Chapter 22

Input/Output

Introduction

- C's input/output library is the biggest and most important part of the standard library.
- The `<stdio.h>` header is the primary repository of input/output functions, including `printf`, `scanf`, `putchar`, `getchar`, `puts`, and `gets`.
- This chapter provides more information about these six functions.
- It also introduces many new functions, most of which deal with files.

Introduction

- Topics to be covered:
  - Streams, the `FILE` type, input and output redirection, and the difference between text files and binary files
  - Functions designed specifically for use with files, including functions that open and close files
  - Functions that perform “formatted” input/output
  - Functions that read and write unformatted data (characters, lines, and blocks)
  - Random access operations on files
  - Functions that write to a string or read from a string

Introduction

- In C99, some I/O functions belong to the `<wchar.h>` header.
- The `<wchar.h>` functions deal with wide characters rather than ordinary characters.
- Functions in `<stdio.h>` that read or write data are known as ***byte input/output functions.***
- Similar functions in `<wchar.h>` are called ***wide-character input/output functions.***

Streams

- In C, the term ***stream*** means any source of input or any destination for output.
- Many small programs obtain all their input from one stream (the keyboard) and write all their output to another stream (the screen).
- Larger programs may need additional streams.
- Streams often represent files stored on various media.
- However, they could just as easily be associated with devices such as network ports and printers.

File Pointers

- Accessing a stream is done through a ***file pointer,*** which has type `FILE *`.
- The `FILE` type is declared in `<stdio.h>`.
- Certain streams are represented by file pointers with standard names.
- Additional file pointers can be declared as needed:

```
FILE *fp1, *fp2;
```

Standard Streams and Redirection

- `<stdio.h>` provides three standard streams:

File Pointer	***Stream***	***Default Meaning***
`stdin`	Standard input	Keyboard
`stdout`	Standard output	Screen
`stderr`	Standard error	Screen

- These streams are ready to use—we don't declare them, and we don't open or close them.

Standard Streams and Redirection

- The I/O functions discussed in previous chapters obtain input from `stdin` and send output to `stdout`.
- Many operating systems allow these default meanings to be changed via a mechanism known as ***redirection.***

Standard Streams and Redirection

- A typical technique for forcing a program to obtain its input from a file instead of from the keyboard:

  ```
  demo <in.dat
  ```

  This technique is known as ***input redirection.***
- ***Output redirection*** is similar:

  ```
  demo >out.dat
  ```

  All data written to `stdout` will now go into the `out.dat` file instead of appearing on the screen.

Standard Streams and Redirection

- Input redirection and output redirection can be combined:

```
demo <in.dat >out.dat
```

- The < and > characters don't have to be adjacent to file names, and the order in which the redirected files are listed doesn't matter:

```
demo < in.dat > out.dat
demo >out.dat <in.dat
```

Standard Streams and Redirection

- One problem with output redirection is that *everything* written to `stdout` is put into a file.
- Writing error messages to `stderr` instead of `stdout` guarantees that they will appear on the screen even when `stdout` has been redirected.

Text Files versus Binary Files

- `<stdio.h>` supports two kinds of files: text and binary.
- The bytes in a ***text file*** represent characters, allowing humans to examine or edit the file.
  - The source code for a C program is stored in a text file.
- In a ***binary file,*** bytes don't necessarily represent characters.
  - Groups of bytes might represent other types of data, such as integers and floating-point numbers.
  - An executable C program is stored in a binary file.

Text Files versus Binary Files

- Text files have two characteristics that binary files don't possess.
- ***Text files are divided into lines.*** Each line in a text file normally ends with one or two special characters.
  - Windows: carriage-return character (`'\x0d'`) followed by line-feed character (`'\x0a'`)
  - UNIX and newer versions of Mac OS: line-feed character
  - Older versions of Mac OS: carriage-return character

Text Files versus Binary Files

- ***Text files may contain a special "end-of-file" marker.***
  - In Windows, the marker is `'\x1a'` (Ctrl-Z), but it is not required.
  - Most other operating systems, including UNIX, have no special end-of-file character.
- In a binary file, there are no end-of-line or end-of-file markers; all bytes are treated equally.

Text Files versus Binary Files

- When data is written to a file, it can be stored in text form or in binary form.
- One way to store the number 32767 in a file would be to write it in text form as the characters 3, 2, 7, 6, and 7:

00110011	00110010	00110111	00110110	00110111
'3'	'2'	'7'	'6'	'7'

Text Files versus Binary Files

- The other option is to store the number in binary, which would take as few as two bytes:

01111111	11111111

- Storing numbers in binary can often save space.

Text Files versus Binary Files

- Programs that read from a file or write to a file must take into account whether it's text or binary.
- A program that displays the contents of a file on the screen will probably assume it's a text file.
- A file-copying program, on the other hand, can't assume that the file to be copied is a text file.
  - If it does, binary files containing an end-of-file character won't be copied completely.
- When we can't say for sure whether a file is text or binary, it's safer to assume that it's binary.

File Operations

- Simplicity is one of the attractions of input and output redirection.
- Unfortunately, redirection is too limited for many applications.
  - When a program relies on redirection, it has no control over its files; it doesn't even know their names.
  - Redirection doesn't help if the program needs to read from two files or write to two files at the same time.
- When redirection isn't enough, we'll use the file operations that `<stdio.h>` provides.

Opening a File

- Opening a file for use as a stream requires a call of the `fopen` function.
- Prototype for `fopen`:

```
FILE *fopen(const char * restrict filename,
            const char * restrict mode);
```

- `filename` is the name of the file to be opened.
  - This argument may include information about the file's location, such as a drive specifier or path.
- `mode` is a "mode string" that specifies what operations we intend to perform on the file.

Opening a File

- The word `restrict` appears twice in the prototype for `fopen`.
- `restrict`, which is a C99 keyword, indicates that `filename` and `mode` should point to strings that don't share memory locations.
- The C89 prototype for `fopen` doesn't contain `restrict` but is otherwise identical.
- `restrict` has no effect on the behavior of `fopen`, so it can usually be ignored.

Opening a File

- In Windows, be careful when the file name in a call of `fopen` includes the \ character.
- The call

```
fopen("c:\project\test1.dat", "r")
```

  will fail, because `\t` is treated as a character escape.
- One way to avoid the problem is to use \\ instead of \:

```
fopen("c:\\project\\test1.dat", "r")
```

- An alternative is to use the `/` character instead of \:

```
fopen("c:/project/test1.dat", "r")
```

Opening a File

- `fopen` returns a file pointer that the program can (and usually will) save in a variable:

```
fp = fopen("in.dat", "r");
  /* opens in.dat for reading */
```

- When it can't open a file, `fopen` returns a null pointer.

Modes

- Factors that determine which mode string to pass to `fopen`:
  - Which operations are to be performed on the file
  - Whether the file contains text or binary data

Modes

- Mode strings for **text** files:

String	***Meaning***
`"r"`	Open for reading
`"w"`	Open for writing (file need not exist)
`"a"`	Open for appending (file need not exist)
`"r+"`	Open for reading and writing, starting at beginning
`"w+"`	Open for reading and writing (truncate if file exists)
`"a+"`	Open for reading and writing (append if file exists)

Modes

- Mode strings for **binary** files:

String	*Meaning*
`"rb"`	Open for reading
`"wb"`	Open for writing (file need not exist)
`"ab"`	Open for appending (file need not exist)
`"r+b"` or `"rb+"`	Open for reading and writing, starting at beginning
`"w+b"` or `"wb+"`	Open for reading and writing (truncate if file exists)
`"a+b"` or `"ab+"`	Open for reading and writing (append if file exists)

Modes

- Note that there are different mode strings for *writing* data and *appending* data.
- When data is written to a file, it normally overwrites what was previously there.
- When a file is opened for appending, data written to the file is added at the end.

