

1.1 Listing files and directories

ls (list)

When you first login, your current working directory is your home directory. Your home directory has the same name as your user-name, for example, **pheneas**, and it is where your personal files and subdirectories are saved.

To find out what is in your home directory, type

```
% ls (short for list)
```

The **ls** command lists the contents of your current working directory.

There may be no files visible in your home directory, in which case, the LUNIX prompt will be returned. Alternatively, there may already be some files inserted by the System Administrator when your account was created.

ls does not, in fact, cause all the files in your home directory to be listed, but only those ones whose name does not begin with a dot (.). Files beginning with a dot (.) are known as hidden files and usually contain important program configuration information. They are hidden because you should not change them unless you are very familiar with LUNIX!!!

To list all files in your home directory including those whose names begin with a dot, type

```
% ls -a
```

ls is an example of a command which can take options: **-a** is an example of an option. The options change the behaviour of the command. There are online manual pages that tell you which options a particular command can take, and how each option modifies the behaviour of the command. (See later in this tutorial)

1.2 Making Directories

mkdir (make directory)

We will now make a subdirectory in your home directory to hold the files you will be creating and using in the course of this tutorial. To make a subdirectory called **ASP2016** in your current working directory type

```
% mkdir ASP2016
```

To see the directory you have just created, type

```
% ls
```

1.3 Changing to a different directory

cd (change directory)

The command `cd directory` means change the current working directory to '*directory*'. The current working directory may be thought of as the directory you are in, i.e. your current position in the file-system tree.

To change to the directory you have just made, type

```
% cd ASP2016
```

Type `ls` to see the contents (which should be empty)

Exercise 1a

Make another directory inside the **ASP2016** directory called **Tutorial**. Inside this directory create another directory **backup**

Answer

```
% mkdir Tutorial
```

```
% cd Tutorial
```

```
% mkdir backup
```

1.4 The directories . and ..

Still in the **ASP2016** directory, type

```
% ls -a
```

As you can see, in the **ASP2016** directory (and in all other directories), there are two special directories called `(.)` and `(..)`

In LUNIX, `(.)` means the current directory, so typing

```
% cd .
```

NOTE: there is a space between cd and the dot

means stay where you are (the **ASP2016** directory).

This may not seem very useful at first, but using `(.)` as the name of the current directory will save a lot of typing, as we shall see later in the tutorial.

`(..)` means the parent of the current directory, so typing

```
% cd ..
```

will take you one directory up the hierarchy (back to your home directory). Try it now.

Note: typing `cd` with no argument always returns you to your home directory. This is very useful if you are lost in the file system.

1.5 Pathnames

pwd (print working directory)

Pathnames enable you to work out where you are in relation to the whole file-system. For example, to find out the absolute pathname of your home-directory, type `cd` to get back to your home-directory and then type

```
% pwd
```

The full pathname will look something like this -

```
/home/pheneas/ASP2016/
```

which means that pheneas (your home directory) is in the directory home (the directory of all users on Mac it is called Users), which is located in the root directory.

Exercise 1b

Use the commands `ls`, `pwd` and `cd` to explore the file system.

(Remember, if you get lost, type `cd` by itself to return to your home-directory)

1.6 More about home directories and pathnames

Understanding pathnames

First type `cd ..` to get back to your home-directory, then type

```
% ls ASP2016
```

to list the contents of your ASP2016 directory.

Now type

```
% ls Tutorial
```

You will get a message like this -

```
Tutorial: No such file or directory
```

The reason is, **Tutorial** is not in your current working directory. To use a command on a file (or directory) not in the current working directory (the directory you are currently in), you must either `cd` to the correct directory, or specify its full pathname. To list the contents of your backups directory, you must type

```
% ls ASP2016/Tutorial
```

~ (your home directory)

Home directories can also be referred to by the tilde ~ character. It can be used to

specify paths starting at your home directory. So typing

```
% ls ~/ASP2016
```

will list the contents of your ASP2016 directory, no matter where you currently are in the file system.

Exercise 1b

What do you think the following command would list:

```
% ls ~
```

```
% ls ../..
```

```
% ls ../../..
```

Summary

ls	list files and directories
ls -a	list all files and directories
mkdir	make a directory
cd <i>directory</i>	change to named directory
cd	change to home-directory
cd ~	change to home-directory
cd ..	change to parent directory
pwd	display the path of the current directory



2.1 Copying Files

cp (copy)

cp file1 file2 is the command which makes a copy of **file1** in the current working directory and calls it **file2**

You have now two files named differently but of the same content. The command can be also used to copy a file in a directory located somewhere else. In this case we use: **cp file1 path_directory**.

