zero of=/tmp/swapex bs=1M count=50`

Argument	Description
	The example uses a block size of one megabyte.
`count`	Count: The number of blocks to be read from the input file.

```
dd if=/dev/zero of=/tmp/swapex bs=1M count=50
```

The example command reads 50 blocks.

Consider This

No block size or count needs to be specified when copying over entire devices. For example, to clone from one hard drive (`/dev/sda`) to another (`/dev/sdb`) execute the following command:
`dd if=/dev/sda of=/dev/sdb`

Removing Files

The `rm` command is used to delete files and directories. It is important to keep in mind that deleted files and directories do not go into a "trash can" as with desktop oriented operating systems. When a file is deleted with the `rm` command, it is almost always permanently gone.

```
rm [OPTIONS] FILE
```

Follow Along

Use the following command to switch to the `Documents` directory:

```
sysadmin@localhost:~$ cd ~/Documents
```

Without any options, the `rm` command is typically used to remove regular files:

```
sysadmin@localhost:~/Documents$ rm linux.txt
sysadmin@localhost:~/Documents$ ls linux.txt
ls: cannot access linux.txt: No such file or directory
```

The `rm` command will ignore directories that it's asked to remove; to delete a directory, use the recursive option, either the `-r` or `-R` options. Just be careful since this will delete all files and all subdirectories:

```
sysadmin@localhost:~/Documents$ rm Work
rm: cannot remove 'Work': Is a directory
sysadmin@localhost:~/Documents$ rm -r Work
```

Warning

The `rm` command removes files permanently. To repeat the examples above, reset the terminal using the reset button.

Consider This

Permissions can have an impact on file management commands, such as the `rm` command.

To delete a file within a directory, a user must have write and execute permission on a directory. Regular users typically only have this type of permission in their home directory and its subdirectories.

Filtering Input

The `grep` command is a text filter that will search input and return lines, which contain a match to a given pattern.

```
grep [OPTIONS] PATTERN [FILE]
```

Follow Along

Use the following command to switch to the `Documents` directory:

```
sysadmin@localhost:~$ cd ~/Documents
```

If the example below fails, repeat the example from Section 11:

```
sysadmin@localhost:~/Documents$ cp /etc/passwd .
```

For example, the `passwd` file we previously copied into the `Documents` directory contains the details of special system accounts and user accounts on the system. This file can be very large, however the `grep` command can be used filter out information about a specific user, like the `sysadmin` user. Use `sysadmin` as the pattern argument and `passwd` as the file argument:

```
sysadmin@localhost:~/Documents$ grep sysadmin passwd
sysadmin:x:1001:1001:System Administrator,,,,:/home/sysadmin
```

The command above returned the line from the `passwd` which contains the pattern `sysadmin`.

This line is the `/etc/passwd` entry pertaining to the user `sysadmin` and provides information that is beyond the scope of this course. To learn more about this file, check out NDG Linux Essentials.

The example above uses a simple search term as the pattern, however `grep` is able to interpret much more complex search patterns.

Regular Expressions

Regular expressions have two common forms: basic and extended. Most commands that use regular expressions can interpret basic regular expressions. However, extended regular expressions are not available for all commands and a command option is typically required for them to work correctly.

The following table summarizes basic regular expression characters:

Basic Regex Character(s)	Meaning
.	Any one single character
[ ]	Any one specified character
[^]	Not the one specified character
*	Zero or more of the previous character
^	If first character in the pattern, then pattern must be at beginning of the line to match, otherwise just a literal ^
$	If last character in the pattern, then pattern must be at the end of the line to match, otherwise just a literal $

The following table summarizes the extended regular expressions, which must be used with either the `egrep` command or the `-E` option with the `grep` command:

Extended Regex Character(s)	Meaning
+	One or more of the previous pattern
?	The preceding pattern is optional
{ }	Specify minimum, maximum or exact matches of the previous pattern
|	Alternation - a logical "or"
( )	Used to create groups

Only basic regular expressions have been covered here. For more information concerning extended regular expressions, check out the NDG Linux Essentials and NDG Introduction to Linux courses.

