Introduction to Unix

Frank G. Fiamingo

Linda DeBula

Linda Condron

University Technology Services

The Ohio State University
# Table of Contents

1 History of Unix ................................................................. 7

2 Unix Structure ................................................................... 9
   2.1 The Operating System ............................................... 9
   2.2 The File System ....................................................... 11
   2.3 Unix Directories, Files and Inodes ........................... 12
   2.4 Unix Programs ....................................................... 13

3 Getting Started ............................................................... 14
   3.1 Logging in ............................................................... 14
      3.1.1 Terminal Type ............................................... 14
      3.1.2 Passwords ..................................................... 15
      3.1.3 Exiting .......................................................... 15
      3.1.4 Identity ......................................................... 16
   3.2 Unix Command Line Structure ................................. 16
   3.3 Control Keys .......................................................... 17
   3.4 stty - terminal control .......................................... 17
   3.5 Getting Help .......................................................... 19
   3.6 Directory Navigation and Control ......................... 20
      3.6.1 pwd - print working directory ......................... 21
      3.6.2 cd - change directory .................................... 21
      3.6.3 mkdir - make a directory ............................... 22
      3.6.4 rmdir - remove directory ............................... 22
      3.6.5 ls - list directory contents ............................ 23
   3.7 File Maintenance Commands ................................. 25
      3.7.1 cp - copy a file .............................................. 26
      3.7.2 mv - move a file ............................................ 26
      3.7.3 rm - remove a file .......................................... 27
      3.7.4 File Permissions ............................................ 27
      3.7.5 chmod - change file permissions .................... 28
      3.7.6 chown - change ownership ............................ 29
      3.7.7 chgrp - change group ................................... 29
   3.8 Display Commands .................................................... 30
      3.8.1 echo - echo a statement ................................. 30
3.8.2 cat - concatenate a file .................................................31
3.8.3 more, less, and pg - page through a file ........................31
3.8.4 head - display the start of a file ...................................32
3.8.5 tail - display the end of a file ......................................32

4 System Resources & Printing ....................................................33
4.1 System Resources ........................................................................33
4.1.1 df - summarize disk block and file usage ....................34
4.1.2 du - report disk space in use ....................................34
4.1.3 ps - show status of active processes ............................35
4.1.4 kill - terminate a process .............................................36
4.1.5 who - list current users ................................................37
4.1.6 whereis - report program locations ............................37
4.1.7 which - report the command found .............................38
4.1.8 hostname/uname - name of machine ...........................38
4.1.9 script - record your screen I/O ....................................38
4.1.10 date - current date and time .........................................40

4.2 Print Commands .........................................................................41
4.2.1 lp/lpr - submit a print job ............................................41
4.2.2 lpstat/lpq - check the status of a print job ...................42
4.2.3 cancel/lprm - cancel a print job ...................................42
4.2.4 pr - prepare files for printing .......................................43

5 Shells ............................................................................................45
5.1 Built-in Commands .....................................................................46
5.1.1 Sh ................................................................................46
5.1.2 Csh ..............................................................................47

5.2 Environment Variables ..............................................................48
5.3 The Bourne Shell, sh ............................................................49
5.4 The C Shell, csh .................................................................50
5.5 Job Control ................................................................................51
5.6 History ........................................................................................52
5.7 Changing your Shell ...................................................................54

6 Special Unix Features .................................................................55
6.1 File Descriptors ...........................................................................55
6.2 File Redirection ...........................................................................55
6.2.1 Csh ................................................................................56
6.2.2 Sh ................................................................................57
6.3 Other Special Command Symbols .............................................58
6.4 Wild Cards ...................................................................................58

7 Text Processing ............................................................................59
7.1 Regular Expression Syntax ........................................................59
7.2 Text Processing Commands .......................................................61
7.2.1 grep .............................................................................61
7.2.2 sed ..............................................................................65
8 Other Useful Commands .................................................................70

8.1 Working With Files .................................................................70
  8.1.1 cmp - compare file contents ...........................................71
  8.1.2 diff - differences in files ...............................................72
  8.1.3 cut - select parts of a line ............................................73
  8.1.4 paste - merge files .......................................................74
  8.1.5 touch - create a file ....................................................76
  8.1.6 wc - count words in a file ............................................77
  8.1.7 ln - link to another file ................................................78
  8.1.8 sort - sort file contents ..............................................79
  8.1.9 tee - copy command output .........................................82
  8.1.10 uniq - remove duplicate lines .....................................84
  8.1.11 strings - find ASCII strings .......................................85
  8.1.12 file - file type ............................................................86
  8.1.13 tr - translate characters ............................................86
  8.1.14 find - find files ........................................................89

8.2 File Archiving, Compression and Conversion .........................91
  8.2.1 File Compression ........................................................91
  8.2.2 tar - archive files .........................................................93
  8.2.3 uudecode - decode a file .............................................94
  8.2.4 dd - block copy and convert .......................................95
  8.2.5 od - octal dump of a file ............................................96

8.3 Remote Connections ...................................................................98
  8.3.1 TELNET and FTP - remote login and file transfer protocols 98
  8.3.2 finger - get information about users ..........................100
  8.3.3 Remote commands ....................................................101

9 Shell Programming ......................................................................103
  9.1 Shell Scripts ........................................................................103
  9.2 Setting Parameter Values .....................................................103
  9.3 Quoting .............................................................................104
  9.4 Variables ............................................................................105
  9.5 Parameter Substitution .......................................................107
  9.6 Here Document ..................................................................109
  9.7 Interactive Input ..................................................................110
    9.7.1 Sh ........................................................................110
    9.7.2 Csh ......................................................................110
  9.8 Functions ..........................................................................111
  9.9 Control Commands ...........................................................113
    9.9.1 Conditional if ..........................................................113
      9.9.1.1 Sh ................................................................113
      9.9.1.2 Csh ................................................................114
    9.9.2 Conditional switch and case ......................................115
      9.9.2.1 Sh ................................................................115
CHAPTER 1  History of Unix

1965  Bell Laboratories joins with MIT and General Electric in the development effort for the new operating system, Multics, which would provide multi-user, multi-processor, and multi-level (hierarchical) file system, among its many forward-looking features.

1969  AT&T was unhappy with the progress and drops out of the Multics project. Some of the Bell Labs programmers who had worked on this project, Ken Thompson, Dennis Ritchie, Rudd Canaday, and Doug McIlroy designed and implemented the first version of the Unix File System on a PDP-7 along with a few utilities. It was given the name UNIX by Brian Kernighan as a pun on Multics.

1970, Jan 1  time zero for UNIX

1971  The system now runs on a PDP-11, with 16Kbytes of memory, including 8Kbytes for user programs and a 512Kbyte disk.

Its first real use is as a text processing tool for the patent department at Bell Labs. That utilization justified further research and development by the programming group. UNIX caught on among programmers because it was designed with these features:

- programmers environment
- simple user interface
- simple utilities that can be combined to perform powerful functions
- hierarchical file system
- simple interface to devices consistent with file format
- multi-user, multi-process system
- architecture independent and transparent to the user.

1973  Unix is re-written mostly in C, a new language developed by Dennis Ritchie. Being written in this high-level language greatly decreased the effort needed to port it to new machines.

1974  Thompson and Ritchie publish a paper in the Communications of the ACM describing the new Unix OS. This generates enthusiasm in the Academic community which sees a potentially great teaching tool for studying programming systems development. Since AT&T is prevented from marketing the product due to the 1956 Consent Decree they license it to Universities for educational purposes and to commercial entities.

1977  There are now about 500 Unix sites world-wide.
1980 BSD 4.1 (Berkeley Software Development)

1983 SunOS, BSD 4.2, SysV

1984 There are now about 100,000 Unix sites running on many different hardware platforms, of vastly different capabilities.

1988 AT&T and Sun Microsystems jointly develop System V Release 4 (SVR4). This would later be developed into UnixWare and Solaris 2.

1993 Novell buys UNIX from AT&T

1994 Novell gives the name "UNIX" to X/Open

1995 Santa Cruz Operations buys UnixWare from Novell. Santa Cruz Operations and Hewlett-Packard announce that they will jointly develop a 64-bit version of Unix.

1996 International Data Corporation forecasts that in 1997 there will be 3 million Unix systems shipped world-wide.
CHAPTER 2  Unix Structure

2.1 The Operating System

Unix is a layered operating system. The innermost layer is the hardware that provides the services for the OS. The operating system, referred to in Unix as the **kernel**, interacts directly with the hardware and provides the services to the user programs. These user programs don’t need to know anything about the hardware. They just need to know how to interact with the kernel and it’s up to the kernel to provide the desired service. One of the big appeals of Unix to programmers has been that most well written user programs are independent of the underlying hardware, making them readily portable to new systems.

User programs interact with the kernel through a set of standard **system calls**. These system calls request services to be provided by the kernel. Such services would include accessing a file: open close, read, write, link, or execute a file; starting or updating accounting records; changing ownership of a file or directory; changing to a new directory; creating, suspending, or killing a process; enabling access to hardware devices; and setting limits on system resources.

Unix is a **multi-user, multi-tasking** operating system. You can have many users logged into a system simultaneously, each running many programs. It’s the kernel’s job to keep each process and user separate and to regulate access to system hardware, including cpu, memory, disk and other I/O devices.
FIGURE 2.1  Unix System Structure

- Programs
- Kernel
- System Calls
- Hardware
2.2 The File System

The Unix file system looks like an inverted tree structure. You start with the root directory, denoted by /, at the top and work down through sub-directories underneath it.
Each node is either a file or a directory of files, where the latter can contain other files and directories. You specify a file or directory by its path name, either the full, or absolute, path name or the one relative to a location. The full path name starts with the root, /, and follows the branches of the file system, each separated by /, until you reach the desired file, e.g.:

/home/condron/source/xntp

A relative path name specifies the path relative to another, usually the current working directory that you are at. Two special directory entries should be introduced now:

. the current directory
.. the parent of the current directory

So if I’m at /home/frank and wish to specify the path above in a relative fashion I could use:

./condron/source/xntp

This indicates that I should first go up one directory level, then come down through the condron directory, followed by the source directory and then to xntp.

---

2.3 Unix Directories, Files and Inodes

Every directory and file is listed in its parent directory. In the case of the root directory, that parent is itself. A directory is a file that contains a table listing the files contained within it, giving file names to the inode numbers in the list. An inode is a special file designed to be read by the kernel to learn the information about each file. It specifies the permissions on the file, ownership, date of creation and of last access and change, and the physical location of the data blocks on the disk containing the file.

The system does not require any particular structure for the data in the file itself. The file can be ASCII or binary or a combination, and may represent text data, a shell script, compiled object code for a program, directory table, junk, or anything you would like.

There’s no header, trailer, label information or EOF character as part of the file.
2.4 Unix Programs

A program, or command, interacts with the kernel to provide the environment and perform the functions called for by the user. A program can be: an executable shell file, known as a shell script; a built-in shell command; or a source compiled, object code file.

The shell is a command line interpreter. The user interacts with the kernel through the shell. You can write ASCII (text) scripts to be acted upon by a shell.

System programs are usually binary, having been compiled from C source code. These are located in places like /bin, /usr/bin, /usr/local/bin, /usr/ucb, etc. They provide the functions that you normally think of when you think of Unix. Some of these are sh, csh, date, who, more, and there are many others.
CHAPTER 3  Getting Started

3.1 Logging in

After connecting with a Unix system, a user is prompted for a login username, then a password. The login username is the user's unique name on the system. The password is a changeable code known only to the user. At the login prompt, the user should enter the username; at the password prompt, the current password should be typed.

Note: Unix is case sensitive. Therefore, the login and password should be typed exactly as issued; the login, at least, will normally be in lower case.

3.1.1 Terminal Type

Most systems are set up so the user is by default prompted for a terminal type, which should be set to match the terminal in use before proceeding. Most computers work if you choose "vt100". Users connecting using a Sun workstation may want to use "sun"; those using an X-Terminal may want to use "xterms" or "xterm".

The terminal type indicates to the Unix system how to interact with the session just opened.

Should you need to reset the terminal type, enter the command:

setenv TERM <term type> - if using the C-shell (see Chapter 4.)

(On some systems, e.g. MAGNUS, it's also necessary to type "unsetenv TERMCP".)

-or-

TERM=<term type>; export TERM - if using the Bourne shell (see Chapter 4.)

where <term type> is the terminal type, such as vt100, that you would like set.
3.1.2 Passwords

When your account is issued, you will be given an initial password. It is important for system and personal security that the password for your account be changed to something of your choosing. The command for changing a password is "passwd". You will be asked both for your old password and to type your new selected password twice. If you mistype your old password or do not type your new password the same way twice, the system will indicate that the password has not been changed.