Modes

- Special rules apply when a file is opened for both reading and writing.
  - Can’t switch from reading to writing without first calling a file-positioning function unless the reading operation encountered the end of the file.
  - Can’t switch from writing to reading without either calling `fflush` or calling a file-positioning function.

Closing a File

- The `fclose` function allows a program to close a file that it's no longer using.
- The argument to `fclose` must be a file pointer obtained from a call of `fopen` or `freopen`.
- `fclose` returns zero if the file was closed successfully.
- Otherwise, it returns the error code `EOF` (a macro defined in `<stdio.h>`).

Closing a File

- The outline of a program that opens a file for reading:

```
#include <stdio.h>
#include <stdlib.h>

#define FILE_NAME "example.dat"

int main(void)
{
  FILE *fp;

  fp = fopen(FILE_NAME, "r");
  if (fp == NULL) {
    printf("Can't open %s\n", FILE_NAME);
    exit(EXIT_FAILURE);
  }
  …
  fclose(fp);
  return 0;
}
```

Closing a File

- It's not unusual to see the call of `fopen` combined with the declaration of `fp`:

  ```
  FILE *fp = fopen(FILE_NAME, "r");
  ```

  or the test against `NULL`:

  ```
  if ((fp = fopen(FILE_NAME, "r")) == NULL) …
  ```

Attaching a File to an Open Stream

- `freopen` attaches a different file to a stream that's already open.
- The most common use of `freopen` is to associate a file with one of the standard streams (`stdin`, `stdout`, or `stderr`).
- A call of `freopen` that causes a program to begin writing to the file `foo`:

```
if (freopen("foo", "w", stdout) == NULL) {
  /* error; foo can't be opened */
}
```

Attaching a File to an Open Stream

- `freopen`'s normal return value is its third argument (a file pointer).
- If it can't open the new file, `freopen` returns a null pointer.

Attaching a File to an Open Stream

- C99 adds a new twist: if `filename` is a null pointer, `freopen` attempts to change the stream's mode to that specified by the `mode` parameter.
- Implementations aren't required to support this feature.
- If they do, they may place restrictions on which mode changes are permitted.

Obtaining File Names from the Command Line

- There are several ways to supply file names to a program.
  - Building file names into the program doesn't provide much flexibility.
  - Prompting the user to enter file names can be awkward.
  - Having the program obtain file names from the command line is often the best solution.
- An example that uses the command line to supply two file names to a program named `demo`:

```
demo names.dat dates.dat
```

Obtaining File Names from the Command Line

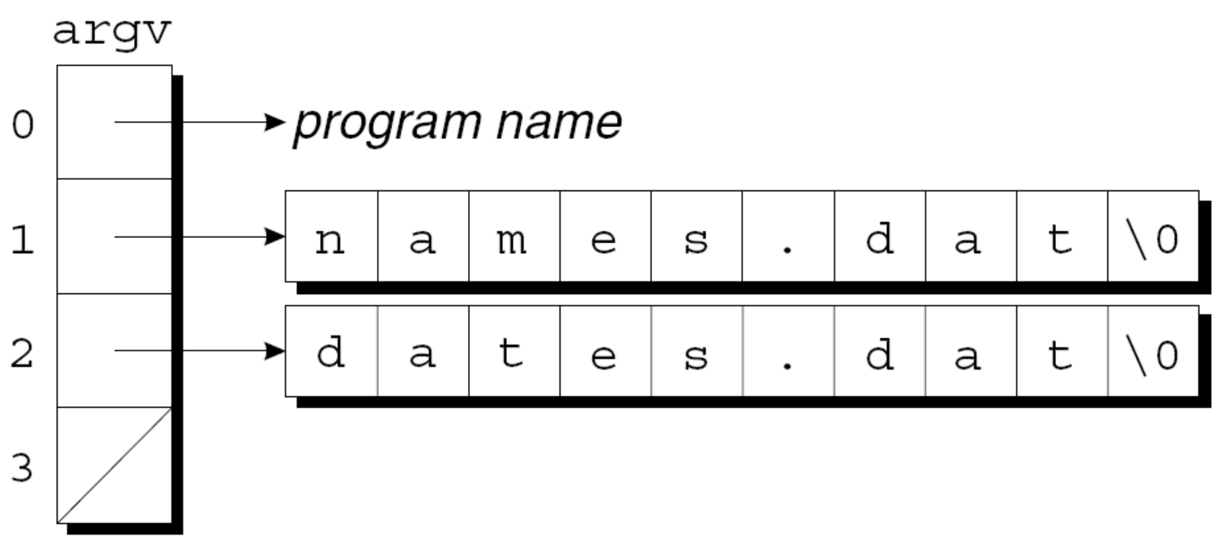
- Chapter 13 showed how to access command-line arguments by defining `main` as a function with two parameters:

```
int main(int argc, char *argv[])
{
  …
}
```

- `argc` is the number of command-line arguments.
- `argv` is an array of pointers to the argument strings.

Obtaining File Names from the Command Line

- `argv[0]` points to the program name, `argv[1]` through `argv[argc-1]` point to the remaining arguments, and `argv[argc]` is a null pointer.
- In the `demo` example, `argc` is 3 and `argv` has the following appearance:



Program: Checking Whether a File Can Be Opened

- The `canopen.c` program determines if a file exists and can be opened for reading.
- The user will give the program a file name to check:

  `canopen` *file*
- The program will then print either *file* `can be opened` or *file* `can't be opened`.
- If the user enters the wrong number of arguments on the command line, the program will print the message `usage: canopen filename`.

canopen.c

```
/* Checks whether a file can be opened for reading */

#include <stdio.h>
#include <stdlib.h>

int main(int argc, char *argv[])
{
  FILE *fp;

  if (argc != 2) {
    printf("usage: canopen filename\n");
    exit(EXIT_FAILURE);
  }

  if ((fp = fopen(argv[1], "r")) == NULL) {
    printf("%s can't be opened\n", argv[1]);
    exit(EXIT_FAILURE);
  }

  printf("%s can be opened\n", argv[1]);
  fclose(fp);
  return 0;
}
```

Temporary Files

- Programs often need to create temporary files—files that exist only as long as the program is running.
- `<stdio.h>` provides two functions, `tmpfile()` and `tmpnam()`, for working with temporary files.

Temporary Files

- `tmpfile` creates a temporary file (opened in `"wb+"` mode) that will exist until it's closed or the program ends.
- A call of `tmpfile` returns a file pointer that can be used to access the file later:

```
FILE *tempptr;
…
tempptr = tmpfile();
  /* creates a temporary file */
```

- If it fails to create a file, `tmpfile` returns a null pointer.

Temporary Files

- Drawbacks of using `tmpfile`:
  - Don't know the name of the file that `tmpfile` creates.
  - Can't decide later to make the file permanent.
- The alternative is to create a temporary file using `fopen`.
- The `tmpnam` function is useful for ensuring that this file doesn't have the same name as an existing file.