Basic Patterns

Regular expressions are patterns that only certain commands are able to interpret. Regular expressions can be expanded to match certain sequences of characters in text.

The examples displayed on this page will make use of regular expressions to demonstrate their power when used with the `grep` command. In addition, these examples provide a very visual demonstration of how regular expressions work, the text that matches will be displayed in a red color.

Follow Along

Use the following `cd` command to change to the `Documents` directory.

```
sysadmin@localhost:~$ cd ~/Documents
```

The simplest of all regular expressions use only literal characters, like the example from the previous page:

```
sysadmin@localhost:~/Documents$ grep sysadmin passwd
sysadmin:x:1001:1001:System Administrator,,,,:/home/sysadmin
```

Anchor Characters

Anchor characters are one of the ways regular expressions can be used to narrow down search results. For example, the pattern `root` appears many times in the `/etc/passwd` file:

```
sysadmin@localhost:~/Documents$ grep 'root' passwd
root:x:0:0:root:/root:bin/bash
operator:x:11:0:operator:/root:/sbin/nologin
```

To prevent the shell from misinterpreting them as special shell characters, these patterns should be protected by strong quotes, which simply means placing them between single quotes.

The first anchor character `^` is used to ensure that a pattern appears at the *beginning* of the line. For example, to find all lines in `/etc/passwd` that *start* with `root` use the pattern `^root`. Note that `^` must be the *first* character in the pattern to be effective.

```
sysadmin@localhost:~/Documents$ grep '^root' /etc/passwd
root:x:0:0:root:/root:bin/bash
```

For the next example, first examine the `alpha-first.txt` file. The `cat` command can be used to print the contents of a file:

```
sysadmin@localhost:~/Documents$ cat alpha-first.txt
A is for Animal
B is for Bear
C is for Cat
D is for Dog
E is for Elephant
F is for Flower
```

The second anchor character `$` can be used to ensure a pattern appears at the *end* of the line, thereby effectively reducing the search results. To find the lines that end with an `r` in the `alpha-first.txt` file, use the pattern `r$`:

```
sysadmin@localhost:~/Documents$ grep 'r$' alpha-first.txt
B is for Bear
F is for Flower
```

Again, the position of this character is important, the `$` must be the *last* character in the pattern in order to be effective as an anchor.

Match a Single Character With .

The following examples will use the `red.txt` file:

```
sysadmin@localhost:~/Documents$ cat red.txt
red
reef
rot
reeed
rd
rod
roof
reed
root
reel
read
```

One of the most useful expressions is `.` It will match any character except for the new line character. The pattern `r..f` would find any line that contained the letter `r` followed by exactly two characters (which can be any character except a newline) and then the letter `f`:

```
sysadmin@localhost:~/Documents$ grep 'r..f' red.txt
reef
roof
```

The same concept can be repeated using other combinations. The following will find four letter words that start with `r` and with `d`:

```
sysadmin@localhost:~/Documents$ grep 'r..d' red.txt
reed
read
```

This character can be used any number of times. To find all words that have at least four characters the following pattern can be used:

```
sysadmin@localhost:~/Documents$ grep '....' red.txt
reef
reeed
roof
reed
root
reel
read
```

The line does not have to be an exact match, it simply must *contain* the pattern, as seen here when `r..t` is searched for in the `/etc/passwd` file:

```
sysadmin@localhost:~/Documents$ grep 'r..t' /etc/passwd
root:x:0:0:root:/root:/bin/bash
operator:x:1000:37::/root:
```

Match a Single Character With [ ]

The square brackets `[ ]` match a *single* character from the list or range of possible characters contained within the brackets.

For example, given the `profile.txt` file:

```
sysadmin@localhost:~/Documents$ cat profile.txt
Hello my name is Joe.
I am 37 years old.
3121991
My favorite food is avocados.
I have 2 dogs.
123456789101112
```

To find all the lines in the `profile.txt` which have a number in them, use the pattern `[0123456789]` or `[0-9]`:

```
sysadmin@localhost:~/Documents$ grep '[0-9]' profile.txt
I am 37 years old.
3121991
I have 2 dogs.
123456789101112
```

On the other hand, to find all the lines which contain any non-numeric characters, insert a `^` as the first character inside the brackets. This character *negates* the characters listed:

```
sysadmin@localhost:~/Documents$ grep '[^0-9]' profile.txt
Hello my name is Joe.
I am 37 years old.
My favorite food is avocados.
I have 2 dogs.
```

Note

Do not mistake `[^0-9]` to match *lines which do not contain numbers*. It actually matches *lines which contain non-numbers*. Look at the original file to see the difference. The third and sixth lines only contain numbers, *they do not contain non-numbers* so those lines do not match.