The command makes a copy of **file1** in the directory for which you specified the path. It maintains its name there **file1**.

What we are going to do now, is to take a file stored in the directory ASP2016 and use the **cp** command to copy it to the directory called Tutorial directory.

First, **cd** to Tutorial directory.

```
% cd ~/ASP2016/Tutorial
```

Then at the UNIX prompt, type,

```
% cp ~/ASP2016/science.txt .
```

(Note: Don't forget the dot (.) at the end. Remember, in UNIX, the dot means the current directory.)

The above command means copy the file **science.txt** to the current directory, keeping the name the same.

(Note: The file **science.txt** is in the directory ASP2016 which is on all Lab computers which will be used during the tutorial. If you are using your own Laptop, you can grab a copy of the file from the facilitator. Open it with a text editor and then Use 'File/Save As..' from the menu bar to save it into your **ASP2016** directory.)

Exercise 2a

Create a backup of your **science.txt** file by copying it to a file called **science.bak**

2.2 Moving files

mv (move)

mv file1 file2 moves (or renames) **file1** to **file2**

To move a file from one place to another, use the **mv** command. This has the effect of moving rather than copying the file, so you end up with only one file rather than two.

It can also be used to rename a file, by moving the file to the same directory, but giving it a different name.

We are now going to move the file `science.bak` to your backup directory.

First, change directories to your ASP2016 directory (can you remember how?). Then, inside the **ASP2016** directory, type

```
% mv science.bak ./Tutorial/
```

Type `ls` and `ls Tutorial` to see if it has worked.

In the same way move the backup file `science.bak` in the directory **backup**

2.3 Removing files and directories

rm (remove), rmdir (remove directory)

To delete (remove) a file, use the `rm` command. As an example, we are going to create a copy of the `science.txt` file then delete it.

Inside your **ASP2016** directory, type

```
% cp science.txt tempfile.txt
% ls (to check if it has created the file)
% rm tempfile.txt
% ls (to check if it has deleted the file)
```

You can use the `rmdir` command to remove a directory (make sure it is empty first). Try to remove the **Tutorial** directory. You will not be able to since UNIX will not let you remove a non-empty directory.

Exercise 2b

Create a directory called `tempstuff` using `mkdir`, then remove it using the `rmdir` command.

To remove a directory containing files, you use `rm -rf directoryname`

Try `rm -rf backup`

2.4 Displaying the contents of a file on the screen

clear (clear screen)

Before you start the next section, you may like to clear the terminal window of the previous commands so the output of the following commands can be clearly understood.

At the prompt, type

```
% clear
```

This will clear all text and leave you with the % prompt at the top of the window.

cat (concatenate)

The command **cat** can be used to display the contents of a file on the screen. Type:

```
% cat science.txt
```

As you can see, the file is longer than than the size of the window, so it scrolls past making it unreadable.

less

The command **less** writes the contents of a file onto the screen a page at a time. Type

```
% less science.txt
```

Press the **[space-bar]** if you want to see another page, type **[q]** if you want to quit reading. As you can see, **less** is used in preference to **cat** for long files.

head

The **head** command writes the first ten lines of a file to the screen.

First clear the screen then type

```
% head science.txt
```

Then type

```
% head -5 science.txt
```

What difference did the -5 do to the head command?

tail

The **tail** command writes the last ten lines of a file to the screen.

Clear the screen and type

```
% tail science.txt
```

How can you view the last 15 lines of the file?

Simple searching using less

Using **less**, you can search through a text file for a keyword (pattern). For example, to search through **science.txt** for the word 'science', type

```
% less science.txt
```

then, still in **less** (i.e. don't press [q] to quit), type a forward slash [/] followed by the word to search

```
/science
```

As you can see, **less** finds and highlights the keyword. Type [n] to search for the next occurrence of the word.

grep (don't ask why it is called grep)

grep is one of many standard UNIX utilities. It searches files for specified words or patterns. First clear the screen, then type

```
% grep science science.txt
```

As you can see, **grep** has printed out each line containing the word science.

Or has it????

Try typing

```
% grep Science science.txt
```

The **grep** command is case sensitive; it distinguishes between Science and science.