Temporary Files

- `tmpnam` generates a name for a temporary file.
- If its argument is a null pointer, `tmpnam` stores the file name in a static variable and returns a pointer to it:

```
char *filename;
…
filename = tmpnam(NULL);
  /* creates a temporary file name */
```

Temporary Files

- Otherwise, `tmpnam` copies the file name into a character array provided by the programmer:

```
char filename[L_tmpnam];
…
tmpnam(filename);
  /* creates a temporary file name */
```

- In this case, `tmpnam` also returns a pointer to the first character of this array.
- `L_tmpnam` is a macro in `<stdio.h>` that specifies how long to make a character array that will hold a temporary file name.

Temporary Files

- The `TMP_MAX` macro (defined in `<stdio.h>`) specifies the maximum number of temporary file names that can be generated by `tmpnam`.
- If it fails to generate a file name, `tmpnam` returns a null pointer.

File Buffering

- Transferring data to or from a disk drive is a relatively slow operation.
- The secret to achieving acceptable performance is **buffering.**
- Data written to a stream is actually stored in a buffer area in memory; when it's full (or the stream is closed), the buffer is "flushed."
- Input streams can be buffered in a similar way: the buffer contains data from the input device; input is read from this buffer instead of the device itself.

File Buffering

- Buffering can result in enormous gains in efficiency, since reading a byte from a buffer or storing a byte in a buffer is very fast.
- It takes time to transfer the buffer contents to or from disk, but one large "block move" is much faster than many tiny byte moves.
- The functions in `<stdio.h>` perform buffering automatically when it seems advantageous.
- On rare occasions, we may need to use the functions `fflush`, `setbuf`, and `setvbuf`.

File Buffering

- `int fflush(FILE *stream)`;
- ```
  void setbuf(FILE * restrict stream,
              char * restrict buf) // old
  ```
- ```
  int setvbuf(FILE * restrict stream,
              char * restrict buf,
              int mode, size_t size)
  ```

File Buffering

- By calling `fflush`, a program can flush a file's buffer as often as it wishes.
- A call that flushes the buffer for the file associated with `fp`:

```
fflush(fp);   /* flushes buffer for fp */
```

- A call that flushes *all* output streams:

```
fflush(NULL);  /* flushes all buffers */
```

- `fflush` returns zero if it's successful and `EOF` if an error occurs.

File Buffering

- `setvbuf` allows us to change the way a stream is buffered and to control the size and location of the buffer.
- The function's third argument specifies the kind of buffering desired:

  `_IOFBF` (full buffering)

  `_IOLBF` (line buffering)

  `_IONBF` (no buffering)
- Full buffering is the default for streams that aren't connected to interactive devices.

File Buffering

- `setvbuf`'s second argument (if it's not a null pointer) is the address of the desired buffer.
- The buffer might have static storage duration, automatic storage duration, or even be allocated dynamically.
- `setvbuf`'s last argument is the number of bytes in the buffer.

File Buffering

- A call of `setvbuf` that changes the buffering of `stream` to full buffering, using the `N` bytes in the `buffer` array as the buffer:

```
char buffer[N];
…
setvbuf(stream, buffer, _IOFBF, N);
```

- `setvbuf` must be called after `stream` is opened but before any other operations are performed on it.

File Buffering

- It's also legal to call `setvbuf` with a null pointer as the second argument, which requests that `setvbuf` create a buffer with the specified size.
- `setvbuf` returns zero if it's successful.
- It returns a nonzero value if the `mode` argument is invalid or the request can't be honored.

File Buffering

- `setbuf` is an older function that assumes default values for the buffering mode and buffer size.
- If `buf` is a null pointer, the call `setbuf(stream, buf)` is equivalent to

```
(void) setvbuf(stream, NULL, _IONBF, 0);
```

- Otherwise, it's equivalent to

```
(void) setvbuf(stream, buf, _IOFBF, BUFSIZ);
```

  where `BUFSIZ` is a macro defined in `<stdio.h>`.
- `setbuf` is considered to be obsolete.

Miscellaneous File Operations

- The `remove` and `rename` functions allow a program to perform basic file management operations.
- Unlike most other functions in this section, `remove` and `rename` work with file *names* instead of file *pointers*.
- Both functions return zero if they succeed and a nonzero value if they fail.

Miscellaneous File Operations

- `remove` deletes a file:

```
remove("foo");
  /* deletes the file named "foo" */
```

- If a program uses `fopen` (instead of `tmpfile`) to create a temporary file, it can use `remove` to delete the file before the program terminates.
- The effect of removing a file that's currently open is implementation-defined.

Miscellaneous File Operations

- `rename` changes the name of a file:

```
rename("foo", "bar");
  /* renames "foo" to "bar" */
```

- `rename` is handy for renaming a temporary file created using `fopen` if a program should decide to make it permanent.
  - If a file with the new name already exists, the effect is implementation-defined.
- `rename` may fail if asked to rename an open file.

Formatted I/O

- The next group of library functions use format strings to control reading and writing.
- `printf` and related functions are able to convert data from numeric form to character form during output.
- `scanf` and related functions are able to convert data from character form to numeric form during input.

The …`printf` Functions

- The `fprintf` and `printf` functions write a variable number of data items to an output stream, using a format string to control the appearance of the output.
- The prototypes for both functions end with the `...` symbol (an ***ellipsis***), which indicates a variable number of additional arguments:

```
int fprintf(FILE * restrict stream,
            const char * restrict format, ...);
int printf(const char * restrict format, ...);
```

- Both functions return the number of characters written; a negative return value indicates that an error occurred.

The …`printf` Functions

- `printf` always writes to `stdout`, whereas `fprintf` writes to the stream indicated by its first argument:

```
printf("Total: %d\n", total);
  /* writes to stdout */
fprintf(fp, "Total: %d\n", total);
  /* writes to fp */
```

- A call of `printf` is equivalent to a call of `fprintf` with `stdout` as the first argument.

The …`printf` Functions

- `fprintf` works with any output stream.
- One of its most common uses is to write error messages to `stderr`:

```
fprintf(stderr, "Error: data file can't be
opened.\n");
```

- Writing a message to `stderr` guarantees that it will appear on the screen even if the user redirects `stdout`.

The …`printf` Functions

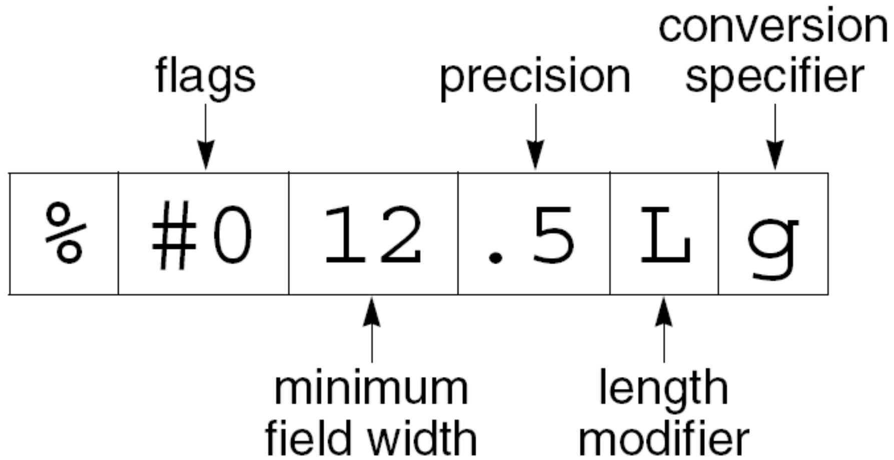
- Two other functions in `<stdio.h>` can write formatted output to a stream.
- These functions, named `vfprintf` and `vprintf`, are fairly obscure.
- Both rely on the `va_list` type, which is declared in `<stdarg.h>`, so they're discussed along with that header.