When other regular expression characters are placed inside of square brackets, they are treated as literal characters. For example, the `.` normally matches any one character, but placed inside the square brackets, then it will just match itself. In the next example, only lines which contain the `.`character are matched.

```
sysadmin@localhost:~/Documents$ grep '[.]' profile.txt
Hello my name is Joe.
I am 37 years old.
My favorite food is avocados.
I have 2 dogs.
```

Match a Repeated Character Or Patterns With *

The regular expression character `*` is used to match zero or more occurrences of a character or pattern preceding it. For example `e*` would match zero or more occurrences of the letter `e`:

```
sysadmin@localhost:~/Documents$ cat red.txt
red
reef
rot
reeed
rd
rod
roof
reed
root
reel
read
```

```
sysadmin@localhost:~/Documents$ grep 're*d' red.txt
red
reeed
rd
□□
reed
```

It is also possible to match zero or more occurrences of a list of characters by utilizing the square brackets. The pattern `[oe]*` used in the following example will match zero or more occurrences of the `o` character *or* the `e` character:

```
sysadmin@localhost:~/Documents$ grep 'r[oe]*d' red.txt
red
reeed
rd
rod
reed
```

When used with only one other character, `*` isn't very helpful. Any of the following patterns would match *every* string or line in the file: `.*` `e*` `b*` `z*`.

```
sysadmin@localhost:~/Documents$ grep 'z*' red.txt
red
reef
rot
reeed
rd
rod
roof
reed
root
reel
read
sysadmin@localhost:~/Documents$ grep 'e*' red.txt
red
reef
rot
reeed
rd
rod
```

```
roof
reed
root
reel
read
```

This is because `*` can match *zero* occurrences of a pattern. In order to make the `*` useful, it is necessary to create a pattern which includes more than just the one character preceding `*`. For example, the results above can be refined by adding another `e` to make the pattern `ee*` effectively matching every line which contains at least one `e`.

```
sysadmin@localhost:~/Documents$ grep 'ee*' red.txt
red
reef
reeed
reed
reel
read
```

Standard Input

If a file name is not given, the `grep` command will read from standard input, which normally comes from the keyboard with input provided by the user who runs the command. This provides an interactive experience with `grep` where the user types in the input and `grep` filters as it goes. Feel free to try it out, just press **Ctrl-D** when you're ready to return to the prompt.

Standard Input

If a file name is not given, the `grep` command will read from standard input, which normally comes from the keyboard with input provided by the user who runs the command. This provides an interactive experience with `grep` where the user types in the input and `grep` filters as it goes. Feel free to try it out, just press **Ctrl-D** when you're ready to return to the prompt.

Follow Along

Use the following `cd` command to return to the home directory:

```
sysadmin@localhost:~/Documents$ cd ~
```

Network Configuration

The `ifconfig` command stands for "interface configuration" and is used to display network configuration information.

```
ifconfig [OPTIONS]
```

Note

The `iwconfig` command is similar to the `ifconfig` command, but it is dedicated to wireless network interfaces.

Not all network settings are important for this module, but it is important to note in the following example that the IPv4 address of the primary network device `eth0` is `192.168.1.2` and that the device is currently active (`UP`):

```
sysadmin@localhost:~$ ifconfig
eth0      Link encap:Ethernet  HWaddr b6:84:ab:e9:8f:0a
          inet addr:192.168.1.2  Bcast:0.0.0.0  Mask:255.255.255.0
          inet6 addr: fe80::b484:abff:fee9:8f0a/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:95 errors:0 dropped:4 overruns:0 frame:0
          TX packets:9 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:25306 (25.3 KB)  TX bytes:690 (690.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:6 errors:0 dropped:0 overruns:0 frame:0
          TX packets:6 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:460 (460.0 B)  TX bytes:460 (460.0 B)
```

Consider This

The `lo` device is referred to as the *loopback* device. It is a special network device used by the system when sending network-based data to itself.