Some system administrators have installed programs that check for appropriateness of password (is it cryptic enough for reasonable system security). A password change may be rejected by this program.

When choosing a password, it is important that it be something that could not be guessed -- either by somebody unknown to you trying to break in, or by an acquaintance who knows you. Suggestions for choosing and using a password follow:

**Don't**
- use a word (or words) in any language
- use a proper name
- use information that can be found in your wallet
- use information commonly known about you (car license, pet name, etc)
- use control characters. Some systems can't handle them
- write your password anywhere
- ever give your password to *anybody*

**Do**
- use a mixture of character types (alphabetic, numeric, special)
- use a mixture of upper case and lower case
- use at least 6 characters
- choose a password you can remember
- change your password often
- make sure nobody is looking over your shoulder when you are entering your password

3.1.3 Exiting

`^D` - indicates end of data stream; can log a user off. The latter is disabled on many systems

`^C` - interrupt

`logout` - leave the system

`exit` - leave the shell
3.1.4 Identity

The system identifies you by the user and group numbers (userid and groupid, respectively) assigned to you by your system administrator. You don’t normally need to know your userid or groupid as the system translates username ↔ userid, and groupname ↔ groupid automatically. You probably already know your username; it’s the name you logon with. The groupname is not as obvious, and indeed, you may belong to more than one group. Your primary group is the one associated with your username in the password database file, as set up by your system administrator. Similarly, there is a group database file where the system administrator can assign you rights to additional groups on the system.

In the examples below % is your shell prompt; you don’t type this in.

You can determine your userid and the list of groups you belong to with the id and groups commands. On some systems id displays your user and primary group information, e.g.:

```
% id
uid=1101(frank) gid=10(staff)
```

on other systems it also displays information for any additional groups you belong to:

```
% id
uid=1101(frank) gid=10(staff) groups=10(staff),5(operator),14(sysadmin),110(uts)
```

The groups command displays the group information for all the groups you belong to, e.g.:

```
% groups
staff sysadmin uts operator
```

3.2 Unix Command Line Structure

A command is a program that tells the Unix system to do something. It has the form:

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

where an argument indicates on what the command is to perform its action, usually a file or series of files. An option modifies the command, changing the way it performs.

Commands are case sensitive. command and Command are not the same.

Options are generally preceded by a hyphen (-), and for most commands, more than one option can be strung together, in the form:

```
command -[option][option][option]
```

e.g.:

```
ls -alR
```

will perform a long list on all files in the current directory and recursively perform the list through all sub-directories.

For most commands you can separate the options, preceding each with a hyphen, e.g.:

```
command -option1 -option2 -option3
```
as in:

```
ls -a -l -R
```

Some commands have options that require parameters. Options requiring parameters are usually specified separately, e.g.:

```
lpr -Pprinter3 -# 2 file
```

will send 2 copies of file to printer3.

These are the standard conventions for commands. However, not all Unix commands will follow the standard. Some don’t require the hyphen before options and some won’t let you group options together, i.e. they may require that each option be preceded by a hyphen and separated by whitespace from other options and arguments.

Options and syntax for a command are listed in the man page for the command.

### 3.3 Control Keys

**Control keys** are used to perform special functions on the command line or within an editor. You type these by holding down the Control key and some other key simultaneously. This is usually represented as ^Key. Control-S would be written as ^S. With control keys upper and lower case are the same, so ^S is the same as ^s. This particular example is a stop signal and tells the terminal to stop accepting input. It will remain that way until you type a start signal, ^Q.

Control-U is normally the "line-kill" signal for your terminal. When typed it erases the entire input line.

In the vi editor you can type a control key into your text file by first typing ^V followed by the control character desired, so to type ^H into a document type ^V^H.

### 3.4 stty - terminal control

**stty** reports or sets terminal control options. The "tty" is an abbreviation that harks back to the days of teletypewriters, which were associated with transmission of telegraph messages, and which were models for early computer terminals.

For new users, the most important use of the stty command is setting the erase function to the appropriate key on their terminal. For systems programmers or shell script writers, the stty command provides an invaluable tool for configuring many aspects of I/O control for a given device, including the following:

- erase and line-kill characters
- data transmission speed
- parity checking on data transmission
- hardware flow control
- newline (NL) versus carriage return plus linefeed (CR-LF)
- interpreting tab characters
- edited versus raw input
- mapping of upper case to lower case

This command is very system specific, so consult the man pages for the details of the stty command on your system.

Syntax

\texttt{stty [options]}

Options

- (none) report the terminal settings
- all (or -a) report on all options
- echo echo ERASE as BS-space-BS
- dec set modes suitable for Digital Equipment Corporation operating systems (which distinguishes between ERASE and BACKSPACE) (Not available on all systems)
- kill set the LINE-KILL character
- erase set the ERASE character
- intr set the INTERRUPT character

Examples

You can display and change your terminal control settings with the \texttt{stty} command. To display all (-a) of the current line settings:

\begin{verbatim}
% stty -a
speed 38400 baud, 24 rows, 80 columns
parenb -parodds cs7 -cstopb -hupcl cread -clocal -crtsets
-ignbrk brkint ignpar -parmrk -inpck istrip -inlcr -igncr icrnl -icrnl
ixon -ixany -ixoff imaxbel
isig iexten icanon -xcase echo echo echok -echo -echonl -noflsh -tostop
echoctl -echoprt echoke
opost -olcuc onlcr -ocrnl -onocr -onlret -ofill -ofdel
erase kill werase rprnt flush lnext susp intr quit stop eof
^H ^U ^W ^R ^O ^V ^Z/^Y ^C ^S/^Q ^D
\end{verbatim}

You can change settings using \texttt{stty}, e.g., to change the erase character from ^? (the delete key) to ^H:

\begin{verbatim}
% stty erase ^H
\end{verbatim}

This will set the terminal options for the current session only. To have this done for you automatically each time you login, it can be inserted into the .login or .profile file that we’ll look at later.
3.5 Getting Help

The Unix manual, usually called man pages, is available on-line to explain the usage of the Unix system and commands. To use a man page, type the command "man" at the system prompt followed by the command for which you need information.

Syntax

    man [options] command_name

Common Options

- `k` keyword  list command synopsis line for all keyword matches
- `M` path    path to man pages
- `a`         show all matching man pages (SVR4)

Examples

You can use man to provide a one line synopsis of any commands that contain the keyword that you want to search on with the "-k" option, e.g. to search on the keyword password, type:

    % man -k password
    passwd (5) - password file
    passwd (1) - change password information

The number in parentheses indicates the section of the man pages where these references were found. You can then access the man page (by default it will give you the lower numbered entry, but you can use a command line option to specify a different one) with:

    % man passwd

Here we’ve paraphrased and truncated the output for space and copyright concerns.
3.6 Directory Navigation and Control

The Unix file system is set up like a tree branching out from the root. The root directory of the system is symbolized by the forward slash (/). System and user directories are organized under the root. The user does not have a root directory in Unix; users generally log into their own home directory. Users can then create other directories under their home. The following table summarizes some directory navigation commands.

<table>
<thead>
<tr>
<th>Command/Syntax</th>
<th>What it will do</th>
</tr>
</thead>
<tbody>
<tr>
<td>cd [directory]</td>
<td>change directory</td>
</tr>
<tr>
<td>ls [options] [directory or file]</td>
<td>list directory contents or file permissions</td>
</tr>
<tr>
<td>mkdir [options] directory</td>
<td>make a directory</td>
</tr>
<tr>
<td>pwd</td>
<td>print working (current) directory</td>
</tr>
<tr>
<td>rmdir [options] directory</td>
<td>remove a directory</td>
</tr>
</tbody>
</table>

If you’re familiar with DOS the following table comparing similar commands might help to provide the proper reference frame.

<table>
<thead>
<tr>
<th>Command</th>
<th>Unix</th>
<th>DOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>list directory contents</td>
<td>ls</td>
<td>dir</td>
</tr>
<tr>
<td>make directory</td>
<td>mkdir</td>
<td>md &amp; mkdir</td>
</tr>
<tr>
<td>change directory</td>
<td>cd</td>
<td>cd &amp; chdir</td>
</tr>
<tr>
<td>delete (remove) directory</td>
<td>rmdir</td>
<td>rd &amp; rmdir</td>
</tr>
<tr>
<td>return to user’s home directory</td>
<td>cd</td>
<td>cd\</td>
</tr>
<tr>
<td>location in path (present working directory)</td>
<td>pwd</td>
<td>cd</td>
</tr>
</tbody>
</table>
3.6.1  

**pwd - print working directory**

At any time you can determine where you are in the file system hierarchy with the *pwd*, print working directory, command, e.g.:

```
% pwd
/home/frank/src
```

3.6.2  

**cd - change directory**

You can change to a new directory with the *cd*, change directory, command. *cd* will accept both absolute and relative path names.

**Syntax**

```
cd [directory]
```

**Examples**

- *cd* (also *chdir* in some shells) changes directory
- *cd* changes to user's home directory
- *cd /* changes directory to the system's root
- *cd ..* goes up one directory level
- *cd ../..* goes up two directory levels
- *cd /full/path/name/from/root* changes directory to absolute path named (note the leading slash)
- *cd path/from/current/location* changes directory to path relative to current location (no leading slash)
- *cd ~username/directory* changes directory to the named username's indicated directory (Note: the ~ is not valid in the Bourne shell; see Chapter 5.)
3.6.3 mkdir - make a directory

You extend your home hierarchy by making sub-directories underneath it. This is done with the `mkdir`, make directory, command. Again, you specify either the full or relative path of the directory:

**Syntax**

```
mkdir [options] directory
```

**Common Options**

- `-p` create the intermediate (parent) directories, as needed
- `-m` mode access permissions (SVR4). (We’ll look at modes later in this Chapter).

**Examples**

```
% mkdir /home/frank/data
```

or, if your present working directory is `/home/frank` the following would be equivalent:

```
% mkdir data
```

3.6.4 rmdir - remove directory

A directory needs to be empty before you can remove it. If it’s not, you need to remove the files first. Also, you can’t remove a directory if it is your present working directory; you must first change out of it.

**Syntax**

```
rmdir directory
```

**Examples**

To remove the empty directory `/home/frank/data` while in `/home/frank` use:

```
% rmdir data
```

or

```
% rmdir /home/frank/data
```
3.6.5 *ls* - list directory contents

The command to list your directories and files is *ls*. With options it can provide information about the size, type of file, permissions, dates of file creation, change and access.

**Syntax**

```
ls [options] [argument]
```

**Common Options**

When no argument is used, the listing will be of the current directory. There are many very useful options for the *ls* command. A listing of many of them follows. When using the command, string the desired options together preceded by "-".

- **-a** lists all files, including those beginning with a dot (.)
- **-d** lists only names of directories, not the files in the directory
- **-F** indicates type of entry with a trailing symbol:
  - directories /
  - sockets =
  - symbolic links @
  - executables *
- **-g** displays Unix group assigned to the file, requires the -l option (BSD only)
  - or- on an SVR4 machine, e.g. Solaris, this option has the opposite effect
- **-L** if the file is a symbolic link, lists the information for the file or directory the link references, not the information for the link itself
- **-l** long listing: lists the mode, link information, owner, size, last modification (time). If the file is a symbolic link, an arrow (-->) precedes the pathname of the linked-to file.

The **mode field** is given by the -l option and consists of 10 characters. The first character is one of the following:

<table>
<thead>
<tr>
<th>CHARACTER</th>
<th>IF ENTRY IS A</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>directory</td>
</tr>
<tr>
<td>-</td>
<td>plain file</td>
</tr>
<tr>
<td>b</td>
<td>block-type special file</td>
</tr>
<tr>
<td>c</td>
<td>character-type special file</td>
</tr>
<tr>
<td>l</td>
<td>symbolic link</td>
</tr>
<tr>
<td>s</td>
<td>socket</td>
</tr>
</tbody>
</table>

The next 9 characters are in 3 sets of 3 characters each. They indicate the **file access permissions**: the first 3 characters refer to the permissions for the **user**, the next three for the users in the Unix **group** assigned to the file, and the last 3 to the permissions for **other** users on the system. Designations are as follows:
Getting Started

r  read permission
w  write permission
x  execute permission
-  no permission

There are a few less commonly used permission designations for special circumstances. These are explained in the man page for `ls`.