To ignore upper/lower case distinctions, use the -i option, i.e. type

```
% grep -i science science.txt
```

To search for a phrase or pattern, you must enclose it in single quotes (the apostrophe symbol). For example to search for spinning top, type

```
% grep -i 'spinning top' science.txt
```

Some of the other options of **grep** are:

- v display those lines that do NOT match
- n precede each matching line with the line number
- c print only the total count of matched lines

Try some of them and see the different results. Don't forget, you can use more than one option at a time, for example, the number of lines without the words science or Science is

```
% grep -ivc science science.txt
```

wc (word count)

A handy little utility is the `wc` command, short for word count. To do a word count on `science.txt`, type

```
% wc -w science.txt
```

To find out how many lines the file has, type

```
% wc -l science.txt
```

Summary

<code>cp file1 file2</code>	copy file1 and call it file2
<code>mv file1 file2</code>	move or rename file1 to file2
<code>rm file</code>	remove a file
<code>rmdir directory</code>	remove a directory
<code>cat file</code>	display a file
<code>more file</code>	display a file a page at a time
<code>head file</code>	display the first few lines of a file
<code>tail file</code>	display the last few lines of a file
<code>grep 'keyword' file</code>	search a file for keywords
<code>wc file</code>	count number of lines/words/characters in file



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3.1 Redirection

Most processes initiated by UNIX commands write to the standard output (that is, they write to the terminal screen), and many take their input from the standard input (that is, they read it from the keyboard). There is also the standard error, where processes write their error messages, by default, to the terminal screen.

We have already seen one use of the `cat` command to write the contents of a file to the screen.

Now type `cat` without specifying a file to read

```
% cat
```

Then type a few words on the keyboard and press the `[Return]` key.

Finally hold the `[Ctrl]` key down and press `[d]` (written as `^D` for short) to end the input.

What has happened?

If you run the `cat` command without specifying a file to read, it reads the standard input (the keyboard), and on receiving the 'end of file' (`^D`), copies it to the standard output (the screen).

In UNIX, we can redirect both the input and the output of commands.

3.2 Redirecting the Output

We use the `>` symbol to redirect the output of a command. For example, to create a file called `list1` containing a list of fruit, type

```
% cat > list1
```

Then type in the names of some fruit. Press `[Return]` after each one.

```
pear  
banana  
apple  
^D (Control D to stop)
```

What happens is the `cat` command reads the standard input (the keyboard) and the `>` redirects the output, which normally goes to the screen, into a file called `list1`

To read the contents of the file, type

```
% cat list1
```

Exercise 3a

Using the above method, create another file called `list2` containing the following fruit:

orange, plum, mango, grapefruit. Read the contents of **list2**

The form `>>` appends standard output to a file. So to add more items to the file **list1**, type

```
% cat >> list1
```

Then type in the names of more fruit

```
peach
grape
orange
^D (Control D to stop)
```

To read the contents of the file, type

```
% cat list1
```

You should now have two files. One contains six fruit, the other contains four fruit. We will now use the **cat** command to join (concatenate) **list1** and **list2** into a new file called **biglist**. Type

```
% cat list1 list2 > biglist
```

What this is doing is reading the contents of **list1** and **list2** in turn, then outputting the text to the file **biglist**

To read the contents of the new file, type

```
% cat biglist
```

3.3 Redirecting the Input

We use the `<` symbol to redirect the input of a command.

The command **sort** alphabetically or numerically sorts a list. Type

```
% sort
```

Then type in the names of some vegetables. Press **[Return]** after each one.

```
carrot
beetroot
artichoke
^D (control d to stop)
```

The output will be

```
artichoke
beetroot
carrot
```

Using `<` you can redirect the input to come from a file rather than the keyboard. For example, to sort the list of fruit, type

```
% sort < biglist
```

and the sorted list will be output to the screen.

To output the sorted list to a file, type,

```
% sort < biglist > slist
```

Use **cat** to read the contents of the file **slist**

3.4 Pipes

To see who is on the system with you, type

```
% who
```

One method to get a sorted list of names is to type,

```
% who > names.txt  
% sort < names.txt
```

This is a bit slow and you have to remember to remove the temporary file called **names** when you have finished. What you really want to do is connect the output of the **who** command directly to the input of the **sort** command. This is exactly what pipes do. The symbol for a pipe is the vertical bar |

For example, typing

```
% who | sort
```

will give the same result as above, but quicker and cleaner.

To find out how many users are logged on, type

```
% who | wc -l
```

Exercise 3b

a2ps -Phockney textfile is the command to print a postscript file to the printer hockney.

Using pipes, print all lines of **list1** and **list2** containing the letter 'p', sort the result, and print to the printer hockney.