The `ifconfig` command can also be used to temporarily modify network settings. Typically these changes should be permanent, so using the `ifconfig` command to make such changes is fairly rare.

Viewing Processes

Running a command results in something called a *process*. In the Linux operating system, processes are executed with the privileges of the user who executes the command. This allows for processes to be limited to certain capabilities based upon the user identity.

Although there are exceptions, generally the operating system will differentiate users based upon whether they are the administrator. Typically regular users, like the `sysadmin` user, cannot control another user's processes. Users who have administrative privileges, like the `root` account, can control any user processes, including stopping any user process.

The `ps` command can be used to list processes.

```
ps [OPTIONS]
```

```
sysadmin@localhost:~$ ps
  PID TTY          TIME CMD
   80 ?        00:00:00 bash
   94 ?        00:00:00 ps
```

The `ps` command will display the processes that are running in the current terminal by default. In the example, the bottom line is the process created by the execution of the `ps` command. The output includes the following columns of information:

- `PID`: The process identifier, which is unique to the process. This information is useful to control the process by its ID number.
- `TTY`: The name of the terminal where the process is running. This information is useful to distinguish between different processes that have the same name.
- `TIME`: The total amount of processor time used by the process. Typically, this information isn't used by regular users.
- `CMD`: The command that started the process.

Instead of viewing just the processes running in the current terminal, users may want to view every process running on the system. The `-e` option will display every process:

```
sysadmin@localhost:~$ ps -e
  PID TTY          TIME CMD
    1 ?        00:00:00 init
   33 ?        00:00:00 rsyslogd
   37 ?        00:00:00 cron
   39 ?        00:00:00 sshd
   56 ?        00:00:00 named
   69 ?        00:00:00 login
   79 ?        00:00:00 bash
   94 ?        00:00:00 ps
```

Typically, the `-f` option is also used as it provides more details in the output of the command, including options and arguments. Look for the `ps` command on the last line, the `CMD` column now includes the options used:

```
sysadmin@localhost:~$ ps -ef
UID        PID  PPID  C STIME TTY          TIME CMD
root         1     0  0 19:16 ?        00:00:00 /sbin??? /init
syslog      33     1  0 19:16 ?        00:00:00 /usr/sbin/rsyslogd
root        37     1  0 19:16 ?        00:00:00 /usr/sbin/cron
root        39     1  0 19:16 ?        00:00:00 /usr/sbin/sshd
```

```
bind        56     1  0 19:16 ?        00:00:00 /usr/sbin/named -u bi
nd
root        69     1  0 19:16 ?        00:00:00 /bin/login -f
sysadmin    79    69  0 19:16 ?        00:00:00 -bash
sysadmin    95    79  0 19:43 ?        00:00:00 ps -ef
```

Package Management

Package management is a system by which software can be installed, updated, queried or removed from a filesystem. In Linux, there are many different software package management systems, but the two most popular are those from Debian and Red Hat. The virtual machines for this course use Ubuntu, a derivative of Debian.

At the lowest level of the Debian package management system is the `dpkg` command. This command can be tricky for novice Linux users, so the Advanced Package Tool, `apt-get`, a front-end program to the `dpkg` tool, makes management of packages even easier.

Follow Along

Many of the package management commands require administrative access, so they will be prefaced with the `sudo` command. Use `netlab123` as the password when prompted.

Installing Packages

Package files are commonly installed by downloading them directly from repositories located on Internet servers. The Debian repositories contain more than 65,000 different packages of software. Before installing a package, it is good practice to use the refresh the list of available packages using the `apt-get update` command.

```
sudo apt-get update
```

```
sysadmin@localhost:~$ sudo apt-get update
[sudo] password for sysadmin:
Ign file: amd64/ InRelease
Ign file: amd64/ Release.gpg
Ign file: amd64/ Release
Reading package lists... Done
```

To search for keywords within these packages, you can use the `apt-cache search` command.

```
apt-cache search [keyword]
```

The keyword that is used should match part of the name or description of the package that is to be located. Multiple keywords can be used to further clarify the search; for example, the search term `web server` would provide better results than `web` or `server`.