Examples

To list the files in a directory:

```
% ls
demofiles  frank  linda
```

To list all files in a directory, including the hidden (dot) files try:

```
% ls -a
.
..  .cshrc  .history  .plan  .rhosts  frank
.
..  .emacs  .login  .profile  demofiles  linda
```

To get a long listing:

```
% ls -al
total 24
```
```
  drwxr-sr-x  5 workshop acs       512 Jun  7 11:12  .
  drwxr-xr-x  6 root     sys       512 May 29 09:59  ..
-rwxr-xr-x  1 workshop acs       532 May 20 15:31  .cshrc
-rwx-------  1 workshop acs       525 May 20 21:29  .emacs
-rwx-------  1 workshop acs       622 May 24 12:13  .history
-rwxr-xr-x  1 workshop acs       238 May 14 09:44  .login
-rw-r--r--  1 workshop acs       273 May 22 23:53  .plan
-rwxr-xr-x  1 workshop acs       413 May 14 09:36  .profile
-rw-------  1 workshop acs        49 May 20 20:23  .rhosts
drwx------  3 workshop acs       512 May 24 11:18  demofiles
drwx------  2 workshop acs       512 May 21 10:48  frank
drwx------  3 workshop acs       512 May 24 10:59  linda
```
3.7 File Maintenance Commands

To create, copy, remove and change permissions on files you can use the following commands.

<table>
<thead>
<tr>
<th>Command/Syntax</th>
<th>What it will do</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>chgrp</code> [options] <code>group file</code></td>
<td>change the group of the file</td>
</tr>
<tr>
<td><code>chmod</code> [options] <code>file</code></td>
<td>change file or directory access permissions</td>
</tr>
<tr>
<td><code>chown</code> [options] <code>owner file</code></td>
<td>change the ownership of a file; can only be done by the superuser</td>
</tr>
<tr>
<td><code>cp</code> [options] <code>file1 file2</code></td>
<td>copy <code>file1</code> into <code>file2</code>; <code>file2</code> shouldn't already exist. This command creates or overwrites <code>file2</code>.</td>
</tr>
<tr>
<td><code>mv</code> [options] <code>file1 file2</code></td>
<td>move <code>file1</code> into <code>file2</code></td>
</tr>
<tr>
<td><code>rm</code> [options] <code>file</code></td>
<td>remove (delete) a file or directory (-r recursively deletes the directory and its contents) (-i prompts before removing files)</td>
</tr>
</tbody>
</table>

If you’re familiar with DOS the following table comparing similar commands might help to provide the proper reference frame.

<table>
<thead>
<tr>
<th>Command</th>
<th>Unix</th>
<th>DOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>copy file</td>
<td><code>cp</code></td>
<td>copy</td>
</tr>
<tr>
<td>move file</td>
<td><code>mv</code></td>
<td>move (not supported on all versions of DOS)</td>
</tr>
<tr>
<td>rename file</td>
<td><code>mv</code></td>
<td>rename &amp; ren</td>
</tr>
<tr>
<td>delete (remove) file</td>
<td><code>rm</code></td>
<td>erase &amp; del</td>
</tr>
<tr>
<td>display file to screen</td>
<td><code>cat</code></td>
<td>type</td>
</tr>
<tr>
<td>entire file</td>
<td></td>
<td>type/p (not supported on all versions of DOS)</td>
</tr>
<tr>
<td>one page at a time</td>
<td><code>more, less, pg</code></td>
<td></td>
</tr>
</tbody>
</table>
3.7.1 cp - copy a file
Copy the contents of one file to another with the cp command.

Syntax

```
cp [options] old_filename new_filename
```

Common Options

- `i` interactive (prompt and wait for confirmation before proceeding)
- `r` recursively copy a directory

Examples

```
% cp old_filename new_filename
```

You now have two copies of the file, each with identical contents. They are completely independent of each other and you can edit and modify either as needed. They each have their own inode, data blocks, and directory table entries.

3.7.2 mv - move a file
Rename a file with the move command, mv.

Syntax

```
mv [options] old_filename new_filename
```

Common Options

- `i` interactive (prompt and wait for confirmation before proceeding)
- `f` don’t prompt, even when copying over an existing target file (overrides -i)

Examples

```
% mv old_filename new_filename
```

You now have a file called new_filename and the file old_filename is gone. Actually all you’ve done is to update the directory table entry to give the file a new name. The contents of the file remain where they were.
3.7.3  rm - remove a file

Remove a file with the `rm`, remove, command.

Syntax

```
rm [options] filename
```

Common Options

- `-i`  interactive (prompt and wait for confirmation before proceeding)
- `-r`  recursively remove a directory, first removing the files and subdirectories beneath it
- `-f`  don’t prompt for confirmation (overrides -i)

Examples

```
% rm old_filename
```

A listing of the directory will now show that the file no longer exists. Actually, all you’ve done is to remove the directory table entry and mark the inode as unused. The file contents are still on the disk, but the system now has no way of identifying those data blocks with a file name. There is no command to "unremove" a file that has been removed in this way. For this reason many novice users alias their remove command to be "rm -i", where the -i option prompts them to answer yes or no before the file is removed. Such aliases are normally placed in the `.cshrc` file for the C shell; see Chapter 5)

3.7.4  File Permissions

Each file, directory, and executable has permissions set for who can read, write, and/or execute it. To find the permissions assigned to a file, the `ls` command with the -l option should be used. Also, using the -g option with "ls -l" will help when it is necessary to know the group for which the permissions are set (BSD only).

When using the "$ls -lg" command on a file (ls -l on SysV), the output will appear as follows:

```
-rwxr-x--- user unixgroup size Month nn hh:mm filename
```

The area above designated by letters and dashes (-rwxr-x---) is the area showing the file type and permissions as defined in the previous Section. Therefore, a permission string, for example, of -rwxr-x--- allows the user (owner) of the file to read, write, and execute it; those in the unixgroup of the file can read and execute it; others cannot access it at all.
### 3.7.5 chmod - change file permissions

The command to change permissions on an item (file, directory, etc) is `chmod` (change mode). The syntax involves using the command with three digits (representing the **user** (owner, `u`) permissions, the **group** (`g`) permissions, and **other** (o) user's permissions) followed by the argument (which may be a file name or list of files and directories). Or by using symbolic representation for the permissions and who they apply to.

Each of the permission types is represented by either a numeric equivalent:

```
read=4, write=2, execute=1
```

or a single letter:

```
read=r, write=w, execute=x
```

A permission of 4 or r would specify **read** permissions. If the permissions desired are read and write, the 4 (representing read) and the 2 (representing write) are added together to make a permission of 6. Therefore, a permission setting of 6 would allow read and write permissions.

Alternatively, you could use symbolic notation which uses the one letter representation for who and for the permissions and an operator, where the operator can be:

```
+ add permissions
-
remove permissions
=
set permissions
```

So to set read and write for the owner we could use "u=rw" in symbolic notation.

**Syntax**

```
chmod nnn [argument list] numeric mode
chmod [who]op[perm] [argument list] symbolic mode
```

where `nnn` are the three numbers representing **user**, **group**, and **other** permissions, **who** is any of `u`, `g`, `o`, or `a` (all) and **perm** is any of `r`, `w`, `x`. In symbolic notation you can separate permission specifications by commas, as shown in the example below.

**Common Options**

```
-f force (no error message is generated if the change is unsuccessful)
-R recursively descend through the directory structure and change the modes
```

**Examples**

If the permission desired for file1 is **user**: read, write, execute, **group**: read, execute, **other**: read, execute, the command to use would be

```
chmod 755 file1           or           chmod u=rwx,go=rx file1
```
Reminder: When giving permissions to group and other to use a file, it is necessary to allow at least execute permission to the directories for the path in which the file is located. The easiest way to do this is to be in the directory for which permissions need to be granted:

\[
\text{chmod 711 .} \quad \text{or} \quad \text{chmod u=rw, +x .} \quad \text{or} \quad \text{chmod u=rwx, go=x .}
\]

where the dot (.) indicates this directory.

### 3.7.6 chown - change ownership

Ownership of a file can be changed with the `chown` command. On most versions of Unix this can only be done by the super-user, i.e. a normal user can’t give away ownership of their files. `chown` is used as below, where # represents the shell prompt for the super-user:

**Syntax**

\[
\text{chown [options] user[:group] file (SVR4)} \\
\text{chown [options] user[.group] file (BSD)}
\]

**Common Options**

- `-R` recursively descend through the directory structure
- `-f` force, and don’t report any errors

**Examples**

# chown new_owner file

### 3.7.7 chgrp - change group

Anyone can change the group of files they own, to another group they belong to, with the `chgrp` command.

**Syntax**

\[
\text{chgrp [options] group file}
\]

**Common Options**

- `-R` recursively descend through the directory structure
- `-f` force, and don’t report any errors

**Examples**

% chgrp new_group file
3.8 Display Commands

There are a number of commands you can use to display or view a file. Some of these are editors which we will look at later. Here we will illustrate some of the commands normally used to display a file.

<table>
<thead>
<tr>
<th>Command/Syntax</th>
<th>What it will do</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>cat [options] file</code></td>
<td>concatenate (list) a file</td>
</tr>
<tr>
<td><code>echo [text string]</code></td>
<td>echo the text string to stdout</td>
</tr>
<tr>
<td><code>head [-number] file</code></td>
<td>display the first 10 (or number of) lines of a file</td>
</tr>
<tr>
<td><code>more</code> (or <code>less</code> or <code>pg</code>) [options] file</td>
<td>page through a text file</td>
</tr>
<tr>
<td><code>tail</code> [options] file</td>
<td>display the last few lines (or parts) of a file</td>
</tr>
</tbody>
</table>

3.8.1 echo - echo a statement

The `echo` command is used to repeat, or echo, the argument you give it back to the standard output device. It normally ends with a line-feed, but you can specify an option to prevent this.

Syntax

```
    echo [string]
```

Common Options

- `-n`  don’t print <new-line> (BSD, shell built-in)
- `
  `  don’t print <new-line> (SVR4)
- `\0n`  where n is the 8-bit ASCII character code (SVR4)
- `
  `  tab (SVR4)
- ``  form-feed (SVR4)
- `\n`  new-line (SVR4)
- `\v`  vertical tab (SVR4)

Examples

```
% echo Hello Class    or    echo "Hello Class"
%
```

To prevent the line feed:

```
% echo -n Hello Class  or    echo "Hello Class \n"
where the style to use in the last example depends on the `echo` command in use.

The \x options must be within pairs of single or double quotes, with or without other string characters.
3.8.2 cat - concatenate a file

Display the contents of a file with the concatenate command, *cat*.

**Syntax**

```
cat [options] [file]
```

**Common Options**

- `-n` precede each line with a line number
- `-v` display non-printing characters, except tabs, new-lines, and form-feeds
- `-e` display $ at the end of each line (prior to new-line) (when used with `-v` option)

**Examples**

```
% cat filename
```

You can list a series of files on the command line, and *cat* will concatenate them, starting each in turn, immediately after completing the previous one, e.g.:

```
% cat file1 file2 file3
```

3.8.3 more, less, and pg - page through a file

*more*, *less*, and *pg* let you page through the contents of a file one screenful at a time. These may not all be available on your Unix system. They allow you to back up through the previous pages and search for words, etc.

**Syntax**