…`printf` Conversion Specifications

- Both `printf` and `fprintf` require a format string containing ordinary characters and/or conversion specifications.
  - Ordinary characters are printed as is.
  - Conversion specifications describe how the remaining arguments are to be converted to character form for display.

…`printf` Conversion Specifications

- A …`printf` conversion specification consists of the % character, followed by as many as five distinct items:



…`printf` Conversion Specifications

- ***Flags*** (optional; more than one permitted):

Flag	*Meaning*
`-`	Left-justify within field.
`+`	Numbers produced by signed conversions always begin with `+` or `-`.
space	Nonnegative numbers produced by signed conversions are preceded by a space.
`#`	Octal numbers begin with `0`, nonzero hexadecimal numbers with `0x` or `0X`. Floating-point numbers always have a decimal point. Trailing zeros aren't removed from numbers printed with the `g` or `G` conversions.
`0` *(zero)*	Numbers are padded with leading zeros up to the field width.

Examples of …`printf` Conversion Specifications

- Examples showing the effect of flags on the `%d` conversion:

Conversion Specification	*Result of Applying Conversion to 123*	*Result of Applying Conversion to –123*
`%8d`	`•••••123`	`••••-123`
`%-8d`	`123•••••`	`-123••••`
`%+8d`	`••••+123`	`••••-123`
`% 8d`	`•••••123`	`••••-123`
`%08d`	`00000123`	`-0000123`
`%-+8d`	`+123••••`	`-123••••`
`%- 8d`	`•123••••`	`-123••••`
`%+08d`	`+0000123`	`-0000123`
`% 08d`	`•0000123`	`-0000123`

Examples of …`printf` Conversion Specifications

- Examples showing the effect of the # flag on the `o`, `x`, `X`, `g`, and `G` conversions:

Conversion Specification	***Result of Applying Conversion to 123***	***Result of Applying Conversion to 123.0***
`%8o`	`•••••173`	
`%#8o`	`••••0173`	
`%8x`	`••••••7b`	
`%#8x`	`••••0x7b`	
`%8X`	`••••••7B`	
`%#8X`	`••••0X7B`	
`%8g`		`•••••123`
`%#8g`		`•123.000`
`%8G`		`•••••123`
`%#8G`		`•123.000`

…`printf` Conversion Specifications

- ***Minimum field width*** (optional). An item that's too small to occupy the field will be padded.
  - By default, spaces are added to the left of the item.
- An item that's too large for the field width will still be displayed in its entirety.
- field width is either **an integer** or the **character `*`**.
  - If `*` is present, the field width is obtained from the next argument.

…`printf` Conversion Specifications

- ***Precision*** (optional). The meaning of the precision depends on the conversion:

  `d`, `i`, `o`, `u`, `x`, `X`: minimum number of digits (leading zeros are added if the number has fewer digits)

  `a`, `A`, `e`, `E`, `f`, `F`: number of digits after the decimal point

  `g`, `G`: number of significant digits

  `s`: maximum number of bytes

- The precision is a period (`.`) followed by an integer or the character `*`.
  - **If `*` is present, the precision is obtained from the next argument**.

…`printf` Conversion Specifications

- ***Length modifier*** (optional). Indicates that the item to be displayed has a type that's longer or shorter than normal.
  - `%d` normally refers to an `int` value; `%hd` is used to display a `short int` and `%ld` is used to display a `long int`.

…printf Conversion Specifications

Length Modifier	Conversion Specifiers	Meaning
hh†	d, i, o, u, x, X	signed char, unsigned char
	n	signed char *
h	d, i, o, u, x, X	short int, unsigned short int
	n	short int *
l	d, i, o, u, x, X	long int, unsigned long int
(ell)	n	long int *
	c	wint_t
	s	wchar_t *
	a, A, e, E, f, F, g, G	no effect

†C99 only

…printf Conversion Specifications

Length Modifier	*Conversion Specifiers*	*Meaning*
ll† (*ell-ell*)	d, i, o, u, x, X	long long int, unsigned long long int
	n	long long int *
j†	d, i, o, u, x, X	intmax_t, uintmax_t
	n	intmax_t *
z†	d, i, o, u, x, X	size_t
	n	size_t *
t†	d, i, o, u, x, X	ptrdiff_t
	n	ptrdiff_t *
L	a, A, e, E, f, F, g, G	long double

†C99 only

…`printf` Conversion Specifications

- ***Conversion specifier.*** Must be one of the characters in the following table.

Conversion Specifier	***Meaning***
`d`, `i`	Converts an `int` value to decimal form.
`o`, `u`, `x`, `X`	Converts an `unsigned int` value to base 8 (`o`), base 10 (`u`), or base 16 (`x`, `X`). `x` displays the hexadecimal digits `a`–`f` in lower case; `X` displays them in upper case.
`f`, `F`†	Converts a `double` value to decimal form, putting the decimal point in the correct position. If no precision is specified, displays six digits after the decimal point.

†C99 only

…`printf` Conversion Specifications

Conversion Specifier	*Meaning*
e, E	Converts a `double` value to scientific notation. If no precision is specified, displays six digits after the decimal point. If `e` is chosen, the exponent is preceded by the letter `e`; if `E` is chosen, the exponent is preceded by `E`.
g, G	`g` converts a `double` value to either `f` form or `e` form. `G` chooses between `F` and `E` forms.
a†, **A**†	Converts a `double` value to hexadecimal scientific notation using the form `[-]0x`*h*`.`*hhhh*`p`±*d*. `a` displays the hex digits `a`–`f` in lower case; `A` displays them in upper case. The choice of `a` or `A` also affects the case of the letters `x` and `p`.

†C99 only

0x1.999999999999ap-4=1.1001100110011001100110011001100110011001100110011001101 x 2^{-4}.
http://www.exploringbinary.com/hexadecimal-floating-point-constants/

…printf Conversion Specifications

Conversion Specifier	*Meaning*
c	Displays an `int` value as an unsigned character.
s	Writes the characters pointed to by the argument. Stops writing when the number of bytes specified by the precision (if present) is reached or a null character is encountered.
p	Converts a `void *` value to printable form.
n	The corresponding argument must point to an object of type `int`. Stores in this object the number of characters written so far by this call of …`printf`; produces no output.
%	Writes the character %.

C99 Changes to …`printf` Conversion Specifications

- C99 changes to the conversion specifications for `printf` and `fprintf`:
  - Additional length modifiers
  - Additional conversion specifiers
  - Ability to write infinity and NaN
  - Support for wide characters
  - Previously undefined conversion specifications now allowed

Examples of ...`printf` Conversion Specifications

- Examples showing the effect of the minimum field width and precision on the `%s` conversion:

Conversion Specification	*Result of Applying Conversion to* **"bogus"**	*Result of Applying Conversion to* **"buzzword"**
`%6s`	`•bogus`	`buzzword`
`%-6s`	`bogus•`	`buzzword`
`%.4s`	`bogu`	`buzz`
`%6.4s`	`••bogu`	`••buzz`
`%-6.4s`	`bogu••`	`buzz••`

Examples of …`printf` Conversion Specifications

- how the `%g` conversion displays some numbers in `%e` form and others in `%f` form: (if num's exponent <-4 or ≥ precision)

Number	***Result of Applying `%.4g` Conversion to Number***
123456.	`1.235e+05`
12345.6	`1.235e+04`
1234.56	`1235`
123.456	`123.5`
12.3456	`12.35`
1.23456	`1.235`
.123456	`0.1235`
.0123456	`0.01235`
.00123456	`0.001235`
.000123456	`0.0001235`
.0000123456	`1.235e-05`
.00000123456	`1.235e-06`

Examples of …`printf` Conversion Specifications

- The minimum field width and precision are usually embedded in the format string.
- Putting the `*` character where either number would normally go allows us to specify it as an argument *after* the format string.
- Calls of `printf` that produce the same output:

```
printf("%6.4d", i);
printf("%*.4d", 6, i);
printf("%6.*d", 4, i);
printf("%*.*d", 6, 4, i);
```

Examples of …`printf` Conversion Specifications

- A major advantage of `*` is that it allows us to use a macro to specify the width or precision:

```
printf("%*d", WIDTH, i);
```

- The width or precision can even be computed during program execution:

```
printf("%*d", page_width / num_cols,
i);
```

Examples of …printf Conversion Specifications

- The %p conversion is used to print the value of a pointer:

```
printf("%p", (void *) ptr);
  /* displays value of ptr */
```

- The pointer is likely to be shown as an octal or hexadecimal number.