Answer

```
% cat list1 list2 | grep p | sort | a2ps -Phockney
```

Summary

command > file	redirect standard output to a file
command >> file	append standard output to a file
command < file	redirect standard input from a file
command1 command2	pipe the output of command1 to the input of command2

cat file1 file2 > file0	concatenate file1 and file2 to file0
sort	sort data
who	list users currently logged in
a2ps -Pprinter textfile	print text file to named printer
lpr -Pprinter psfile	print postscript file to named printer



4.1 Wildcards

The characters * and ?

The character * is called a wildcard, and will match against none or more character(s) in a file (or directory) name. For example, in your **ASP2016** directory, type

```
% ls list*
```

This will list all files in the current directory starting with **list....**

Try typing

```
% ls *list
```

This will list all files in the current directory ending with **...list**

The character ? will match exactly one character.

So **ls ?ouse** will match files like **house** and **mouse**, but not **grouse**.

Try typing

```
% ls ?list
```

4.2 Filename conventions

We should note here that a directory is merely a special type of file. So the rules and conventions for naming files apply also to directories.

In naming files, characters with special meanings such as / * & % , should be avoided. Also, avoid using spaces within names. The safest way to name a file is to use only alphanumeric characters, that is, letters and numbers, together with _ (underscore) and . (dot).

File names conventionally start with a lower-case letter, and may end with a dot followed by a group of letters indicating the contents of the file. For example, all files consisting of C code may be named with the ending .c, for example, prog1.c . Then in order to list all files containing C code in your home directory, you need only type **ls *.c** in that directory.

Beware: some applications give the same name to all the output files they generate.

For example, some compilers, unless given the appropriate option, produce compiled files named **a.out**. Should you forget to use that option, you are advised to rename the compiled file immediately, otherwise the next such file will overwrite it and it will be lost.

4.3 Getting Help

On-line Manuals

There are on-line manuals which gives information about most commands. The manual pages tell you which options a particular command can take, and how each option modifies the behaviour of the command. Type `man` command to read the manual page for a particular command.

For example, to find out more about the `wc` (word count) command, type

```
% man wc
```

Alternatively

```
% whatis wc
```

gives a one-line description of the command, but omits any information about options etc.

Apropos

When you are not sure of the exact name of a command,

```
% apropos keyword
```

will give you the commands with keyword in their manual page header. For example, try typing

```
% apropos copy
```

Summary

*	match any number of characters
?	match one character
man <i>command</i>	read the online manual page for a command
whatis <i>command</i>	brief description of a command
apropos <i>keyword</i>	match commands with keyword in their man pages



5.1 File system security (access rights)

In your ASP2016 directory, type

```
% ls -l (l for long listing!)
```

You will see that you now get lots of details about the contents of your directory, similar to the example below.

```
|-rw-r--r--@ 1 pheneas staff 95771 Jul 24 15:09 ASP2016-ScientificProg
```

In the left-hand column is a 10 symbol string consisting of the symbols d, r, w, x, -, and, occasionally, s or S. If d is present, it will be at the left hand end of the string, and indicates a directory: otherwise - will be the starting symbol of the string.

The 9 remaining symbols indicate the permissions, or access rights, and are taken as three groups of 3.

- The left group of 3 gives the file permissions for the user that owns the file (or directory) (ee51ab in the above example);
- the middle group gives the permissions for the group of people to whom the file (or directory) belongs (eebeng95 in the above example);
- the rightmost group gives the permissions for all others.

The symbols r, w, etc., have slightly different meanings depending on whether they refer to a simple file or to a directory.

Access rights on files.

- r (or -), indicates read permission (or otherwise), that is, the presence or absence of permission to read and copy the file
- w (or -), indicates write permission (or otherwise), that is, the permission (or otherwise) to change a file
- x (or -), indicates execution permission (or otherwise), that is, the permission to execute a file, where appropriate

Access rights on directories.

- r allows users to list files in the directory;
- w means that users may delete files from the directory or move files into it;
- x means the right to access files in the directory. This implies that you may read files in the directory provided you have read permission on the individual files.

So, in order to read a file, you must have execute permission on the directory containing that file, and hence on any directory containing that directory as a subdirectory, and so on, up the tree.

Some examples

<code>-rwxrwxrwx</code>	a file that everyone can read, write and execute (and delete).
<code>-rw-----</code>	a file that only the owner can read and write - no-one else can read or write and no-one has execution rights (e.g. your mailbox file).