To find packages associated with the `cow` keyword:

```
sysadmin@localhost:~$ apt-cache search cow
```

```
cowsay - configurable talking cow
```

Once you've found the package that you want to install, you can install it with the `apt-get install`command:

```
sudo apt-get install [package]
```

```
sysadmin@localhost:~$ sudo apt-get install cowsay
[sudo] password for sysadmin:
Reading package lists... Done
Building dependency tree
Reading state information... Done
Suggested packages:
  filters
The following NEW packages will be installed:
  cowsay
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 0 B/18.5 kB of archives.
After this operation, 90.1 kB of additional disk space will be used.

Selecting previously unselected package cowsay.
(Reading database ... 24313 files and directories currently installed
.)
Preparing to unpack .../cowsay_3.03+dfsg1-6_all.deb ...
Unpacking cowsay (3.03+dfsg1-6) ...
Processing triggers for man-db (2.6.7.1-1ubuntu1) ...
Setting up cowsay (3.03+dfsg1-6) ...
```

Consider This

The `cowsay` command is a configurable talking cow! Use a word or phrase as an argument:

```
sysadmin@localhost:~$ cowsay 'NDG Linux Unhatched'
 ______________________
< NDG Linux Unhatched >
 ----------------------
        \   ^__^
         \  (oo)\_______
            (__)\       )\/\
                ||----w |
                ||     ||
```

We recommend enclosing the argument in single quotes to prevent the shell from interpreting special characters.

Updating Packages

The `apt-get install` command can also update a package, if that package is installed and a newer version is available. If the package is not already on the system, it would be installed; if it is on the system, it would be updated.

Updating all packages of the system should be done in two steps. First, update the cache of all packages available with `apt-get update`. Second, execute the `apt-get upgrade` command and all packages and dependencies will be updated.

```
apt-get update
apt-get upgrade
```

```
sysadmin@localhost:~$ sudo apt-get update
[sudo] password for sysadmin:
Ign file: amd64/ InRelease
Ign file: amd64/ Release.gpg
Ign file: amd64/ Release
Reading package lists... Done
sysadmin@localhost:~$ sudo apt-get upgrade
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

Removing Packages

The `apt-get` command is able to either remove or purge a package. The difference between the two is that purging deletes all package files, while removing deletes all but the configuration files for the package.

An administrator can execute the `apt-get remove` command to remove a package or the `apt-get purge` command to purge a package completely from the system.

```
apt-get remove [package]
apt-get purge [package]
```

For example, to purge `cowsay` completely, execute the following command. Enter **Y** when prompted:

```
sysadmin@localhost:~$ sudo apt-get purge cowsay
Reading package lists... Done
Building dependency tree
```

```
Reading state information... Done
The following packages will be REMOVED:
  cowsay*
0 upgraded, 0 newly installed, 1 to remove and 0 not upgraded.
After this operation, 90.1 kB disk space will be freed.
Do you want to continue? [Y/n] y
(Reading database ... 24377 files and directories currently installed
.)
Removing cowsay (3.03+dfsg1-6) ...
Processing triggers for man-db (2.6.7.1-1ubuntu1) ...
```

Updating User Passwords

The `passwd` command is used to update a user's password. Users can only change their own passwords, whereas the root user can update the password for any user.