Examples of …`printf` Conversion Specifications

- The `%n` conversion is used to find out how many characters have been printed so far by a call of … `printf`.
- After the following call, the value of `len` will be 3:

```
printf("%d%n\n", 123, &len);
```

The …`scanf` Functions

- `fscanf` and `scanf` read data items from an input stream, using a format string to indicate the layout of the input.
- After the format string, any number of pointers—each pointing to an object—follow as additional arguments.
- Input items are converted (according to conversion specifications in the format string) and stored in these objects.

The …scanf Functions

- `scanf` always reads from `stdin`, whereas `fscanf` reads from the stream indicated by its first argument:

```
scanf("%d%d", &i, &j);
  /* reads from stdin */
fscanf(fp, "%d%d", &i, &j);
  /* reads from fp */
```

- A call of `scanf` is equivalent to a call of `fscanf` with `stdin` as the first argument.

The …`scanf` Functions

- Errors that cause the …`scanf` functions to return prematurely:
  - ***Input failure*** (no more input characters could be read)
  - ***Matching failure*** (the input characters didn't match the format string)
- In C99, an input failure can also occur because of an ***encoding error.***

The …`scanf` Functions

- The …`scanf` functions return **the number of data items** that were read and assigned to objects.
- They return `EOF` if an input failure occurs before any data items can be read.
- Loops that test `scanf`'s return value are common.
- A loop that reads a series of integers one by one, stopping at the first sign of trouble:

```
while (scanf("%d", &i) == 1) {
  …
}
```

…`scanf` Format Strings

- Calls of the …`scanf` functions resemble those of the …`printf` functions.
- However, the …`scanf` functions work differently.
- The format string represents a pattern that a …`scanf` function attempts to match as it reads input.
  - If the input doesn't match the format string, the function returns.
  - The input character that didn't match is "pushed back" to be read in the future.

…`scanf` Format Strings

- A …`scanf` format string may contain three things:
  - Conversion specifications
  - White-space characters
  - Non-white-space characters

…`scanf` Format Strings

- ***Conversion specifications.*** Conversion specifications in a …`scanf` format string resemble those in a …`printf` format string.
- Most conversion specifications skip white-space characters at the beginning of an input item (the exceptions are `%[`, `%c`, and `%n`).
- Conversion specifications never skip *trailing* white-space characters, however.

…`scanf` Format Strings

- ***White-space characters.*** One or more white-space characters in a format string match zero or more white-space characters in the input stream.
- ***Non-white-space characters.*** A non-white-space character other than % matches the same character in the input stream.

…`scanf` Format Strings

- The format string `"ISBN %d-%d-%ld-%d"` specifies that the input will consist of:
  - the letters ISBN
  - possibly some white-space characters
  - an integer
  - the `-` character
  - an integer (possibly preceded by white-space characters)
  - the `-` character
  - a long integer (possibly preceded by white-space characters)
  - the `-` character
  - an integer (possibly preceded by white-space characters)

…`scanf` Conversion Specifications

- A …`scanf` conversion specification consists of the character % followed by:
  - `*`
  - Maximum field width
  - Length modifier
  - Conversion specifier
- **`*` (optional).** Signifies ***assignment suppression:*** an input item is read but not assigned to an object.
  - Items matched using `*` aren't included in the count that …`scanf` returns.

…`scanf` Conversion Specifications

- ***Maximum field width*** (optional). Limits the number of characters in an input item.
  - White-space characters skipped at the beginning of a conversion don't count.
- ***Length modifier*** (optional). Indicates that the object in which the input item will be stored has a type that's longer or shorter than normal.
- The table on the next slide lists each length modifier and the type indicated when it is combined with a conversion specifier.

…scanf Conversion Specifications

Length Modifier	*Conversion Specifiers*	*Meaning*
hh†	d, i, o, u, x, X, n	signed char *, unsigned char *
h	d, i, o, u, x, X, n	short int *, unsigned short int *
l (*ell*)	d, i, o, u, x, X, n	long int *, unsigned long int *
	a, A, e, E, f, F, g, G	double *
	c, s, or [	wchar_t *
ll† (*ell-ell*)	d, i, o, u, x, X, n	long long int *, unsigned long long int *
j†	d, i, o, u, x, X, n	intmax_t *, uintmax_t *
z†	d, i, o, u, x, X, n	size_t *
t†	d, i, o, u, x, X, n	ptrdiff_t *
L	a, A, e, E, f, F, g, G	long double *

†C99 only

…`scanf` Conversion Specifications

- ***Conversion specifier***. Must be one of the characters in the following table.

Conversion Specifier	***Meaning***
`d`	Matches a decimal integer; the corresponding argument is assumed to have type `int *`.
`i`	Matches an integer; the corresponding argument is assumed to have type `int *`. The integer is assumed to be in base 10 unless it begins with `0` (indicating octal) or with `0x` or `0X` (hexadecimal).
`o`	Matches an octal integer; the corresponding argument is assumed to have type `unsigned int *`.
`u`	Matches a decimal integer; the corresponding argument is assumed to have type `unsigned int *`.

…`scanf` Conversion Specifications

Conversion Specifier	***Meaning***
`x`, `X`	Matches a hexadecimal integer; the corresponding argument is assumed to have type unsigned `int *`.
`a`†, `A`†, `e`, `E`, `f`, `F`†, `g`, `G`	Matches a floating-point number; the corresponding argument is assumed to have type `float *`.
`c`	Matches *n* characters, where *n* is the maximum field width, or one character if no field width is specified. The corresponding argument is assumed to be a pointer to a character array (or a character object, if no field width is specified). Doesn't add a null character at the end.
`s`	Matches a sequence of non-white-space characters, then adds a null character at the end. The corresponding argument is assumed to be a pointer to a character array.

†C99 only

…`scanf` Conversion Specifications

Conversion Specifier	*Meaning*
`[`	Matches a nonempty sequence of characters from a scanset, then adds a null character at the end. The corresponding argument is assumed to be a pointer to a character array.
`p`	Matches a pointer value in the form that …`printf` would have written it. The corresponding argument is assumed to be a pointer to a `void *` object.
`n`	The corresponding argument must point to an object of type `int`. Stores in this object the number of characters read so far by this call of …`scanf`. No input is consumed and the return value of …`scanf` isn't affected.
`%`	Matches the character `%`.