5.2 Changing access rights

chmod (changing a file mode)

Only the owner of a file can use **chmod** to change the permissions of a file. The options of **chmod** are as follows

Symbol	Meaning
u	user
g	group
o	other
a	all
r	read
w	write (and delete)
x	execute (and access directory)
+	add permission
-	take away permission

For example, to remove read write and execute permissions on the file **biglist** for the group and others, type

```
% chmod go-rwx biglist
```

This will leave the other permissions unaffected.

To give read and write permissions on the file **biglist** to all,

```
% chmod a+rw biglist
```

Exercise 5a

Try changing access permissions on the file **science.txt** and on the directory **backups**

Use **ls -l** to check that the permissions have changed.

5.3 Processes and Jobs

A process is an executing program identified by a unique PID (process identifier). To see information about your processes, with their associated PID and status, type

```
% ps
```

A process may be in the foreground, in the background, or be suspended. In general the shell does not return the UNIX prompt until the current process has finished executing.

Some processes take a long time to run and hold up the terminal. Backgrounding a long process has the effect that the UNIX prompt is returned immediately, and other tasks can be carried out while the original process continues executing.

Running background processes

To background a process, type an **&** at the end of the command line. For example, the command **sleep** waits a given number of seconds before continuing. Type

```
% sleep 10
```

This will wait 10 seconds before returning the command prompt **%**. Until the command prompt is returned, you can do nothing except wait.

To run **sleep** in the background, type

```
% sleep 10 &
```

```
[1] 6259
```

The **&** runs the job in the background and returns the prompt straight away, allowing you to run other programs while waiting for that one to finish.

The first line in the above example is typed in by the user; the next line, indicating job number and PID, is returned by the machine. The user is notified of a job number (numbered from 1) enclosed in square brackets, together with a PID and is notified when a background process is finished. Backgrounding is useful for jobs which will take a long time to complete.

Backgrounding a current foreground process

At the prompt, type

```
% sleep 100
```

You can suspend the process running in the foreground by holding down the **[control]** key and typing **[z]** (written as **^Z**). Then to put it in the background, type

```
% bg
```

Note: do not background programs that require user interaction e.g. pine

5.4 Listing suspended and background processes

When a process is running, backgrounded or suspended, it will be entered onto a list along with a job number. To examine this list, type

```
% jobs
```

An example of a job list could be

```
[1] Suspended sleep 100  
[2] Running netscape  
[3] Running nedit
```

To restart (foreground) a suspended process, type

```
% fg %jobnumber
```

For example, to restart **sleep 100**, type

```
% fg %1
```

Typing **fg** with no job number foregrounds the last suspended process.

5.5 Killing a process

kill (terminate or signal a process)

It is sometimes necessary to kill a process (for example, when an executing program is in an infinite loop)

To kill a job running in the foreground, type **^C** (control c). For example, run

```
% sleep 100  
^C
```

To kill a suspended or background process, type

```
% kill %jobnumber
```

For example, run

```
% sleep 100 &  
% jobs
```

If it is job number 4, type

```
% kill %4
```

To check whether this has worked, examine the job list again to see if the process has been removed.

ps (process status)

Alternatively, processes can be killed by finding their process numbers (PIDs) and using **kill PID_number**

```
% sleep 100 &  
% ps
```

```
PID TT S TIME COMMAND  
20077 pts/5 S 0:05 sleep 100  
21563 pts/5 T 0:00 netscape  
21873 pts/5 S 0:25 nedit
```

To kill off the process **sleep 100**, type

```
% kill 20077
```

and then type **ps** again to see if it has been removed from the list.

If a process refuses to be killed, uses the **-9** option, i.e. type

```
% kill -9 20077
```

Note: It is not possible to kill off other users' processes !!!

Summary

ls -lag	list access rights for all files
chmod [options] file	change access rights for named file
command &	run command in background
^C	kill the job running in the foreground
^Z	suspend the job running in the foreground
bg	background the suspended job
jobs	list current jobs
fg %1	foreground job number 1
kill %1	kill job number 1
ps	list current processes
kill 26152	kill process number 26152



Other useful UNIX commands

quota

All students are allocated a certain amount of disk space on the file system for their personal files, usually about 100Mb. If you go over your quota, you are given 7 days to remove excess files.