```
more [options] [+pattern] [filename]
less [options] [+pattern] [filename]
pag [options] [+pattern] [filename]
```

**Options**

<table>
<thead>
<tr>
<th>more</th>
<th>less</th>
<th>pg</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-c</code></td>
<td><code>-c</code></td>
<td><code>-c</code></td>
<td>clear display before displaying</td>
</tr>
<tr>
<td><code>-i</code></td>
<td></td>
<td></td>
<td>ignore case</td>
</tr>
<tr>
<td><code>-w</code></td>
<td>default</td>
<td>default</td>
<td>don’t exit at end of input, but prompt and wait</td>
</tr>
<tr>
<td><code>-lines</code></td>
<td></td>
<td><code>-lines</code></td>
<td># of lines/screenful</td>
</tr>
<tr>
<td><code>+/pattern</code></td>
<td><code>+/pattern</code></td>
<td><code>+/pattern</code></td>
<td>search for the pattern</td>
</tr>
</tbody>
</table>
Internal Controls

more displays (one screen at a time) the file requested

<space bar> to view next screen
<return> or <CR> to view one more line
q to quit viewing the file
h help
b go back up one screenful
/word search for word in the remainder of the file
See the man page for additional options

less similar to more; see the man page for options

pg the SVR4 equivalent of more (page)

3.8.4 head - display the start of a file

head displays the head, or start, of the file.

Syntax

    head [options] file

Common Options

- number number of lines to display, counting from the top of the file
- number same as above

Examples

By default head displays the first 10 lines. You can display more with the "-n number", or "-number" options, e.g., to display the first 40 lines:

    % head -40 filename or head -n 40 filename

3.8.5 tail - display the end of a file

tail displays the tail, or end, of the file.

Syntax

    tail [options] file

Common Options

- number number of lines to display, counting from the bottom of the file

Examples

The default is to display the last 10 lines, but you can specify different line or byte numbers, or a different starting point within the file. To display the last 30 lines of a file use the -number style:

    % tail -30 filename
## 4.1 System Resources

Commands to report or manage system resources.

<table>
<thead>
<tr>
<th>Command/Syntax</th>
<th>What it will do</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>chsh (passwd -e/-s) username login_shell</code></td>
<td>change the user’s login shell (often only by the superuser)</td>
</tr>
<tr>
<td><code>date [options]</code></td>
<td>report the current date and time</td>
</tr>
<tr>
<td><code>df [options] [resource]</code></td>
<td>report the summary of disk blocks and inodes free and in use</td>
</tr>
<tr>
<td><code>du [options] [directory or file]</code></td>
<td>report amount of disk space in use+</td>
</tr>
<tr>
<td><code>hostname/uname</code></td>
<td>display or set (super-user only) the name of the current machine</td>
</tr>
<tr>
<td><code>kill [options] [-SIGNAL] [pid#] [%job]</code></td>
<td>send a signal to the process with the process id number (pid#) or job control number (%n). The default signal is to kill the process.</td>
</tr>
<tr>
<td><code>man [options] command</code></td>
<td>show the manual (man) page for a command</td>
</tr>
<tr>
<td><code>passwd [options]</code></td>
<td>set or change your password</td>
</tr>
<tr>
<td><code>ps [options]</code></td>
<td>show status of active processes</td>
</tr>
<tr>
<td><code>script file</code></td>
<td>saves everything that appears on the screen to file until exit is executed</td>
</tr>
<tr>
<td><code>stty [options]</code></td>
<td>set or display terminal control options</td>
</tr>
<tr>
<td><code>whereis [options] command</code></td>
<td>report the binary, source, and man page locations for the command named</td>
</tr>
<tr>
<td><code>which command</code></td>
<td>reports the path to the command or the shell alias in use</td>
</tr>
<tr>
<td><code>who or w</code></td>
<td>report who is logged in and what processes are running</td>
</tr>
</tbody>
</table>
4.1.1 df - summarize disk block and file usage

`df` is used to report the number of disk blocks and inodes used and free for each file system. The output format and valid options are very specific to the OS and program version in use.

Syntax

```
df [options] [resource]
```

Common Options

```
-l     local file systems only (SVR4)
-k     report in kilobytes (SVR4)
```

Examples

```
{unix prompt 1} df

Filesystem            kbytes    used   avail  capacity  Mounted on
/dev/sd0a              20895   19224       0   102%    /
/dev/sd0h             319055  131293  155857    46%    /usr
/dev/sd1g             637726  348809  225145    61%    /usr/local
/dev/sd1a             240111  165489   50611    77%
/home/guardian
peri:/usr/local/backup 1952573  976558  780758    56%
/usr/local/backup
peri:/home/peri       726884  391189  263007    60%    /home/peri
peri:/usr/spool/mail  192383    1081  172064     1%
/var/spool/mail
peri:/acs/peri/2      723934  521604  129937    80%    /acs/peri/2
```

4.1.2 du - report disk space in use

`du` reports the amount of disk space in use for the files or directories you specify.

Syntax

```
du [options] [directory or file]
```

Common Options

```
-a     display disk usage for each file, not just subdirectories
-s     display a summary total only
-k     report in kilobytes (SVR4)
```
Examples

{unix prompt 3} du
1 ./elm
1 ./Mail
1 ./News
20 ./uc
86 .

{unix prompt 4} du -a uc
7 uc/unixgrep.txt
5 uc/editors.txt
1 uc/.emacs
1 uc/.exrc
4 uc/telnet.ftp
1 uc/uniq.tee.txt
20 uc

4.1.3 ps - show status of active processes

ps is used to report on processes currently running on the system. The output format and valid options are very specific to the OS and program version in use.

Syntax

ps [options]

Common Options

<table>
<thead>
<tr>
<th>BSD</th>
<th>SVR4</th>
</tr>
</thead>
<tbody>
<tr>
<td>-a</td>
<td>-e</td>
</tr>
<tr>
<td>-e</td>
<td></td>
</tr>
<tr>
<td>-g</td>
<td></td>
</tr>
<tr>
<td>-l</td>
<td>-l</td>
</tr>
<tr>
<td>-u</td>
<td>-u user</td>
</tr>
<tr>
<td>-x</td>
<td>-e</td>
</tr>
<tr>
<td></td>
<td>-f</td>
</tr>
<tr>
<td>-w</td>
<td></td>
</tr>
</tbody>
</table>

note -- Because the ps command is highly system-specific, it is recommended that you consult the man pages of your system for details of options and interpretation of ps output.
Examples

```
{unix prompt 5} ps

    PID TT STAT    TIME COMMAND
15549 p0 IW    0:00  -tcsh (tcsh)
15588 p0 IW    0:00  man nice
15594 p0 IW    0:00  sh  -c less /tmp/man15588
15595 p0 IW    0:00  less /tmp/man15588
15486 p1 S     0:00  -tcsh (tcsh)
15599 p1 T     0:00  emacs unixgrep.txt
15600 p1 R     0:00  ps
```

4.1.4 kill - terminate a process

`kill` sends a signal to a process, usually to terminate it.

Syntax

```
kill [-signal] process-id
```

Common Options

- `-l` displays the available kill signals:

```
HUP INT QUIT ILL TRAP IOT EMT FPE KILL BUS SEGV SYS PIPE ALRM TERM URG STOP
TSTP CONT CHLD TTIN TTOU IO XCPU XFSZ VTALRM PROF WINCH LOST USR1 USR2
```

The `-KILL` signal, also specified as `-9` (because it is 9th on the above list), is the most commonly used `kill` signal. Once seen, it can’t be ignored by the program whereas the other signals can.

```
{unix prompt 10} kill -9 15599

[1] + Killed   emacs unixgrep.txt
```
4.1.5 who - list current users

who reports who is logged in at the present time.

Syntax

    who [am i]

Examples

beauty condron>who

wmtell  ttyp1  Apr 21 20:15  (apple.acs.ohio-s)
fbwalk  ttyp2  Apr 21 23:21  (worf.acs.ohio-st)
stwang  ttyp3  Apr 21 23:22  (127.99.25.8)
david   ttyp4  Apr 21 22:27  (slip1-61.acs.ohi)
tgardner ttyp5  Apr 21 23:07  (picard.acs.ohio-)
awallace ttyp6  Apr 21 23:00  (ts31-4.homenet.o)
gtl27    ttyp7  Apr 21 23:24  (data.acs.ohio-st)
cchang   ttyp8  Apr 21 23:32  (slip3-10.acs.ohi)
condron  ttypc  Apr 21 23:38  (lcondron-mac.acs)
dgildman ttyte  Apr 21 22:30  (slip3-36.acs.ohi)
fcbetz   ttyq2  Apr 21 21:12  (ts24-10.homenet.)

beauty condron>who am i

beauty!condron  ttypc  Apr 21 23:38    (lcondron-mac.acs)

4.1.6 whereis - report program locations

whereis reports the filenames of source, binary, and manual page files associated with command(s).

Syntax

    whereis [options] command(s)

Common Options

    -b               report binary files only
    -m               report manual sections only
    -s               report source files only

Examples

brigadier: condron [69]> whereis Mail

Mail: /usr/ucb/Mail /usr/lib/Mail.help /usr/lib/Mail.rc /usr/man/man1/Mail.1
brigadier: condron [70]> whereis -b Mail
Mail: /usr/ucb/Mail /usr/lib/Mail.help /usr/lib/Mail.rc

brigadier: condron [71]> whereis -m Mail
Mail: /usr/man/man1/Mail.1

4.1.7 which - report the command found

*which* will report the name of the file that is to be executed when the command is invoked. This will be the full path name or the alias that's found first in your path.

**Syntax**

```
which command(s)
```

**Example**--

brigadier: condron [73]> which Mail
/usr/ucb/Mail

4.1.8 hostname/uname - name of machine

*hostname* (*uname -n* on SysV) reports the host name of the machine the user is logged into, e.g.:

brigadier: condron [91]> hostname
brigadier

*uname* has additional options to print information about system hardware type and software version.

4.1.9 script - record your screen I/O

*script* creates a script of your session input and output. Using the *script* command, you can capture all the data transmission from and to your terminal screen until you *exit* the script program. This can be useful during the programming-and-debugging process, to document the combination of things you have tried, or to get a printed copy of it all for later perusal.

**Syntax**

```
script [-a] [file] <...> exit
```

**Common Options**

- `-a` append the output to file

*typescript* is the name of the default file used by *script*.

You must remember to type *exit* to end your script session and close your typescript file.
Examples

beauty condron>script
    Script started, file is typescript
beauty condron>ps
    PID TT STAT   TIME COMMAND
    23323 p8 S      0:00  -h -i  (tcsh)
    23327 p8 R      0:00  ps
    18706 pa S      0:00  -tcsh  (tcsh)
    23315 pa T      0:00  emacs
    23321 pa S      0:00  script
    23322 pa S      0:00  script
    3400 pb I      0:00  -tcsh  (tcsh)
beauty condron>kill -9 23315
beauty condron>date
    Mon Apr 22 22:29:44 EDT 1996
beauty condron>exit
    exit
    Script done, file is typescript
    [1] + Killed emacs

beauty condron>cat typescript
    Script started on Mon Apr 22 22:28:36 1996
beauty condron>ps
    PID TT STAT   TIME COMMAND
    23323 p8 S      0:00  -h -i  (tcsh)
    23327 p8 R      0:00  ps
    18706 pa S      0:00  -tcsh  (tcsh)
    23315 pa T      0:00  emacs
    23321 pa S      0:00  script
    23322 pa S      0:00  script
    3400 pb I      0:00  -tcsh  (tcsh)
beauty condron>kill -9 23315
beauty condron>date
    Mon Apr 22 22:29:44 EDT 1996
beauty condron>exit
    exit

    script done on Mon Apr 22 22:30:02 1996
beauty condron>
4.1.10 date - current date and time

date displays the current date and time. A superuser can set the date and time.

Syntax

date [options] [+format]

Common Options

- **-u** use Universal Time (or Greenwich Mean Time)
  
+format specify the output format

  %a weekday abbreviation, Sun to Sat
  
  %h month abbreviation, Jan to Dec
  
  %j day of year, 001 to 366
  
  %n <new-line>
  
  %t <TAB>
  
  %y last 2 digits of year, 00 to 99
  
  %D MM/DD/YY date
  
  %H hour, 00 to 23
  
  %M minute, 00 to 59
  
  %S second, 00 to 59
  
  %T HH:MM:SS time

Examples

beauty condron>date

    Mon Jun 10 09:01:05 EDT 1996

beauty condron>date -u

    Mon Jun 10 13:01:33 GMT 1996

beauty condron>date +%a%t%D

    Mon 06/10/96

beauty condron>date '+%y:%j'

    96:162
4.2 Print Commands

The print commands allow us to print files to standard output (pr) or to a line printer (lp/lpr) while filtering the output. The BSD and SysV printer commands use different names and different options to produce the same results: lpr, lprm, and lpq vs lp, cancel, and lpstat for the BSD and SysV submit, cancel, and check the status of a print job, respectively.

4.2.1 lp/lpr - submit a print job

lp and lpr submit the specified file, or standard input, to the printer daemon to be printed. Each job is given a unique request-id that can be used to follow or cancel the job while it’s in the queue.

Syntax

lp [options] filename
lpr [options] filename

Common Options

<table>
<thead>
<tr>
<th>lpr</th>
<th>lp</th>
</tr>
</thead>
<tbody>
<tr>
<td>-n number</td>
<td>-t title</td>
</tr>
<tr>
<td>-#number</td>
<td>-T title</td>
</tr>
<tr>
<td>-d destination</td>
<td>-d destination</td>
</tr>
<tr>
<td>-P printer</td>
<td>-d destination</td>
</tr>
<tr>
<td>-c (default)</td>
<td>(default)</td>
</tr>
<tr>
<td>-s</td>
<td>-o option</td>
</tr>
</tbody>
</table>

Files beginning with the string "%!" are assumed to contain PostScript commands.

Examples

To print the file ssh.ps:

% lp ssh.ps
    request id is lp-153 (1 file(s))

This submits the job to the queue for the default printer, lp, with the request-id lp-153.
4.2.2 \texttt{lpstat/lpq} - check the status of a print job

You can check the status of your print job with \texttt{lpstat} or \texttt{lpq}.

Syntax

\begin{verbatim}
lpstat [options]
lpq [options] [job#] [username]
\end{verbatim}

Common Options

\begin{tabular}{lll}
\textbf{lpstat} & \textbf{lpq} & \textbf{function} \\
-d & (defaults to lp) & list system default destination \\
-s & & summarize print status \\
-t & & print all status information \\
-u [login-ID-list] & & user list \\
-v & & list printers known to the system \\
-p printer\textunderscore dest & -P printer\textunderscore dest & list status of printer, \texttt{printer\_dest}
\end{tabular}

Examples

\begin{verbatim}
% lpstat
lp-153 frank 208068 Apr 29 15:14 on lp
\end{verbatim}

4.2.3 \texttt{cancel/lprm} - cancel a print job

Any user can cancel only their own print jobs.

Syntax

\begin{verbatim}
cancel [request-ID] [printer]
lprm [options] [job#] [username]
\end{verbatim}

Common Options

\begin{tabular}{lll}
\textbf{cancel} & \textbf{lprm} & \textbf{function} \\
-Pprinter & & specify printer \\
- & & all jobs for user \\
-u [login-ID-list] & & user list
\end{tabular}

Examples

To cancel the job submitted above:

\begin{verbatim}
% cancel lp-153
\end{verbatim}
4.2.4 **pr - prepare files for printing**

*pr* prints header and trailer information surrounding the formatted file. You can specify the number of pages, lines per page, columns, line spacing, page width, etc. to print, along with header and trailer information and how to treat `<tab>` characters.

**Syntax**