…`scanf` Conversion Specifications

- Numeric data items can always begin with a sign (`+` or `-`).
- The `o`, `u`, `x`, and `X` specifiers convert the item to unsigned form, however, so they're not normally used to read negative numbers.

…`scanf` Conversion Specifications

- The `[` specifier is a more complicated (and more flexible) version of the `s` specifier.
- A conversion specification using `[` has the form `%[`*set*`]` or `%[^`*set*`]`, where *set* can be any set of characters.
- `%[`*set*`]` matches any sequence of characters in *set* (the ***scanset***).
- `%[^`*set*`]` matches any sequence of characters not in *set*.
- Examples:

  `%[abc]` matches any string containing only `a`, `b`, and `c`.

  `%[^abc]` matches any string that doesn't contain `a`, `b`, or `c`.

…`scanf` Conversion Specifications

- Many of the …`scanf` conversion specifiers are closely related to the numeric conversion functions in `<stdlib.h>`.
- These functions convert strings (like `"-297"`) to their equivalent numeric values (–297).
- The `d` specifier, for example, looks for an optional `+` or `-` sign, followed by decimal digits; this is the same form that the `strtol` function requires.

…`scanf` Conversion Specifications

- Correspondence between …`scanf` conversion specifiers and numeric conversion functions:

Conversion Specifier	***Numeric Conversion Function***
`d`	`strtol` with 10 as the base
`i`	`strtol` with 0 as the base
`o`	`strtoul` with 8 as the base
`u`	`strtoul` with 10 as the base
`x`, `X`	`strtoul` with 16 as the base
`a`, `A`, `e`, `E`, `f`, `F`, `g`, `G`	`strtod`

C99 Changes to …`scanf` Conversion Specifications

- C99 changes to the conversion specifications for `scanf` and `fscanf`:
  - Additional length modifiers
  - Additional conversion specifiers
  - Ability to read infinity and NaN
  - Support for wide characters

`scanf` Examples

- The next three tables contain sample calls of `scanf`.
- Characters printed in ~~strikeout~~ are consumed by the call.

scanf Examples

- Examples that combine conversion specifications, white-space characters, and non-white-space characters:

scanf ***Call***	***Input***	***Variables***
`n = scanf("%d%d", &i, &j);`	~~12•~~,•34¤	n: 1 i: 12 j: unchanged
`n = scanf("%d,%d", &i, &j);`	~~12~~•,•34¤	n: 1 i: 12 j: unchanged
`n = scanf("%d ,%d", &i, &j);`	~~12•,•34~~¤	n: 2 i: 12 j: 34
`n = scanf("%d, %d", &i, &j);`	~~12~~•,•34¤	n: 1 i: 12 j: unchanged

`scanf` Examples

- Examples showing the effect of assignment suppression and specifying a field width:

`scanf` *Call*	*Input*	*Variables*
`n = scanf("%*d%d", &i);`	~~12•34~~¤	`n`: 1 `i`: 34
`n = scanf("%*s%s", str);`	~~My•Fair~~•Lady¤	`n`: 1 `str`: `"Fair"`
`n = scanf("%1d%2d%3d", &i, &j, &k);`	~~12345~~¤	`n`: 3 `i`: 1 `j`: 23 `k`: 45
`n = scanf("%2d%2s%2d", &i, str, &j);`	~~123456~~¤	`n`: 3 `i`: 12 `str`: `"34"` `j`: 56

`scanf` Examples

- Examples that illustrate the `i`, `[`, and `n` conversion specifiers:

`scanf` *Call*	*Input*	*Variables*
`n = scanf("%i%i%i", &i, &j, &k);`	~~`12•012•0x12`~~`¤`	`n`: 3 `i`: 12 `j`: 10 `k`: 18
`n = scanf("%[0123456789]", str);`	~~`123`~~`abc¤`	`n`: 1 `str`: `"123"`
`n = scanf("%[0123456789]", str);`	`abc123¤`	`n`: 0 `str`: unchanged
`n = scanf("%[^0123456789]", str);`	~~`abc`~~`123¤`	`n`: 1 `str`: `"abc"`
`n = scanf("%*d%d%n", &i, &j);`	~~`10•20`~~`•30¤`	`n`: 1 `i`: 20 `j`: 5

Detecting End-of-File and Error Conditions

- If we ask a …`scanf` function to read and store *n* data items, we expect its return value to be *n*.
- If the return value is less than *n*, something went wrong:
  - ***End-of-file.*** The function encountered end-of-file before matching the format string completely.
  - ***Read error.*** The function was unable to read characters from the stream.
  - ***Matching failure.*** A data item was in the wrong format.

Detecting End-of-File and Error Conditions

- Every stream has two indicators associated with it: an ***error indicator*** and an ***end-of-file indicator.***
- These indicators are cleared when the stream is opened.
- Encountering end-of-file sets the end-of-file indicator, and a read error sets the error indicator.
  - The error indicator is also set when a write error occurs on an output stream.
- **A matching failure doesn't change either indicator**.

Detecting End-of-File and Error Conditions

- Once the error or end-of-file indicator is set, it remains in that state until it's explicitly cleared, perhaps by a call of the `clearerr` function.
- `clearerr` clears both the end-of-file and error indicators:

```
clearerr(fp);
  /* clears eof and error indicators for fp */
```

- `clearerr` isn't needed often, since some of the other library functions clear one or both indicators as a side effect.

Detecting End-of-File and Error Conditions

- The `feof` and `ferror` functions can be used to test a stream's indicators to determine why a prior operation on the stream failed.
- The call `feof(fp)` returns a nonzero value if the end-of-file indicator is set for the stream associated with `fp`.
- The call `ferror(fp)` returns a nonzero value if the error indicator is set.

Detecting End-of-File and Error Conditions

- When `scanf` returns a smaller-than-expected value, `feof` and `ferror` can be used to determine the reason.
  - If `feof` returns a nonzero value, the end of the input file has been reached.
  - If `ferror` returns a nonzero value, a read error occurred during input.
  - If neither returns a nonzero value, a matching failure must have occurred.
- The return value of `scanf` indicates how many data items were read before the problem occurred.

Detecting End-of-File and Error Conditions

- The `find_int` function is an example that shows how `feof` and `ferror` might be used.
- `find_int` searches a file for a line that begins with an integer:

```
n = find_int("foo");
```

- `find_int` returns the value of the integer that it finds or an error code:

  –1 File can't be opened

  –2 Read error

  –3 No line begins with an integer

```
int find_int(const char *filename)
{
  FILE *fp = fopen(filename, "r");
  int n;

  if (fp == NULL)
    return -1;                  /* can't open file */

  while (fscanf(fp, "%d", &n) != 1) {
    if (ferror(fp)) {
      fclose(fp);
      return -2;                /* read error */
    }
    if (feof(fp)) {
      fclose(fp);
      return -3;                /* integer not found */
    }
    fscanf(fp, "%*[^\n]");      /* skips rest of line */
  }

  fclose(fp);
  return n;
}
```

Character I/O

- The next group of library functions can read and write single characters.
- These functions work equally well with text streams and binary streams.
- The functions treat characters as values of type `int`, not `char`.
- One reason is that the input functions indicate an end-of-file (or error) condition by returning `EOF`, which is a negative integer constant.

Output Functions

- `putchar` writes one character to the `stdout` stream:

```
putchar(ch);    /* writes ch to stdout */
```

- `fputc` and `putc` write a character to an arbitrary stream:

```
fputc(ch, fp);  /* writes ch to fp */
putc(ch, fp);   /* writes ch to fp */
```

- `putc` is usually implemented as a macro (as well as a function), while `fputc` is implemented only as a function.