To check your current quota and how much of it you have used, type

```
% quota -v
```

df

The df command reports on the space left on the file system. For example, to find out how much space is left on the fileserver, type

```
% df .
```

du

The du command outputs the number of kilobytes used by each subdirectory. Useful if you have gone over quota and you want to find out which directory has the most files. In your home-directory, type

```
% du
```

compress

This reduces the size of a file, thus freeing valuable disk space. For example, type

```
% ls -l science.txt
```

and note the size of the file. Then to compress science.txt, type

```
% compress science.txt
```

This will compress the file and place it in a file called science.txt.Z

To see the change in size, type ls -l again.

To uncompress the file, use the uncompress command.

```
% uncompress science.txt.Z
```

gzip

This also compresses a file, and is more efficient than compress. For example, to zip science.txt, type

```
% gzip science.txt
```

This will zip the file and place it in a file called science.txt.gz

To unzip the file, use the gunzip command.

```
% gunzip science.txt.gz
```

tar

For compressing a directory the tar command is used as follows (syntax of tar command):

```
tar -zcvf archive-name.tar.gz directory-name
```

Example we have a directory called /Users/ASP2016 and you would like to compress this directory then you can type tar command as follows

```
tar -zcvf ASP2016.tar.gz ~/ASP2016
```

Where,

-z : Compress archive using gzip program

-c: Create archive

-v: Verbose i.e display progress while creating archive

-f: Archive File name

If you wish to restore your archive then you need to use the following command (it will extract all files in current directory):

```
$ tar -zxvf ASP2016.tar.gz
```

file

file classifies the named files according to the type of data they contain, for example ascii (text), pictures, compressed data, etc.. To report on all files in your home directory, type

```
% file *
```

history

The C shell keeps an ordered list of all the commands that you have entered. Each command is given a number according to the order it was entered.

```
% history (show command history list)
```

If you are using the C shell, you can use the exclamation character (!) to recall commands easily.

```
% !! (recall last command)
```

```
% !-3 (recall third most recent command)
```

```
% !5 (recall 5th command in list)
```

```
% !grep (recall last command starting with grep)
```

You can increase the size of the history buffer by typing

```
% set history=100
```



7.1 Compiling UNIX software packages

We have many public domain and commercial software packages installed on our systems, which are available to all users. However, students are allowed to download and install small software packages in their own home directory, software usually only useful to them personally.

There are a number of steps needed to install the software.

- Locate and download the source code (which is usually compressed)
- Unpack the source code
- Compile the code
- Install the resulting executable
- Set paths to the installation directory

Of the above steps, probably the most difficult is the compilation stage.

Compiling Source Code

All high-level language code must be converted into a form the computer understands. For example, C language source code is converted into a lower-level language called assembly language. The assembly language code made by the previous stage is then converted into object code which are fragments of code which the computer understands directly. The final stage in compiling a program involves linking the object code to code libraries which contain certain built-in functions. This final stage produces an executable program.

To do all these steps by hand is complicated and beyond the capability of the ordinary user. A number of utilities and tools have been developed for programmers and end-users to simplify these steps.

make and the Makefile

The **make** command allows programmers to manage large programs or groups of programs. It aids in developing large programs by keeping track of which portions of the entire program have been changed, compiling only those parts of the program which have changed since the last compile.

The **make** program gets its set of compile rules from a text file called **Makefile** which resides in the same directory as the source files. It contains information on how to compile the software, e.g. the optimisation level, whether to include debugging info in the executable. It also contains information on where to install the finished compiled binaries (executables), manual pages, data files, dependent library files, configuration files, etc.

Some packages require you to edit the Makefile by hand to set the final installation directory and any other parameters. However, many packages are now being distributed with the GNU configure utility.

configure

As the number of UNIX variants increased, it became harder to write programs which could run on all variants. Developers frequently did not have access to every system, and the characteristics of some systems changed from version to version. The GNU configure and build system simplifies the building of programs distributed as source code. All programs are built using a simple, standardised, two step process. The program builder need not install any special tools in order to build the program.

The **configure** shell script attempts to guess correct values for various system-dependent variables used during compilation. It uses those values to create a **Makefile** in each directory of the package.

The simplest way to compile a package is:

1. **cd** to the directory containing the package's source code.
2. Type **./configure** to configure the package for your system.
3. Type **make** to compile the package.
4. Optionally, type **make check** to run any self-tests that come with the package.
5. Type **make install** to install the programs and any data files and documentation.
6. Optionally, type **make clean** to remove the program binaries and object files from the source code directory

The configure utility supports a wide variety of options. You can usually use the **--help** option to get a list of interesting options for a particular configure script.

The only generic options you are likely to use are the **--prefix** and **--exec-prefix** options. These options are used to specify the installation directories.