```
passwd [OPTIONS] [USER]
```

For example, since we are logged in as the `sysadmin` user we can change the password for that account. Execute the `passwd` command. You will be prompted to enter the existing password once and the new password twice. For security reasons, no output is displayed while the password is being typed. The output is shown as follows:

```
sysadmin@localhost:~$ passwd
Changing password for sysadmin.
(current) UNIX password: netlab123
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
```

If the user wants to view *status* information about their password, they can use the `-S` option:

```
sysadmin@localhost:~$ passwd -S sysadmin
sysadmin P 03/01/2015 0 99999 7 -1
```

The output fields are explained below:

Field	Example	Meaning
User Name	`sysadmin`	The name of the user.

Field	Example	Meaning
Password Status	`P`	`P` indicates a usable password. `L` indicates a locked password. `NP` indicates no password.
Change Date	`03/01/2015`	The date when the password was last changed.
Minimum	`0`	The minimum number of days that must pass before the current password can be changed by the user.
Maximum	`99999`	The maximum number of days remaining for the password to expire.
Warn	`7`	The number of days prior to password expiry that the user is warned.
Inactive	`-1`	The number of days after password expiry that the user account remains active.

Follow Along

Switch the `root` account using the following command:

```
sysadmin@localhost:~$ su root
Password:
root@localhost:~#
```

Use `netlab123` as the password.

The root user can change the password of any user. If the root user wants to change the password for `sysadmin`, they would execute the following command:

```
root@localhost:~# passwd sysadmin
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
```

Follow Along

Exit the `root` account using the `exit` command:

```
root@localhost:~# exit
logout
```

Text Editor

The premier text editor for Linux and UNIX is a program called `vi`. While there are numerous editors available for Linux that range from the tiny editor `nano` to massive `emacs` editor, there are several advantages to the `vi` editor:

- The `vi` editor is available on every Linux distribution in the world. This is not true of any other editor.
- The `vi` editor can be executed both in a CLI (command line interface) and a GUI (graphical user interface).
- While new features have been added to the `vi` editor, the core functions have been around for decades. This means if someone learned the `vi` editor in the 1970s, they could use a modern version without any problem. While that seems trivial, it may not seem to so trivial twenty years from now.

Consider This

The correct way to pronounce the vi editor is the *vee-eye* editor. The letters vi stand for *visual*, but it was never pronounced this way by the developers, but rather the letter *v* followed by the letter *i*.

In reality, most Linux systems don't include the original `vi`, but an improved version of it known as `vim`, for *vi improved*. This fact may be hidden by most Linux distributions. For the most part, `vim`works just like `vi`, but has additional features. For the topics that will be covered in this course, either `vi` or `vim` will work.

To get started using `vi`, simply type the command followed by the pathname to the file to edit or create:

```
sysadmin@localhost:~$ vi newfile.txt
```

There are three modes used in `vi`: command mode, insert mode, and ex mode.

Command Mode Movement

Initially, the program starts in command mode. Command mode is used to type commands, such as those used to move around a document, manipulate text, and access the other two modes. To return to command mode at any time, press the **Esc** key.

Once some text has been added into a document, to perform actions like moving the cursor, the **Esc**key needs to be pressed first to return to command mode. This seems like a lot of work, but remember that `vi` works in a terminal environment where a mouse is useless.

Movement commands in `vi` have two aspects, a motion and an optional number prefix, which indicates how many times to repeat that motion. The general format is as follows:

```
[count] motion
```

The following table summarizes the motion keys available:

Motion	Result
`h`	Left one character
`j`	Down one line

Motion	Result
`k`	Up one line
`l`	Right one character
`w`	One word forward
`b`	One word back
`^`	Beginning of line
`$`	End of the line

Note

Since the upgrade to `vim` it is also possible to use the arrow keys `←↓↑→` instead of `hjkl` respectively.

These motions can be prefixed with a number to indicate how many times to perform the movement. For example, `5h` would move the cursor five characters to the left,`3w` would move the cursor three words to the right.

To move the cursor to a specific line number, type that line number followed by the `G` character. For example, to get to the fifth line of the file type `5G`. `1G` or `gg` can be used to go to the first line of the file, while a lone `G` will take you to the last line. To find out which line the cursor is currently on, use **CTRL-G**.

Command Mode Actions

The standard convention for editing content with word processors is to use copy, cut, and paste. The `vi` program has none of these, instead `vi` uses the following three commands:

Standard	Vi	Meaning
cut	`d`	delete
copy	`y`	yank
paste	`P` | `p`	put

The motions learned from the previous page are used to specify where the action is to take place, always beginning with the present cursor location. Either of the following general formats for action commands is acceptable:

```
action [count] motion
[count] action motion
```

Delete

Delete removes the indicated text from the page and saves it into the buffer, the buffer being the equivalent of the "clipboard" used in Windows or Mac OSX. The following table provides some common usage examples:

Action	Result
`dd`	Delete current line
`3dd`	Delete the next three lines
`dw`	Delete the current word
`d3w`	Delete the next three words
`d4h`	Delete four characters to the left

Change

Change is very similar to delete, the text is removed and saved into the buffer, however the program is switched to insert mode to allow immediate changes to the text. The following table provides some common usage examples:

Action	Result
`cc`	Change current line
`cw`	Change current word
`c3w`	Change the next three words
`c5h`	Change five characters to the left

Yank

Yank places content into the buffer without deleting it. The following table provides some common usage examples:

Action	Result
`yy`	Yank current line
`3yy`	Yank the next three lines
`yw`	Yank the current word
`y$`	Yank to the end of the line

Put

Put places the text saved in the buffer either before or after the cursor position. Notice that these are the only two options, put does not use the motions like the previous action commands.

Action	Result
`p`	Put (paste) after cursor
`P`	Put before cursor

Searching in vi

Another standard function that word processors offer is find. Often, people use **CTRL+F** or look under the edit menu. The `vi` program uses search. Search is more powerful than find because it supports both literal text patterns and regular expressions.

To search forward from the current position of the cursor, use the `/` to start the search, type a search term, and then press the **Enter** key to begin the search. The cursor will move to the first match that is found.

To proceed to the next match using the same pattern, press the `n` key. To go back to a previous match, press the `N` key. If the end or the beginning of the document is reached, it will automatically wrap around to the other side of the document.

To start searching backwards from the cursor position, start by typing `?`, then type the pattern to search for matches and press the **Enter** key.

Insert Mode

Insert mode is used to add text to the document. There a few ways to enter insert mode from command mode, each differing by where the text insertion will begin. The following table covers the most common:

Input	Purpose
`a`	Enter insert mode right after the cursor
`A`	Enter insert mode at the end of the line
`i`	Enter insert mode right before the cursor
`I`	Enter insert mode at the beginning of the line
`o`	Enter insert mode on a blank line after the cursor
`O`	Enter insert mode on a blank line before the cursor

Ex Mode

Originally, the `vi` editor was called the `ex` editor. The name `vi` was the abbreviation of the **visual**command in the `ex` editor that switched the editor to "visual" mode.

In the original normal mode, the `ex` editor only allowed users to see and modify one line at a time. In the visual mode, users could see as much of the document that will fit on the screen. Since most users preferred the visual mode to the line editing mode, the `ex` program file was linked to a `vi` file, so that users could start `ex` directly in visual mode when they ran the `vi` link.

Eventually, the actual program file was renamed `vi` and the `ex` editor became a link that pointed the `vi` editor.

When the ex mode of the `vi` editor is being used, it is possible to view or change settings, as well as carry out file-related commands like opening, saving or aborting changes to a file. In order to get to the ex mode, type a `:` character in command mode. The following table lists some common actions performed in ex mode:

Input	Purpose
`:w`	Write the current file to the filesystem
`:w` *filename*	Save a copy of the current file as filename

Input	Purpose
`:w!`	Force writing to the current file
`:1`	Go to line number 1 or whatever number is given
`:e` *filename*	Open filename
`:q`	Quit if no changes made to file
`:q!`	Quit without saving changes to file

A quick analysis of the table above reveals if an exclamation mark `!` is added to a command, it then attempts to force the operation. For example, imagine you make changes to a file in the `vi` editor and then try to quit with `:q`, only to discover that the command fails. The `vi` editor doesn't want to quit without saving the changes you made to a file, but you can force it to quit with the ex command `:q!`.

Consider This

Although the ex mode offers several ways to save and quit, there's also `ZZ` that is available in command mode; this is the equivalent of `:wq`. There are many more overlapping functions between ex mode and command mode. For example, ex mode can be used to navigate to any line in the document by typing `:` followed by the line number, while the `G` can be used in command mode as previously demonstrated.

Follow Along

If you have a text file open, exit it by executing the `:q!` command. This will quit without saving changes.