Output Functions

- `putchar` itself is usually a macro:

```
#define putchar(c) putc((c), stdout)
```

- The C standard allows the `putc` macro to evaluate the stream argument more than once, which `fputc` isn't permitted to do.
- Programmers usually prefer `putc`, which gives a faster program.
- If a write error occurs, all three functions set the error indicator for the stream and return `EOF`.
- Otherwise, they return the character that was written.

Input Functions

- `getchar` reads a character from `stdin`:

```
ch = getchar();
```

- `fgetc` and `getc` read a character from an arbitrary stream:

```
ch = fgetc(fp);
ch = getc(fp);
```

- All three functions treat the character as an `unsigned char` value (which is then converted to `int` type before it's returned).
- As a result, they never return a negative value other than `EOF`.

Input Functions

- `getc` is usually implemented as a macro (as well as a function), while `fgetc` is implemented only as a function.
- `getchar` is normally a macro as well:

```
#define getchar() getc(stdin)
```

- Programmers usually prefer `getc` over `fgetc`.

Input Functions

- The `fgetc`, `getc`, and `getchar` functions behave the same if a problem occurs.
- At end-of-file, they set the stream's end-of-file indicator and return `EOF`.
- If a read error occurs, they set the stream's error indicator and return `EOF`.
- To differentiate between the two situations, we can call either `feof` or `ferror`.

Input Functions

- One of the most common uses of `fgetc`, `getc`, and `getchar` is to read characters from a file.
- A typical `while` loop for that purpose:

```
while ((ch = getc(fp)) != EOF) {
  …
}
```

- Always store the return value in an `int` variable, not a `char` variable.
- Testing a `char` variable against `EOF` may give the wrong result.

Input Functions

- The `ungetc` function "pushes back" a character read from a stream and clears the stream's end-of-file indicator.
- A loop that reads a series of digits, stopping at the first nondigit:

```
while (isdigit(ch = getc(fp))) {
  …
}
ungetc(ch, fp);
  /* pushes back last character read */
```

Input Functions

- The number of characters that can be pushed back by consecutive calls of `ungetc` varies; only the first call is guaranteed to succeed.
- Calling a file-positioning function (`fseek`, `fsetpos`, or `rewind`) causes the pushed-back characters to be lost.
- `ungetc` returns the character it was asked to push back.
  - It returns `EOF` if an attempt is made to push back `EOF` or to push back more characters than allowed.

Program: Copying a File

- The `fcopy.c` program makes a copy of a file.
- The names of the original file and the new file will be specified on the command line when the program is executed.
- An example that uses `fcopy` to copy the file `f1.c` to `f2.c`:

```
fcopy f1.c f2.c
```

- `fcopy` will issue an error message if there aren't exactly two file names on the command line or if either file can't be opened.

Program: Copying a File

- Using `"rb"` and `"wb"` as the file modes enables `fcopy` to copy both text and binary files.
- If we used `"r"` and `"w"` instead, the program wouldn't necessarily be able to copy binary files.

fcopy.c

```
/* Copies a file */

#include <stdio.h>
#include <stdlib.h>

int main(int argc, char *argv[])
{
  FILE *source_fp, *dest_fp;
  int ch;

  if (argc != 3) {
    fprintf(stderr, "usage: fcopy source dest\n");
    exit(EXIT_FAILURE);
  }
```

```
  if ((source_fp = fopen(argv[1], "rb")) == NULL) {
    fprintf(stderr, "Can't open %s\n", argv[1]);
    exit(EXIT_FAILURE);
  }

  if ((dest_fp = fopen(argv[2], "wb")) == NULL) {
    fprintf(stderr, "Can't open %s\n", argv[2]);
    fclose(source_fp);
    exit(EXIT_FAILURE);
  }

  while ((ch = getc(source_fp)) != EOF)
    putc(ch, dest_fp);

  fclose(source_fp);
  fclose(dest_fp);
  return 0;
}
```

Line I/O

- Library functions in the next group are able to read and write lines.
- These functions are used mostly with text streams, although it's legal to use them with binary streams as well.

Output Functions

- The `puts` function writes a string of characters to `stdout`:

```
puts("Hi, there!");  /* writes to stdout */
```

- After it writes the characters in the string, `puts` always adds a new-line character.

Output Functions

- `fputs` is a more general version of `puts`.
- Its second argument indicates the stream to which the output should be written:

```
fputs("Hi, there!", fp);  /* writes to fp */
```

- Unlike `puts`, the `fputs` function doesn't write a new-line character unless one is present in the string.
- Both functions return `EOF` if a write error occurs; otherwise, they return a nonnegative number.

Input Functions

- The `gets` function reads a line of input from `stdin`:

```
gets(str); /* reads a line from stdin */
```

- `gets` reads characters one by one, storing them in the array pointed to by `str`, until it reads a new-line character (which it discards).
- `fgets` is a more general version of `gets` that can read from any stream.
- `fgets` is also safer than `gets`, since it limits the number of characters that it will store.

Input Functions

- A call of `fgets` that reads a line into a character array named `str`:

```
fgets(str, sizeof(str), fp);
```

- `fgets` will read characters until it reaches the first new-line character or `sizeof(str)` – 1 characters have been read.
- If it reads the new-line character, `fgets` stores it along with the other characters.

Input Functions

- Both `gets` and `fgets` return a null pointer if a read error occurs or they reach the end of the input stream before storing any characters.
- Otherwise, both return their first argument, which points to the array in which the input was stored.
- Both functions store a null character at the end of the string.

Input Functions

- `fgets` should be used instead of `gets` in most situations.
- `gets` is safe to use only when the string being read is *guaranteed* to fit into the array.
- When there's no guarantee (and there usually isn't), it's much safer to use `fgets`.
- `fgets` will read from the standard input stream if passed `stdin` as its third argument:

```
fgets(str, sizeof(str), stdin);
```

Block I/O

- The `fread` and `fwrite` functions allow a program to read and write large blocks of data in a single step.
- `fread` and `fwrite` are used primarily with binary streams, although—with care—it's possible to use them with text streams as well.

Block I/O

- `fwrite` is designed to copy an array from memory to a stream.
- Arguments in a call of `fwrite`:
  - Address of array
  - Size of each array element (in bytes)
  - Number of elements to write
  - File pointer
- A call of `fwrite` that writes the entire contents of the array `a`:

```
fwrite(a, sizeof(a[0]),
       sizeof(a) / sizeof(a[0]), fp);
```

Block I/O

- `fwrite` returns the number of elements actually written.
- This number will be less than the third argument if a write error occurs.

Block I/O

- `fread` will read the elements of an array from a stream.
- A call of `fread` that reads the contents of a file into the array `a`:

```
n = fread(a, sizeof(a[0]),
          sizeof(a) / sizeof(a[0]), fp);
```

- `fread`'s return value indicates the actual number of elements read.
- This number should equal the third argument unless the end of the input file was reached or a read error occurred.

Block I/O

- `fwrite` is convenient for a program that needs to store data in a file before terminating.
- Later, the program (or another program) can use `fread` to read the data back into memory.
- The data doesn't need to be in array form.
- A call of `fwrite` that writes a structure variable `s` to a file:

```
fwrite(&s, sizeof(s), 1, fp);
```

File Positioning

- Every stream has an associated ***file position.***
- When a file is opened, the file position is set at the beginning of the file.
  - In "append" mode, the initial file position may be at the beginning or end, depending on the implementation.
- When a read or write operation is performed, the file position advances automatically, providing sequential access to data.