The directory named by the **--prefix** option will hold machine independent files such as documentation, data and configuration files.

The directory named by the **--exec-prefix** option, (which is normally a subdirectory of the **--prefix** directory), will hold machine dependent files such as executables.

7.2 Downloading source code

For this example, we will download a piece of free software that converts between different units of measurements.

First create a download directory

```
% mkdir download
```

[Download the software here](#) and save it to your new download directory.

7.3 Extracting the source code

Go into your **download** directory and list the contents.

```
% cd download
```

```
% ls -l
```

As you can see, the filename ends in tar.gz. The **tar** command turns several files and directories into one single tar file. This is then compressed using the **gzip** command (to create a tar.gz file).

First unzip the file using the **gunzip** command. This will create a .tar file.

```
% gunzip units-1.74.tar.gz
```

Then extract the contents of the tar file.

```
% tar -xvf units-1.74.tar
```

Again, list the contents of the **download** directory, then go to the **units-1.74** sub-directory.

```
% cd units-1.74
```

7.4 Configuring and creating the Makefile

The first thing to do is carefully read the **README** and **INSTALL** text files (use the **less** command). These contain important information on how to compile and run the software.

The units package uses the GNU configure system to compile the source code. We will need to specify the installation directory, since the default will be the main system area which you will not have write permissions for. We need to create an install directory in your home directory.

```
% mkdir ~/units174
```

Then run the configure utility setting the installation path to this.

```
% ./configure --prefix=$HOME/units174
```

NOTE:

The **\$HOME** variable is an example of an environment variable. The value of **\$HOME** is the path to your home directory. Just type

```
% echo $HOME
```

to show the contents of this variable. We will learn more about environment variables in a later chapter.

If configure has run correctly, it will have created a Makefile with all necessary options. You can view the Makefile if you wish (use the **less** command), but do not edit the contents of this.

7.5 Building the package

Now you can go ahead and build the package by running the **make** command.

```
% make
```

After a minute or two (depending on the speed of the computer), the executables will be created. You can check to see everything compiled successfully by typing

```
% make check
```

If everything is okay, you can now install the package.

```
% make install
```

This will install the files into the `~/units174` directory you created earlier.

7.6 Running the software

You are now ready to run the software (assuming everything worked).

```
% cd ~/units174
```

If you list the contents of the units directory, you will see a number of subdirectories.

bin	The binary executables
info	GNU info formatted documentation
man	Man pages
share	Shared data files

To run the program, change to the **bin** directory and type

```
% ./units
```

As an example, convert 6 feet to metres.

```
You have: 6 feet
```

```
You want: metres
```

```
* 1.8288
```

If you get the answer 1.8288, congratulations, it worked.

To view what units it can convert between, view the data file in the share directory (the list is quite comprehensive).

To read the full documentation, change into the **info** directory and type

```
% info --file=units.info
```

7.7 Stripping unnecessary code

When a piece of software is being developed, it is useful for the programmer to include debugging information into the resulting executable. This way, if there are problems encountered when running the executable, the programmer can load the executable into a debugging software package and track down any software bugs.

This is useful for the programmer, but unnecessary for the user. We can assume that the package, once finished and available for download has already been tested and debugged. However, when we compiled the software above, debugging information was still compiled into the final executable. Since it is unlikely that we are going to need this debugging information, we can strip it out of the final executable. One of the advantages of this is a much smaller executable, which should run slightly faster.

What we are going to do is look at the before and after size of the binary file. First change into the **bin** directory of the units installation directory.

```
% cd ~/units174/bin
```

```
% ls -l
```

As you can see, the file is over 100 kbytes in size. You can get more information on the type of file by using the **file** command.

```
% file units
```

```
units: ELF 32-bit LSB executable, Intel 80386, version 1,  
dynamically linked (uses shared libs), not stripped
```

To strip all the debug and line numbering information out of the binary file, use the **strip** command

```
% strip units
```

```
% ls -l
```

As you can see, the file is now 36 kbytes - a third of its original size. Two thirds of the binary file was debug code !!!

Check the file information again.

```
% file units
```

```
units: ELF 32-bit LSB executable, Intel 80386, version 1,  
dynamically linked (uses shared libs), stripped
```

HINT: You can use the make command to install pre-stripped copies of all the binary files when you install the package.

Instead of typing **make install**, simply type **make install-strip**



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8.1 UNIX Variables

Variables are a way of passing information from the shell to programs when you run them. Programs look "in the environment" for particular variables and if they are found will use the values stored. Some are set by the system, others by you, yet others by the shell, or any program that loads another program.