File Positioning

- Although sequential access is fine for many applications, some programs need the ability to jump around within a file.
- If a file contains a series of records, we might want to jump directly to a particular record.
- `<stdio.h>` provides five functions that allow a program to determine the current file position or to change it.

File Positioning

- The `fseek` function changes the file position associated with the first argument (a file pointer).
- The third argument is one of three macros:

`SEEK_SET`	Beginning of file
`SEEK_CUR`	Current file position
`SEEK_END`	End of file

- The second argument, which has type `long int`, is a (possibly negative) byte count.

File Positioning

- Using `fseek` to move to the beginning of a file:
  ```
  fseek(fp, 0L, SEEK_SET);
  ```
- Using `fseek` to move to the end of a file:
  ```
  fseek(fp, 0L, SEEK_END);
  ```
- Using `fseek` to move back 10 bytes:
  ```
  fseek(fp, -10L, SEEK_CUR);
  ```
- If an error occurs (the requested position doesn't exist, for example), `fseek` returns a nonzero value.

File Positioning

- The file-positioning functions are best used with binary streams.
- C doesn’t prohibit programs from using them with text streams, but certain restrictions apply.
- For text streams, `fseek` can be used only to move to the beginning or end of a text stream or to return to a place that was visited previously.
- For binary streams, `fseek` isn’t required to support calls in which the third argument is `SEEK_END`.

File Positioning

- The `ftell` function returns the current file position as a long integer.
- The value returned by `ftell` may be saved and later supplied to a call of `fseek`:

```
long file_pos;
…
file_pos = ftell(fp);
  /* saves current position */
…
fseek(fp, file_pos, SEEK_SET);
  /* returns to old position */
```

File Positioning

- If `fp` is a binary stream, the call `ftell(fp)` returns the current file position as a byte count, where zero represents the beginning of the file.
- If `fp` is a text stream, `ftell(fp)` isn't necessarily a byte count.
- As a result, it's best not to perform arithmetic on values returned by `ftell`.

File Positioning

- The `rewind` function sets the file position at the beginning.
- The call `rewind(fp)` is nearly equivalent to `fseek(fp, 0L, SEEK_SET)`.
  - The difference? `rewind` doesn't return a value but does clear the error indicator for `fp`.

File Positioning

- `fseek` and `ftell` are limited to files whose positions can be stored in a long integer.
- For working with very large files, C provides two additional functions: `fgetpos` and `fsetpos`.
- These functions can handle large files because they use values of type `fpos_t` to represent file positions.
  - An `fpos_t` value isn't necessarily an integer; it could be a structure, for instance.

File Positioning

- The call `fgetpos(fp, &file_pos)` stores the file position associated with `fp` in the `file_pos` variable.
- The call `fsetpos(fp, &file_pos)` sets the file position for `fp` to be the value stored in `file_pos`.
- If a call of `fgetpos` or `fsetpos` fails, it stores an error code in `errno`.
- Both functions return zero when they succeed and a nonzero value when they fail.

File Positioning

- An example that uses `fgetpos` and `fsetpos` to save a file position and return to it later:

```
fpos_t file_pos;
…
fgetpos(fp, &file_pos);
  /* saves current position */
…
fsetpos(fp, &file_pos);
  /* returns to old position */
```

Program: Modifying a File of Part Records

- Actions performed by the `invclear.c` program:
  - Opens a binary file containing part structures.
  - Reads the structures into an array.
  - Sets the `on_hand` member of each structure to 0.
  - Writes the structures back to the file.
- The program opens the file in `"rb+"` mode, allowing both reading and writing.

invclear.c

```
/* Modifies a file of part records by setting the quantity
   on hand to zero for all records */

#include <stdio.h>
#include <stdlib.h>

#define NAME_LEN 25
#define MAX_PARTS 100

struct part {
  int number;
  char name[NAME_LEN+1];
  int on_hand;
} inventory[MAX_PARTS];

int num_parts;
```

```
int main(void)
{
  FILE *fp;
  int i;

  if ((fp = fopen("inventory.dat", "rb+")) == NULL) {
    fprintf(stderr, "Can't open inventory file\n");
    exit(EXIT_FAILURE);
  }

  num_parts = fread(inventory, sizeof(struct part),
                    MAX_PARTS, fp);

  for (i = 0; i < num_parts; i++)
    inventory[i].on_hand = 0;

  rewind(fp);
  fwrite(inventory, sizeof(struct part), num_parts, fp);
  fclose(fp);

  return 0;
}
```

String I/O

- The functions described in this section can read and write data using a string as though it were a stream.
- `sprintf` and `snprintf` write characters into a string.
- `sscanf` reads characters from a string.

String I/O

- Three similar functions (`vsprintf`, `vsnprintf`, and `vsscanf`) also belong to `<stdio.h>`.
- These functions rely on the `va_list` type, which is declared in `<stdarg.h>`, so they are discussed in Chapter 26.

Output Functions

- The `sprintf` function writes output into a character array (pointed to by its first argument) instead of a stream.
- A call that writes `"9/20/2010"` into `date`:

```
sprintf(date, "%d/%d/%d", 9, 20, 2010);
```

- `sprintf` adds a null character at the end of the string.
- It returns the number of characters stored (not counting the null character).

Output Functions

- `sprintf` can be used to format data, with the result saved in a string until it's time to produce output.
- `sprintf` is also convenient for converting numbers to character form.

Output Functions

- The `snprintf` function (new in C99) is the same as `sprintf`, except for an additional second parameter named `n`.
- No more than `n` – 1 characters will be written to the string, not counting the terminating null character, which is always written unless `n` is zero.
- Example:

```
snprintf(name, 13, "%s, %s", "Einstein", "Albert");
```

The string `"Einstein, Al"` is written into `name`.

Output Functions

- `snprintf` returns the number of characters that would have been written (not including the null character) had there been no length restriction.
- If an encoding error occurs, `snprintf` returns a negative number.
- To see if `snprintf` had room to write all the requested characters, we can test whether its return value was nonnegative and less than `n`.

Input Functions

- The `sscanf` function is similar to `scanf` and `fscanf`.
- `sscanf` reads from a string (pointed to by its first argument) instead of reading from a stream.
- `sscanf`'s second argument is a format string identical to that used by `scanf` and `fscanf`.

Input Functions

- `sscanf` is handy for extracting data from a string that was read by another input function.
- An example that uses `fgets` to obtain a line of input, then passes the line to `sscanf` for further processing:

```
fgets(str, sizeof(str), stdin);
  /* reads a line of input */
sscanf(str, "%d%d", &i, &j);
  /* extracts two integers */
```

Input Functions

- One advantage of using `sscanf` is that we can examine an input line as many times as needed.
- This makes it easier to recognize alternate input forms and to recover from errors.
- Consider the problem of reading a date that's written either in the form *month*/*day*/*year* or *month*-*day*-*year*:

```
if (sscanf(str, "%d /%d /%d", &month, &day, &year) == 3)
  printf("Month: %d, day: %d, year: %d\n", month, day, year);
else if (sscanf(str, "%d -%d -%d", &month, &day, &year) == 3)
  printf("Month: %d, day: %d, year: %d\n", month, day, year);
else
  printf("Date not in the proper form\n");
```

Input Functions

- Like the `scanf` and `fscanf` functions, `sscanf` returns the number of data items successfully read and stored.
- `sscanf` returns `EOF` if it reaches the end of the string (marked by a null character) before finding the first item.