Standard UNIX variables are split into two categories, environment variables and shell variables. In broad terms, shell variables apply only to the current instance of the shell and are used to set short-term working conditions; environment variables have a farther reaching significance, and those set at login are valid for the duration of the session. By convention, environment variables have UPPER CASE and shell variables have lower case names.

8.2 Environment Variables

An example of an environment variable is the OSTYPE variable. The value of this is the current operating system you are using. Type

```
% echo $OSTYPE
```

More examples of environment variables are

- USER (your login name)
- HOME (the path name of your home directory)
- HOST (the name of the computer you are using)
- ARCH (the architecture of the computers processor)
- DISPLAY (the name of the computer screen to display X windows)
- PRINTER (the default printer to send print jobs)
- PATH (the directories the shell should search to find a command)

Finding out the current values of these variables.

ENVIRONMENT variables are set using the `setenv` command, displayed using the `printenv` or `env` commands, and unset using the `unsetenv` command.

To show all values of these variables, type

```
% printenv | less
```

8.3 Shell Variables

An example of a shell variable is the history variable. The value of this is how many shell commands to save, allow the user to scroll back through all the commands they have previously entered. Type

```
% echo $history
```

More examples of shell variables are

- `cwd` (your current working directory)

- home (the path name of your home directory)
- path (the directories the shell should search to find a command)
- prompt (the text string used to prompt for interactive commands shell your login shell)

Finding out the current values of these variables.

SHELL variables are both set and displayed using the `set` command. They can be unset by using the `unset` command.

To show all values of these variables, type

```
% set | less
```

So what is the difference between PATH and path ?

In general, environment and shell variables that have the same name (apart from the case) are distinct and independent, except for possibly having the same initial values. There are, however, exceptions.

Each time the shell variables `home`, `user` and `term` are changed, the corresponding environment variables `HOME`, `USER` and `TERM` receive the same values. However, altering the environment variables has no effect on the corresponding shell variables.

`PATH` and `path` specify directories to search for commands and programs. Both variables always represent the same directory list, and altering either automatically causes the other to be changed.

8.4 Using and setting variables

Each time you login to a UNIX host, the system looks in your home directory for initialisation files. Information in these files is used to set up your working environment. The C and TC shells uses two files called `.login` and `.cshrc` (note that both file names begin with a dot).

At login the C shell first reads `.cshrc` followed by `.login`

.login is to set conditions which will apply to the whole session and to perform actions that are relevant only at login.

.cshrc is used to set conditions and perform actions specific to the shell and to each invocation of it.

The guidelines are to set ENVIRONMENT variables in the **.login** file and SHELL variables in the **.cshrc** file.

WARNING: NEVER put commands that run graphical displays (e.g. a web browser) in your `.cshrc` or `.login` file.

8.5 Setting shell variables in the .cshrc file

For example, to change the number of shell commands saved in the history list, you need to set the shell variable `history`. It is set to 100 by default, but you can increase this if you wish.

```
% set history = 200
```

Check this has worked by typing

```
% echo $history
```

However, this has only set the variable for the lifetime of the current shell. If you open a new xterm window, it will only have the default history value set. To PERMANENTLY set the value of history, you will need to add the set command to the .cshrc file.

First open the **.cshrc** file in a text editor. An easy, user-friendly editor to use is nedit.

```
% nedit ~/.cshrc
```

Add the following line AFTER the list of other commands.

```
set history = 200
```

Save the file and force the shell to reread its .cshrc file by using the shell source command.

```
% source .cshrc
```

Check this has worked by typing

```
% echo $history
```

8.6 Setting the path

When you type a command, your path (or PATH) variable defines in which directories the shell will look to find the command you typed. If the system returns a message saying "command: Command not found", this indicates that either the command doesn't exist at all on the system or it is simply not in your path.

For example, to run units, you either need to directly specify the units path (**~/units174/bin/units**), or you need to have the directory **~/units174/bin** in your path.

You can add it to the end of your existing path (the **\$path** represents this) by issuing the command:

```
% set path = ($path ~/units174/bin)
```

Test that this worked by trying to run units in any directory other than where units is actually located.

```
% cd; units
```

HINT: You can run multiple commands on one line by separating them with a semicolon.

To add this path PERMANENTLY, add the following line to your .cshrc AFTER the list of other commands.

```
set path = ($path ~/units174/bin)
```