```
pr [options] file
```

**Common Options**

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+page_number</td>
<td>start printing with page page_number of the formatted input file</td>
</tr>
<tr>
<td>-column</td>
<td>number of columns</td>
</tr>
<tr>
<td>-a</td>
<td>modify -column option to fill columns in round-robin order</td>
</tr>
<tr>
<td>-d</td>
<td>double spacing</td>
</tr>
<tr>
<td>-e[char][gap]</td>
<td>tab spacing</td>
</tr>
<tr>
<td>-h header_string</td>
<td>header for each page</td>
</tr>
<tr>
<td>-l lines</td>
<td>lines per page</td>
</tr>
<tr>
<td>-t</td>
<td>don’t print the header and trailer on each page</td>
</tr>
<tr>
<td>-w width</td>
<td>width of page</td>
</tr>
</tbody>
</table>

**Examples**

The file containing the list of P. G. Wodehouse’s Lord Emsworth books could be printed, at 14 lines per page (including 5 header and 5 (empty) trailer lines) below, where the `-e` option specifies the `<tab>` conversion style:

```
% pr -l 14 -e42 wodehouse
```

```
Apr 29 11:11 1996  wodehouse_emsworth_books Page 1

Something Fresh [1915]          Uncle Dynamite [1948]
Leave it to Psmith [1923]        Pigs Have Wings [1952]
Summer Lightning [1929]          Cocktail Time [1958]
Heavy Weather [1933]             Service with a Smile [1961]
```
Blandings Castle and Elsewhere [1935]  Galahad at Blandings [1965]
Chapter 5  Shells

The shell sits between you and the operating system, acting as a command interpreter. It reads your terminal input and translates the commands into actions taken by the system. The shell is analogous to command.com in DOS. When you log into the system you are given a default shell. When the shell starts up it reads its startup files and may set environment variables, command search paths, and command aliases, and executes any commands specified in these files.

The original shell was the Bourne shell, sh. Every Unix platform will either have the Bourne shell, or a Bourne compatible shell available. It has very good features for controlling input and output, but is not well suited for the interactive user. To meet the latter need the C shell, csh, was written and is now found on most, but not all, Unix systems. It uses C type syntax, the language Unix is written in, but has a more awkward input/output implementation. It has job control, so that you can reattach a job running in the background to the foreground. It also provides a history feature which allows you to modify and repeat previously executed commands.

The default prompt for the Bourne shell is $ (or #, for the root user). The default prompt for the C shell is %.

Numerous other shells are available from the network. Almost all of them are based on either sh or csh with extensions to provide job control to sh, allow in-line editing of commands, page through previously executed commands, provide command name completion and custom prompt, etc. Some of the more well known of these may be on your favorite Unix system: the Korn shell, ksh, by David Korn and the Bourne Again SHell, bash, from the Free Software Foundations GNU project, both based on sh, the T-C shell, tcsh, and the extended C shell, cshe, both based on csh. Below we will describe some of the features of sh and csh so that you can get started.
5.1 **Built-in Commands**

The shells have a number of **built-in**, or native commands. These commands are executed directly in the shell and don’t have to call another program to be run. These built-in commands are different for the different shells.

5.1.1 **Sh**

For the Bourne shell some of the more commonly used built-in commands are:

- `:` null command
- `.` source (read and execute) commands from a file
- `case` case conditional loop
- `cd` change the working directory (default is $HOME)
- `echo` write a string to standard output
- `eval` evaluate the given arguments and feed the result back to the shell
- `exec` execute the given command, replacing the current shell
- `exit` exit the current shell
- `export` share the specified environment variable with subsequent shells
- `for` for conditional loop
- `if` if conditional loop
- `pwd` print the current working directory
- `read` read a line of input from stdin
- `set` set variables for the shell
- `test` evaluate an expression as true or false
- `trap` trap for a typed signal and execute commands
- `umask` set a default file permission mask for new files
- `unset` unset shell variables
- `wait` wait for a specified process to terminate
- `while` while conditional loop
5.1.2 Csh

For the C shell the more commonly used built-in functions are:

- **alias**: assign a name to a function
- **bg**: put a job into the background
- **cd**: change the current working directory
- **echo**: write a string to stdout
- **eval**: evaluate the given arguments and feed the result back to the shell
- **exec**: execute the given command, replacing the current shell
- **exit**: exit the current shell
- **fg**: bring a job to the foreground
- **foreach**: for conditional loop
- **glob**: do filename expansion on the list, but no "\" escapes are honored
- **history**: print the command history of the shell
- **if**: if conditional loop
- **jobs**: list or control active jobs
- **kill**: kill the specified process
- **limit**: set limits on system resources
- **logout**: terminate the login shell
- **nice command**: lower the scheduling priority of the process, **command**
- **nohup command**: do not terminate **command** when the shell exits
- **popd**: pop the directory stack and return to that directory
- **pushd**: change to the new directory specified and add the current one to the directory stack
- **rehash**: recreate the hash table of paths to executable files
- **repeat**: repeat a command the specified number of times
- **set**: set a shell variable
- **setenv**: set an environment variable for this and subsequent shells
- **source**: source (read and execute) commands from a file
- **stop**: stop the specified background job
- **switch**: switch conditional loop
- **umask**: set a default file permission mask for new files
- **unalias**: remove the specified alias name
- **unset**: unset shell variables
- **unsetenv**: unset shell environment variables
- **wait**: wait for all background processes to terminate
- **while**: while conditional loop
5.2 Environment Variables

Environmental variables are used to provide information to the programs you use. You can have both global environment and local shell variables. Global environment variables are set by your login shell and new programs and shells inherit the environment of their parent shell. Local shell variables are used only by that shell and are not passed on to other processes. A child process cannot pass a variable back to its parent process.

The current environment variables are displayed with the "env" or "printenv" commands. Some common ones are:

- **DISPLAY** The graphical display to use, e.g. nyssa:0.0
- **EDITOR** The path to your default editor, e.g. /usr/bin/vi
- **GROUP** Your login group, e.g. staff
- **HOME** Path to your home directory, e.g. /home/frank
- **HOST** The hostname of your system, e.g. nyssa
- **IFS** Internal field separators, usually any white space (defaults to tab, space and <newline>)
- **LOGNAME** The name you login with, e.g. frank
- **PATH** Paths to be searched for commands, e.g. /usr/bin:/usr/ucb:/usr/local/bin
- **PS1** The primary prompt string, Bourne shell only (defaults to $)
- **PS2** The secondary prompt string, Bourne shell only (defaults to >)
- **SHELL** The login shell you’re using, e.g. /usr/bin/csh
- **TERM** Your terminal type, e.g. xterm
- **USER** Your username, e.g. frank

Many environment variables will be set automatically when you login. You can modify them or define others with entries in your startup files or at anytime within the shell. Some variables you might want to change are **PATH** and **DISPLAY**. The **PATH** variable specifies the directories to be automatically searched for the command you specify. Examples of this are in the shell startup scripts below.

You set a global environment variable with a command similar to the following for the C shell:

```
% setenv NAME value
```

and for Bourne shell:

```
$ NAME=value; export NAME
```

You can list your global environmental variables with the **env** or **printenv** commands. You unset them with the **unsetenv** (C shell) or **unset** (Bourne shell) commands.

To set a local shell variable use the **set** command with the syntax below for C shell. Without options **set** displays all the local variables.

```
% set name=value
```

For the Bourne shell set the variable with the syntax:

```
$ name=value
```

The current value of the variable is accessed via the "$name", or "${name}" notation.
5.3 The Bourne Shell, sh

`sh` uses the startup file `.profile` in your home directory. There may also be a system-wide startup file, e.g. `/etc/profile`. If so, the system-wide one will be sourced (executed) before your local one.

A simple `.profile` could be the following:

```bash
PATH=/usr/bin:/usr/ucb:/usr/local/bin:. # set the PATH
export PATH # so that PATH is available to subshells

# Set a prompt
PS1="\`
hostname` `whoami`\` " # set the prompt, default is "$"

# functions
ls() { /bin/ls -sbF "$@";}
ll() { ls -al "$@";}

# Set the terminal type
stty erase ^H # set Control-H to be the erase key
eval `tset -Q -s -m ':?xterm'` # prompt for the terminal type, assume xterm

#

umask 077
```

Whenever a `#` symbol is encountered the remainder of that line is treated as a comment. In the `PATH` variable each directory is separated by a colon (`:`) and the dot (`.`) specifies that the current directory is in your path. If the latter is not set it’s a simple matter to execute a program in the current directory by typing:

```
./program_name
```

It’s actually a good idea not to have dot (`.`) in your path, as you may inadvertently execute a program you didn’t intend to when you `cd` to different directories.

A variable set in `.profile` is set only in the login shell unless you "export" it or `source .profile` from another shell. In the above example `PATH` is exported to any subshells. You can source a file with the built-in `"."` command of `sh`, i.e.:

```
./.profile
```

You can make your own functions. In the above example the function `ll` results in an "ls -al" being done on the specified files or directories.

With `stty` the erase character is set to Control-H (^H), which is usually the Backspace key.

The `tset` command prompts for the terminal type, and assumes "xterm" if we just hit <CR>. This command is run with the shell built-in, `eval`, which takes the result from the tset command and uses it as an argument for the shell. In this case the "-s" option to tset sets the `TERM` and `TERMCAP` variables and exports them.

The last line in the example runs the `umask` command with the option such that any files or directories you create will not have read/write/execute permission for `group` and `other`.

For further information about `sh` type "man sh" at the shell prompt.
5.4 The C Shell, csh

Csh uses the startup files .cshrc and .login. Some versions use a system-wide startup file, e.g. /etc/csh.login. Your .login file is sourced (executed) only when you login. Your .cshrc file is sourced every time you start a csh, including when you login. It has many similar features to .profile, but a different style of doing things. Here we use the set or setenv commands to initialize a variable, where set is used for this shell and setenv for this and any subshells. The environment variables: USER, TERM, and PATH, are automatically imported to and exported from the user, term, and path variables of the csh. So setenv doesn’t need to be done for these. The C shell uses the symbol, ~, to indicate the user’s home directory in a path, as in ~/.cshrc, or to specify another user’s login directory, as in ~username/.cshrc.

Predefined variables used by the C shell include:

- **argv**: The list of arguments of the current shell
- **cwd**: The current working directory
- **history**: Sets the size of the history list to save
- **home**: The home directory of the user; starts with $HOME
- **ignoreeof**: When set ignore EOF (^D) from terminals
- **noclobber**: When set prevent output redirection from overwriting existing files
- **noglob**: When set prevent filename expansion with wildcard pattern matching
- **path**: The command search path; starts with $PATH
- **prompt**: Set the command line prompt (default is %)
- **savehist**: number of lines to save in the history list to save in the .history file
- **shell**: The full pathname of the current shell; starts with $SHELL
- **status**: The exit status of the last command (0=normal exit, 1=failed command)
- **term**: Your terminal type, starts with $TERM
- **user**: Your username, starts with $USER

A simple .cshrc could be:

```bash
set path=/usr/bin /usr/ucb /usr/local/bin ~/bin . ) # set the path
set prompt = "{'hostname' 'whoami' !} " # set the primary prompt; default is "%
set noclobber # don't redirect output to existing files
set ignoreeof # ignore EOF (^D) for this shell
set history=100 savehist=50 # keep a history list and save it between logins
# aliases
alias h history # alias h to "history"
alias ls "/usr/bin/ls -sbF" # alias ls to "ls -sbF"
alias ll ls -al # alias ll to "ls -sbFal" (combining these options with those for "ls" above)
alias cd ’cd \!*;pwd’ # alias cd so that it prints the current working directory after the change
umask 077
```
Some new features here that we didn’t see in .profile are noclobber, ignoreeof, and history. **Noclobber** indicates that output will not be redirected to existing files, while **ignoreeof** specifies that EOF (^D) will not cause the login shell to exit and log you off the system.

With the **history** feature you can recall previously executed commands and re-execute them, with changes if desired.

An alias allows you to use the specified alias name instead of the full command. In the "ls" example above, typing "ls" will result in "/usr/bin/ls -sbF" being executed. You can tell which "ls" command is in your path with the built-in **which** command, i.e.:

```bash
which ls
ls: aliased to /usr/bin/ls -sbF
```

A simple **.login** could be:

```bash
# .login
stty erase ^H  # set Control-H to be the erase key
set noglob    # prevent wild card pattern matching
eval \(tset -Q -s -m ':?xterm'\)  # prompt for the terminal type, assume "xterm"
unset noglob  # re-enable wild card pattern matching
```

Setting and unsetting **noglob** around **tset** prevents it from being confused by any **csh** filename wild card pattern matching or expansion.

Should you make any changes to your startup files you can initiate the change by sourcing the changed file. For **csh** you do this with the built-in **source** command, i.e.:

```bash
source .cshrc
```

For further information about csh type "**man csh**" at the shell prompt.

### 5.5 Job Control

With the C shell, **csh**, and many newer shells including some newer Bourne shells, you can put jobs into the background at anytime by appending ";&" to the command, as with **sh**. After submitting a command you can also do this by typing ^Z (Control-Z) to suspend the job and then "bg" to put it into the background. To bring it back to the foreground type "fg".

You can have many jobs running in the background. When they are in the background they are no longer connected to the keyboard for input, but they may still display output to the terminal, interspersing with whatever else is typed or displayed by your current job. You may want to redirect I/O to or from files for the job you intend to background. Your keyboard is connected only to the current, foreground, job.

The built-in **jobs** command allows you to list your background jobs. You can use the **kill** command to kill a background job. With the 
\(\%n\) notation you can reference the \(n\)th background job with either of these commands, replacing \(n\) with the job number from the output of **jobs**. So kill the second background job with "**kill \%2**" and bring the third job to the foreground with "**fg \%3**".
5.6 History

The C shell, the Korn shell and some other more advanced shells, retain information about the former commands you’ve executed in the shell. How history is done will depend on the shell used. Here we’ll describe the C shell history features.

You can use the `history` and `savehist` variables to set the number of previously executed commands to keep track of in this shell and how many to retain between logins, respectively. You could put a line such as the following in `.cshrc` to save the last 100 commands in this shell and the last 50 through the next login.

```
set history=100 savehist=50
```

The shell keeps track of the history list and saves it in `~/.history` between logins.

You can use the built-in `history` command to recall previous commands, e.g. to print the last 10:

```
% history 10
52 cd workshop
53 ls
54 cd unix_intro
55 ls
56 pwd
57 date
58 w
59 alias
60 history
61 history 10
```

You can repeat the last command by typing `!!`:

```
% !!
53 ls
54 cd unix_intro
55 ls
56 pwd
57 date
58 w
59 alias
60 history
61 history 10
62 history 10
```
You can repeat any numbered command by prefacing the number with a !, e.g.:

```
% !57
```
```
date
Tue Apr 9 09:55:31 EDT 1996
```

Or repeat a command starting with any string by prefacing the starting unique part of the string with a !, e.g.:

```
% !da
```
```
date
Tue Apr 9 09:55:31 EDT 1996
```

When the shell evaluates the command line it first checks for history substitution before it interprets anything else. Should you want to use one of these special characters in a shell command you will need to escape, or quote it first, with a \ before the character, i.e. \!. The history substitution characters are summarized in the following table.

<table>
<thead>
<tr>
<th>Command</th>
<th>Substitution Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>!!</td>
<td>repeat last command</td>
</tr>
<tr>
<td>!n</td>
<td>repeat command number n</td>
</tr>
<tr>
<td>!-n</td>
<td>repeat command n from last</td>
</tr>
<tr>
<td>!str</td>
<td>repeat command that started with string str</td>
</tr>
<tr>
<td>!?str?</td>
<td>repeat command with str anywhere on the line</td>
</tr>
<tr>
<td>!?str?%</td>
<td>select the first argument that had str in it</td>
</tr>
<tr>
<td>!:</td>
<td>repeat the last command, generally used with a modifier</td>
</tr>
<tr>
<td>!:n</td>
<td>select the n\textsuperscript{th} argument from the last command (n=0 is the command name)</td>
</tr>
<tr>
<td>!:n-m</td>
<td>select the n\textsuperscript{th} through m\textsuperscript{th} arguments from the last command</td>
</tr>
<tr>
<td>!^</td>
<td>select the first argument from the last command (same as !:1)</td>
</tr>
<tr>
<td>!$</td>
<td>select the last argument from the last command</td>
</tr>
<tr>
<td>!*</td>
<td>select all arguments to the previous command</td>
</tr>
<tr>
<td>!:*</td>
<td>select the n\textsuperscript{th} through last arguments from the previous command</td>
</tr>
<tr>
<td>!n-</td>
<td>select the n\textsuperscript{th} through next to last arguments from the previous command</td>
</tr>
<tr>
<td>^str1^str2^</td>
<td>replace str1 with str2 in its first occurrence in the previous command</td>
</tr>
<tr>
<td>!n:s/str1/str2/</td>
<td>substitute str1 with str2 in its first occurrence in the n\textsuperscript{th} command, ending with a g substitute globally</td>
</tr>
</tbody>
</table>

Additional editing modifiers are described in the \texttt{man page}.  

---

**TABLE 5.1**  

<table>
<thead>
<tr>
<th>C Shell History Substitution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Command</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>!!</td>
</tr>
<tr>
<td>!n</td>
</tr>
<tr>
<td>!-n</td>
</tr>
<tr>
<td>!str</td>
</tr>
<tr>
<td>!?str?</td>
</tr>
<tr>
<td>!?str?%</td>
</tr>
<tr>
<td>!:</td>
</tr>
<tr>
<td>!:n</td>
</tr>
<tr>
<td>!:n-m</td>
</tr>
<tr>
<td>!^</td>
</tr>
<tr>
<td>!$</td>
</tr>
<tr>
<td>!*</td>
</tr>
<tr>
<td>!:*</td>
</tr>
<tr>
<td>!n-</td>
</tr>
<tr>
<td>^str1^str2^</td>
</tr>
<tr>
<td>!n:s/str1/str2/</td>
</tr>
</tbody>
</table>

---
5.7 Changing your Shell

To change your shell you can usually use the "chsh" or "passwd -e" commands. The option flag, here -e, may vary from system to system (-s on BSD based systems), so check the man page on your system for proper usage. Sometimes this feature is disabled. If you can’t change your shell check with your System Administrator.

The new shell must be the full path name for a valid shell on the system. Which shells are available to you will vary from system to system. The full path name of a shell may also vary. Normally, though, the Bourne and C shells are standard, and available as:

/bin/sh
/bin/csh

Some systems will also have the Korn shell standard, normally as:

/bin/ksh

Some shells that are quite popular, but not normally distributed by the OS vendors are bash and tcsh. These might be placed in /bin or a locally defined directory, e.g. /usr/local/bin or /opt/local/bin. Should you choose a shell not standard to the OS make sure that this shell, and all login shells available on the system, are listed in the file /etc/shells. If this file exists and your shell is not listed in this file the file transfer protocol daemon, ftpd, will not let you connect to this machine. If this file does not exist only accounts with "standard" shells are allowed to connect via ftp.

You can always try out a shell before you set it as your default shell. To do this just type in the shell name as you would any other command.
CHAPTER 6 Special Unix Features

One of the most important contributions Unix has made to Operating Systems is the provision of many utilities for doing common tasks or obtaining desired information. Another is the standard way in which data is stored and transmitted in Unix systems. This allows data to be transmitted to a file, the terminal screen, or a program, or from a file, the keyboard, or a program; always in a uniform manner. The standardized handling of data supports two important features of Unix utilities: I/O redirection and piping.

With output redirection, the output of a command is redirected to a file rather than to the terminal screen. With input redirection, the input to a command is given via a file rather than the keyboard. Other tricks are possible with input and output redirection as well, as you will see. With piping, the output of a command can be used as input (piped) to a subsequent command. In this chapter we discuss many of the features and utilities available to Unix users.

6.1 File Descriptors

There are 3 standard file descriptors:

- stdin 0 Standard input to the program
- stdout 1 Standard output from the program
- stderr 2 Standard error output from the program

Normally input is from the keyboard or a file. Output, both stdout and stderr, normally go to the terminal, but you can redirect one or both of these to one or more files.

You can also specify additional file descriptors, designating them by a number 3 through 9, and redirect I/O through them.

6.2 File Redirection

Output redirection takes the output of a command and places it into a named file. Input redirection reads the file as input to the command. The following table summarizes the redirection options.
An example of output redirection is:

```
cat file1 file2 > file3
```

The above command concatenates `file1` then `file2` and redirects (sends) the output to `file3`. If `file3` doesn't already exist it is created. If it does exist it will either be truncated to zero length before the new contents are inserted, or the command will be rejected, if the `noclobber` option of the `csh` is set. (See the `csh` in Chapter 4). The original files, `file1` and `file2`, remain intact as separate entities.

Output is appended to a file in the form:

```
cat file1 >> file2
```

This command appends the contents of `file1` to the end of what already exists in `file2`. (Does not overwrite `file2`).

Input is redirected from a file in the form:

```
program < file
```

This command takes the input for `program` from `file`.

To pipe output to another command use the form:

```
command | command
```

This command makes the output of the first command the input of the second command.

### 6.2.1 Csh

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Redirection</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;</td>
<td>output redirect</td>
</tr>
<tr>
<td>&gt;!</td>
<td>same as above, but overrides <code>noclobber</code> option of <code>csh</code></td>
</tr>
<tr>
<td>&gt;&gt;</td>
<td>append output</td>
</tr>
<tr>
<td>&gt;&gt;!</td>
<td>same as above, but overrides <code>noclobber</code> option on <code>csh</code> and creates the file if it doesn’t already exist.</td>
</tr>
<tr>
<td>[</td>
<td>pipe output to another command</td>
</tr>
<tr>
<td>&lt;</td>
<td>input redirection</td>
</tr>
<tr>
<td>&lt;&lt;String</td>
<td>read from standard input until &quot;String&quot; is encountered as the only thing on the line. Also known as a &quot;here document&quot; (see Chapter 8).</td>
</tr>
<tr>
<td>&lt;&lt;=String</td>
<td>same as above, but don’t allow shell substitutions</td>
</tr>
</tbody>
</table>

TABLE 6.1 File Redirection

An example of output redirection is:

```
cat file1 file2 > file3
```

To redirect stdout and stderr to two separate files you need to first redirect stdout in a sub-shell, as in:

```
% (command > out_file) >& err_file
```
6.2.2 Sh

2> file  
> file 2>&1  
>> file 2>&1  
2>&1 | command

direct stderr to file

direct both stdout and stderr to file
append both stdout and stderr to file
pipe stdout and stderr to command

To redirect stdout and stderr to two separate files you can do:

$ command 1> out_file 2> err_file

or, since the redirection defaults to stdout:

$ command > out_file 2> err_file

With the Bourne shell you can specify other file descriptors (3 through 9) and redirect output through them. This is done with the form:

n>&m  

redirect file descriptor n to file descriptor m

We used the above to send stderr (2) to the same place as stdout (1), 2>&1, when we wanted to have error messages and normal messages to go to file instead of the terminal. If we wanted only the error messages to go to the file we could do this by using a place holder file descriptor, 3. We’ll first redirect 3 to 2, then redirect 2 to 1, and finally, we’ll redirect 1 to 3:

$ (command 3>&2 2>&1 1>&3) > file

This sends stderr to 3 then to 1, and stdout to 3, which is redirected to 2. So, in effect, we’ve reversed file descriptors 1 and 2 from their normal meaning. We might use this in the following example:

$ (cat file 3>&2 2>&1 1>&3) > errfile

So if file is read the information is discarded from the command output, but if file can’t be read the error message is put in errfile for your later use.

You can close file descriptors when you’re done with them:

m<&-  
<&-  
m>&-  
>&-

closes an input file descriptor

closes stdin

closes an output file descriptor

closes stdout
6.3 Other Special Command Symbols

In addition to file redirection symbols there are a number of other special symbols you can use on a command line. These include:

; command separator
& run the command in the background
&& run the command following this only if the previous command completes successfully, e.g.:
    grep string file && cat file
|| run the command following only if the previous command did not complete successfully, e.g.:
    grep string file || echo "String not found."
() the commands within the parentheses are executed in a subshell. The output of the subshell can be manipulated as above.
" " literal quotation marks. Don’t allow any special meaning to any characters within these quotations.
\ escape the following character (take it literally)
" " regular quotation marks. Allow variable and command substitution with these quotations (does not disable $ and \ within the string).
‘command‘ take the output of this command and substitute it as an argument(s) on the command line
# everything following until <newline> is a comment

The \ character can also be used to escape the <newline> character so that you can continue a long command on more than one physical line of text.

6.4 Wild Cards

The shell and some text processing programs will allow meta-characters, or wild cards, and replace them with pattern matches. For filenames these meta-characters and their uses are:

? match any single character at the indicated position
* match any string of zero or more characters
[abc...] match any of the enclosed characters
[a-e] match any characters in the range a,b,c,d,e
[!def] match any characters not one of the enclosed characters, sh only
{abc,bcd,cde} match any set of characters separated by comma (,) (no spaces), csh only
~ home directory of the current user, csh only
~user home directory of the specified user, csh only
7.1 Regular Expression Syntax

Some text processing programs, such as `grep`, `egrep`, `sed`, `awk` and `vi`, let you search on patterns instead of fixed strings. These text patterns are known as regular expressions. You form a regular expression by combining normal characters and special characters, also known as meta-characters, with the rules below. With these regular expressions you can do pattern matching on text data. Regular expressions come in three different forms:

- **Anchors** which tie the pattern to a location on the line
- **Character sets** which match a character at a single position
- **Modifiers** which specify how many times to repeat the previous expression

Regular expression syntax is as follows. Some programs will accept all of these, others may only accept some.

- `.` match any single character except <newline>
- `*` match zero or more instances of the single character (or meta-character) immediately preceding it
- `[abc]` match any of the characters enclosed
- `[a-d]` match any character in the enclosed range
- `[^exp]` match any character not in the following expression
- `^abc` the regular expression must start at the beginning of the line (Anchor)
- `abc$` the regular expression must end at the end of the line (Anchor)
- `\` treat the next character literally. This is normally used to escape the meaning of special characters such as "," and "*".
- `{n,m}` match the regular expression preceding this a minimum number of n times and a maximum of m times (0 through 255 are allowed for n and m). The `{` and `}` sets should be thought of as single operators. In this case the \ preceding the bracket does not escape its special meaning, but rather turns on a new one.
- `<abc>` will match the enclosed regular expression as long as it is a separate word. Word boundaries are defined as beginning with a <newline> or anything except a letter, digit or underscore (_) or ending with the same or a end-of-line character. Again the < and > sets should be thought of as single operators.
\(\text{\textbackslash(abc\)}\) saves the enclosed pattern in a buffer. Up to nine patterns can be saved for each line. You can reference these latter with the \text{\textbackslash n} character set. Again the \text{\textbackslash(} and \text{\textbackslash)} sets should be thought of as single operators.

\text{\textbackslash n} where \(n\) is between 1 and 9. This matches the \(n\)th expression previously saved for this line. Expressions are numbered starting from the left. The \text{\textbackslash n} should be thought of as a single operator.

\& print the previous search pattern (used in the replacement string)

There are a few meta-characters used only by \textit{awk} and \textit{egrep}. These are:

- \texttt{+} match one or more of the preceding expression
- \texttt{?} match zero or more of the preceding expression
- \texttt{|} separator. Match either the preceding or following expression.
- \texttt{( )} group the regular expressions within and apply the match to the set.

Some examples of the more commonly used regular expressions are:

<table>
<thead>
<tr>
<th>regular expression</th>
<th>matches</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{cat}</td>
<td>the string \texttt{cat}</td>
</tr>
<tr>
<td>\texttt{.at}</td>
<td>any occurrence of a letter, followed by \texttt{at}, such as \texttt{cat}, \texttt{rat}, \texttt{mat}, \texttt{bat}, \texttt{fat}, \texttt{hat}</td>
</tr>
<tr>
<td>\texttt{xy*z}</td>
<td>any occurrence of an \texttt{x}, followed by zero or more \texttt{y}'s, followed by a \texttt{z}.</td>
</tr>
<tr>
<td>\texttt{^cat}</td>
<td>\texttt{cat} at the beginning of the line</td>
</tr>
<tr>
<td>\texttt{cat$}</td>
<td>\texttt{cat} at the end of the line</td>
</tr>
<tr>
<td>\texttt{*}</td>
<td>any occurrence of an asterisk</td>
</tr>
<tr>
<td>\texttt{[cC]at}</td>
<td>\texttt{cat} or \texttt{Cat}</td>
</tr>
<tr>
<td>\texttt{[^a-zA-Z]}</td>
<td>any occurrence of a non-alphabetic character</td>
</tr>
<tr>
<td>\texttt{[0-9]$}</td>
<td>any line ending with a number</td>
</tr>
<tr>
<td>\texttt{[A-Z][A-Z]*/}</td>
<td>one or more upper case letters</td>
</tr>
<tr>
<td>\texttt{[A-Z]*}</td>
<td>zero or more upper case letters (In other words, anything.)</td>
</tr>
</tbody>
</table>
7.2 Text Processing Commands

This section provides an introduction to the use of regular expressions and `grep`.

The `grep` utility is used to search for generalized regular expressions occurring in Unix files. Regular expressions, such as those shown above, are best specified in apostrophes (or single quotes) when specified in the `grep` utility. The `egrep` utility provides searching capability using an extended set of meta-characters. The syntax of the `grep` utility, some of the available options, and a few examples are shown below.

**Syntax**

```
grep [options] regexp [file[s]]
```

**Common Options**

- `-i`  
  ignore case

- `-c`  
  report only a count of the number of lines containing matches, not the matches themselves

- `-v`  
  invert the search, displaying only lines that do not match

- `-n`  
  display the line number along with the line on which a match was found

- `-s`  
  work silently, reporting only the final status:
  0, for match(es) found
  1, for no matches
  2, for errors

- `-l`  
  list filenames, but not lines, in which matches were found
Examples

Consider the following file:

\{unix prompt 5\} cat num.list

1   15   fifteen
2   14   fourteen
3   13   thirteen
4   12   twelve
5   11   eleven
6   10   ten
7    9    nine
8    8    eight
9    7    seven
10   6    six
11   5    five
12   4    four
13   3    three
14   2    two
15   1    one

Here are some grep examples using this file. In the first we’ll search for the number 15:

\{unix prompt 6\} grep '15' num.list

1   15   fifteen
15   1    one

Now we’ll use the "-c" option to count the number of lines matching the search criterion:

\{unix prompt 7\} grep -c '15' num.list

2

Here we’ll be a little more general in our search, selecting for all lines containing the character 1 followed by either of 1, 2 or 5:

\{unix prompt 8\} grep '1[125]' num.list

1   15   fifteen
4   12   twelve
5   11   eleven
11   5    five
12   4    four
15   1    one
Now we’ll search for all lines that *begin* with a *space*:

```{unix prompt 9} grep '^ ' num.list
```

<table>
<thead>
<tr>
<th></th>
<th>15</th>
<th>fifteen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14</td>
<td>fourteen</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>thirteen</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>twelve</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>eleven</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>ten</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>nine</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>eight</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>seven</td>
</tr>
</tbody>
</table>

Or all lines that *don’t begin* with a *space*:

```{unix prompt 10} grep '^[^ ]' num.list
```

<table>
<thead>
<tr>
<th></th>
<th>6</th>
<th>six</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>5</td>
<td>five</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>four</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>three</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>two</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>one</td>
</tr>
</tbody>
</table>

The latter could also be done by using the `-v` option with the original search string, e.g.:

```{unix prompt 11} grep -v '^ ' num.list
```

<table>
<thead>
<tr>
<th></th>
<th>6</th>
<th>six</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>5</td>
<td>five</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>four</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>three</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>two</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>one</td>
</tr>
</tbody>
</table>

Here we search for all lines that *begin* with the characters *1 through 9*:

```{unix prompt 12} grep '^[1-9]' num.list
```

<table>
<thead>
<tr>
<th></th>
<th>6</th>
<th>six</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>5</td>
<td>five</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>four</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>three</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>two</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>one</td>
</tr>
</tbody>
</table>
This example will search for any instances of t followed by zero or more occurrences of e:

{unix prompt 13} grep 'te*' num.list

1      15      fifteen
2      14      fourteen
3      13      thirteen
4      12      twelve
6      10      ten
8      8       eight
13     3       three
14     2       two

This example will search for any instances of t followed by one or more occurrences of e:

{unix prompt 14} grep 'tee*' num.list

1      15      fifteen
2      14      fourteen
3      13      thirteen
6      10      ten

We can also take our input from a program, rather than a file. Here we report on any lines output by the who program that begin with the letter I.

{unix prompt 15} who | grep '^l'

lcondron ttyp0  Dec  1 02:41   (lcondron-pc.acs.)
7.2.2 sed

The non-interactive, stream editor, sed, edits the input stream, line by line, making the specified changes, and sends the result to standard output.

Syntax

```
sed [options] edit_command [file]
```

The format for the editing commands are:

```
[address1[,address2]][function][arguments]
```

where the addresses are optional and can be separated from the function by spaces or tabs. The function is required. The arguments may be optional or required, depending on the function in use.

Line-number Addresses are decimal line numbers, starting from the first input line and incremented by one for each. If multiple input files are given the counter continues cumulatively through the files. The last input line can be specified with the "$" character.

Context Addresses are the regular expression patterns enclosed in slashes (/).

Commands can have 0, 1, or 2 comma-separated addresses with the following affects:

<table>
<thead>
<tr>
<th># of addresses</th>
<th>lines affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>every line of input</td>
</tr>
<tr>
<td>1</td>
<td>only lines matching the address</td>
</tr>
<tr>
<td>2</td>
<td>first line matching the first address and all lines until, and including, the line matching the second address. The process is then repeated on subsequent lines.</td>
</tr>
</tbody>
</table>

Substitution functions allow context searches and are specified in the form:

```
s/regular_expression_pattern/replacement_string/flag
```

and should be quoted with single quotes (’) if additional options or functions are specified. These patterns are identical to context addresses, except that while they are normally enclosed in slashes (/), any normal character is allowed to function as the delimiter, other than <space> and <newline>. The replacement string is not a regular expression pattern; characters do not have special meanings here, except:

```
& substitute the string specified by regular_expression_pattern
\n substitute the nth string matched by regular_expression_pattern enclosed in '(', ')' pairs.
```

These special characters can be escaped with a backslash (\) to remove their special meaning.
Common Options

- `e script`    edit script
- `n`          don’t print the default output, but only those lines specified by p or s///p functions
- `f script_file` take the edit scripts from the file, script_file

Valid flags on the substitution functions include:

- `d` delete the pattern
- `g` globally substitute the pattern
- `p` print the line

Examples

This example changes all incidents of a comma (,) into a comma followed by a space (, ) when doing output:

% cat filey | sed s/,/ ,/g

The following example removes all incidents of Jr preceded by a space ( Jr) in filey:

% cat filey | sed s/ \Jr//g

To perform multiple operations on the input precede each operation with the `-e` (edit) option and quote the strings. For example, to filter for lines containing "Date: " and "From: " and replace these without the colon (:), try:

```
sed -e 's/Date: /Date /' -e 's/From: /From /'
```

To print only those lines of the file from the one beginning with "Date:" up to, and including, the one beginning with "Name:" try:

```
sed -n '/^Date:/,/^Name:/p'
```

To print only the first 10 lines of the input (a replacement for `head`):

```
sed -n 1,10p
```
7.2.3 awk, nawk, gawk

*awk* is a pattern scanning and processing language. Its name comes from the last initials of the three authors: Alfred. V. Aho, Brian. W. Kernighan, and Peter. J. Weinberger. *nawk* is *new awk*, a newer version of the program, and *gawk* is *gnu awk*, from the Free Software Foundation. Each version is a little different. Here we’ll confine ourselves to simple examples which should be the same for all versions. On some OSs *awk* is really *nawk*.

*awk* searches its input for patterns and performs the specified operation on each line, or fields of the line, that contain those patterns. You can specify the pattern matching statements for *awk* either on the command line, or by putting them in a file and using the `-f program_file` option.

**Syntax**

```
awk program [file]
```

where `program` is composed of one or more:

```
  pattern { action }
```

fields. Each input line is checked for a pattern match with the indicated action being taken on a match. This continues through the full sequence of patterns, then the next line of input is checked.

**Input** is divided into records and fields. The default record separator is `<newline>`, and the variable NR keeps the record count. The default field separator is whitespace, spaces and tabs, and the variable NF keeps the field count. Input field, FS, and record, RS, separators can be set at any time to match any single character. Output field, OFS, and record, ORS, separators can also be changed to any single character, as desired. $n, where n is an integer, is used to represent the nth field of the input record, while $0 represents the entire input record.

BEGIN and END are special patterns matching the beginning of input, before the first field is read, and the end of input, after the last field is read, respectively.

**Printing** is allowed through the `print`, and formatted print, `printf`, statements.

**Patterns** may be regular expressions, arithmetic relational expressions, string-valued expressions, and boolean combinations of any of these. For the latter the patterns can be combined with the boolean operators below, using parentheses to define the combination:

```
|| or
& & and
!
```

Comma separated patterns define the range for which the pattern is applicable, e.g.:

```
/first/..last/
```

selects all lines starting with the one containing first, and continuing inclusively, through the one containing last.
To select lines 15 through 20 use the pattern range:

\[ \text{NR} == 15, \text{NR} == 20 \]

**Regular expressions** must be enclosed with slashes (/) and meta-characters can be escaped with the backslash (\). Regular expressions can be grouped with the operators:

- `|` or, to separate alternatives
- `+` one or more
- `?` zero or one

A regular expression match can be either of:

- `~` contains the expression
- `!~` does not contain the expression

So the program:

\[ $1 ~ /\text{[Ff]rank}/ \]

is true if the first field, $1$, contains "Frank" or "frank" anywhere within the field. To match a field identical to "Frank" or "frank" use:

\[ $1 ~ /\text{^[Ff]rank\$}/ \]

**Relational expressions** are allowed using the relational operators:

- `<` less than
- `<=` less than or equal to
- `==` equal to
- `>=` greater than or equal to
- `!=` not equal to
- `>` greater than

Offhand you don’t know if variables are strings or numbers. If neither operand is known to be numeric, than string comparisons are performed. Otherwise, a numeric comparison is done. In the absence of any information to the contrary, a string comparison is done, so that:

\[ $1 > $2 \]

will compare the string values. To ensure a numerical comparison do something similar to:

\[ ( $1 + 0 ) > $2 \]

The **mathematical functions**: `exp`, `log` and `sqrt` are built-in.
Some other **built-in functions** include:

- \texttt{index(s,t)} returns the position of string \texttt{s} where \texttt{t} first occurs, or 0 if it doesn’t occur.
- \texttt{length(s)} returns the length of string \texttt{s}.
- \texttt{substr(s,m,n)} returns the \texttt{n}-character substring of \texttt{s}, beginning at position \texttt{m}.

**Arrays** are declared automatically when they are used, e.g.:

\begin{verbatim}
arr[i] = $1
\end{verbatim}

assigns the first field of the current input record to the \texttt{i}th element of the array.

Flow control statements using **if-else**, **while**, and **for** are allowed with \texttt{C} type syntax:

\begin{verbatim}
for (i=1; i <= NF; i++) {actions}
while (i<=NF) {actions}
if (i<NF) {actions}
\end{verbatim}

**Common Options**

- \texttt{-f program_file} read the commands from \texttt{program_file}
- \texttt{-Fc} use character \texttt{c} as the field separator character

**Examples**

\begin{verbatim}
% cat filex \tr a-z A-Z \texttt{awk -F: '{printf ("7R %6s %9s %24s \n",$1,$2,$3)}'} upload.file
\end{verbatim}

\texttt{cats filex}, which is formatted as follows:

\begin{verbatim}
nfb791:99999999:smith
7ax791:999999999:jones
8ab792:99999999:chen
8aa791:999999999:mcnulty
\end{verbatim}

changes all lower case characters to upper case with the **tr** utility, and formats the file into the following which is written into the file **upload.file**:

\begin{verbatim}
7R NFB791 99999999 SMITH
7R 7AX791 999999999 JONES
7R 8AB792 99999999 CHEN
7R 8AA791 999999999 MCNULTY
\end{verbatim}
CHAPTER 8

Other Useful Commands

8.1 Working With Files

This section will describe a number of commands that you might find useful in examining and manipulating the contents of your files.

### TABLE 8.1

<table>
<thead>
<tr>
<th>Command/Syntax</th>
<th>What it will do</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>cmp [options] file1 file2</code></td>
<td>compare two files and list where differences occur (text or binary files)</td>
</tr>
<tr>
<td><code>cut [options] [file(s)]</code></td>
<td>cut specified field(s)/character(s) from lines in file(s)</td>
</tr>
<tr>
<td><code>diff [options] file1 file2</code></td>
<td>compare the two files and display the differences (text files only)</td>
</tr>
<tr>
<td><code>file [options] file</code></td>
<td>classify the file type</td>
</tr>
<tr>
<td><code>find directory [options] [actions]</code></td>
<td>find files matching a type or pattern</td>
</tr>
<tr>
<td><code>ln [options] source_file target</code></td>
<td>link the <code>source_file</code> to the <code>target</code></td>
</tr>
<tr>
<td><code>paste [options] file</code></td>
<td>paste field(s) onto the lines in file</td>
</tr>
<tr>
<td><code>sort [options] file</code></td>
<td>sort the lines of the <code>file</code> according to the options chosen</td>
</tr>
<tr>
<td><code>strings [options] file</code></td>
<td>report any sequence of 4 or more printable characters ending in &lt;NL&gt; or &lt;NULL&gt;. Usually used to search binary files for ASCII strings.</td>
</tr>
<tr>
<td><code>tee [options] file</code></td>
<td>copy stdout to one or more files</td>
</tr>
<tr>
<td><code>touch [options] [date] file</code></td>
<td>create an empty file, or update the access time of an existing file</td>
</tr>
<tr>
<td><code>tr [options] string1 string2</code></td>
<td>translate the characters in string1 from stdin into those in string2 in stdout</td>
</tr>
<tr>
<td><code>uniq [options] file</code></td>
<td>remove repeated lines in a file</td>
</tr>
<tr>
<td><code>wc [options] [file(s)]</code></td>
<td>display word (or character or line) count for <code>file(s)</code></td>
</tr>
</tbody>
</table>
8.1.1 cmp - compare file contents

The *cmp* command compares two files, and (without options) reports the location of the first difference between them. It can deal with both binary and ASCII file comparisons. It does a byte-by-byte comparison.

**Syntax**

```
cmp [options] file1 file2 [skip1] [skip2]
```

The *skip* numbers are the number of bytes to skip in each file before starting the comparison.

**Common Options**

- `-l` report on each difference
- `-s` report exit status only, not byte differences

**Examples**

Given the files mon.logins:and tues.logins:

```
ageorge ageorge
bsmith cbetts
cbetts jchen
jchen jdoe
jmarsch jmarsch
lkeres lkeres
mschmidt proy
sphillip sphillip
wyepp wyepp
```

The comparison of the two files yields:

```
% cmp mon.logins tues.logins
mon.logins tues.logins differ: char 9, line 2
```

The default it to report only the first difference found.

This command is useful in determining which version of a file should be kept when there is more than one version.
8.1.2 diff - differences in files

The *diff* command compares two files, directories, etc, and reports all differences between the two. It deals only with ASCII files. It’s output format is designed to report the changes necessary to convert the first file into the second.

Syntax

```bash
diff [options] file1 file2
```

**Common Options**

- `-b` ignore trailing blanks
- `-i` ignore the case of letters
- `-w` ignore `<space>` and `<tab>` characters
- `-e` produce an output formatted for use with the editor, *ed*
- `-r` apply diff recursively through common sub-directories

**Examples**

For the *mon.logins* and *tues.logins* files above, the difference between them is given by:

```
% diff mon.logins tues.logins
  2d1
  < bsmith
  4a4
  > jdoe
  7c7
  < mschmidt
  ---
  > proy
```

Note that the output lists the differences as well as in which file the difference exists. Lines in the first file are preceded by "< "}, and those in the second file are preceded by "> ".

8.1.3 cut - select parts of a line

The *cut* command allows a portion of a file to be extracted for another use.

Syntax

```
cut [options] file
```

**Common Options**

- `-c` character_list character positions to select (first character is 1)
- `-d` delimiter field delimiter (defaults to `<TAB>`)  
- `-f` field_list fields to select (first field is 1)

Both the character and field lists may contain comma-separated or blank-character-separated numbers (in increasing order), and may contain a hyphen (-) to indicate a range. Any numbers missing at either before (e.g. -5) or after (e.g. 5-) the hyphen indicates the full range starting with the first, or ending with the last character or field, respectively. Blank-character-separated lists must be enclosed in quotes. The field delimiter should be enclosed in quotes if it has special meaning to the shell, e.g. when specifying a `<space>` or `<TAB>` character.

**Examples**

In these examples we will use the file *users*:

```
  jdoe   John Doe   4/15/96
  lsmith Laura Smith 3/12/96
  pchen  Paul Chen 1/5/96
  jhsu   Jake Hsu 4/17/96
  sphilip Sue Phillip 4/2/96
```

If you only wanted the username and the user's real name, the *cut* command could be used to get only that information:

```
% cut -f 1,2 users
  jdoe   John Doe
  lsmith Laura Smith
  pchen  Paul Chen
  jhsu   Jake Hsu
  sphilip Sue Phillip
```
The `cut` command can also be used with other options. The `-c` option allows characters to be the selected cut. To select the first 4 characters:

```
% cut -c 1-4 users
```

This yields:

```
jdoe
lsmi
pche
jhsu
sphi
```

thus cutting out only the first 4 characters of each line.

### 8.1.4 `paste` - merge files

The `paste` command allows two files to be combined side-by-side. The default delimiter between the columns in a paste is a tab, but options allow other delimiters to be used.

**Syntax**

```
paste [options] file1 file2
```

**Common Options**

- `-d` list
  - list of delimiting characters
- `-s`
  - concatenate lines

The list of delimiters may include a single character such as a comma; a quoted string, such as a space; or any of the following escape sequences:

- `
`  \ `<newline> character`
- `\t`  \ `<tab> character`
- `\\`  \ `backslash character`
- `\\`  \ `empty string (non-null character)`

It may be necessary to quote delimiters with special meaning to the shell.

A hyphen (`-`) in place of a file name is used to indicate that field should come from standard input.
Examples

Given the file **users**:  

<table>
<thead>
<tr>
<th>username</th>
<th>real name</th>
<th>last login</th>
<th>phone number</th>
</tr>
</thead>
<tbody>
<tr>
<td>jdoe</td>
<td>John Doe</td>
<td>4/15/96</td>
<td></td>
</tr>
<tr>
<td>lsmith</td>
<td>Laura Smith</td>
<td>3/12/96</td>
<td></td>
</tr>
<tr>
<td>pchen</td>
<td>Paul Chen</td>
<td>1/5/96</td>
<td></td>
</tr>
<tr>
<td>jhsu</td>
<td>Jake Hsu</td>
<td>4/17/96</td>
<td></td>
</tr>
<tr>
<td>sphilip</td>
<td>Sue Phillip</td>
<td>4/2/96</td>
<td></td>
</tr>
</tbody>
</table>

and the file **phone**:

<table>
<thead>
<tr>
<th>username</th>
<th>phone number</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Doe</td>
<td>555-6634</td>
</tr>
<tr>
<td>Laura Smith</td>
<td>555-3382</td>
</tr>
<tr>
<td>Paul Chen</td>
<td>555-0987</td>
</tr>
<tr>
<td>Jake Hsu</td>
<td>555-1235</td>
</tr>
<tr>
<td>Sue Phillip</td>
<td>555-7623</td>
</tr>
</tbody>
</table>

the **paste** command can be used in conjunction with the **cut** command to create a new file, **listing**, that includes the username, real name, last login, and phone number of all the users. First, extract the phone numbers into a temporary file, **temp.file**:

```bash
% cut -f2 phone > temp.file
```

```plaintext
555-6634
555-3382
555-0987
555-1235
555-7623
```

The result can then be pasted to the end of each line in **users** and directed to the new file, **listing**:

```bash
% paste users temp.file > listing
```

```plaintext
jdoe John Doe 4/15/96 237-6634
lsmith Laura Smith 3/12/96 878-3382
pchen Paul Chen 1/5/96 888-0987
jhsu Jake Hsu 4/17/96 545-1235
sphilip Sue Phillip 4/2/96 656-7623
```

This could also have been done on one line without the temporary file as:

```bash
% cut -f2 phone | paste users - > listing
```

with the same results. In this case the hyphen (−) is acting as a placeholder for an input field (namely, the output of the **cut** command).
8.1.5 touch - create a file

The touch command can be used to create a new (empty) file or to update the last access date/time on an existing file. The command is used primarily when a script requires the pre-existence of a file (for example, to which to append information) or when the script is checking for last date or time a function was performed.

Syntax

```
touch [options] [date_time] file

touch [options] [-t time] file
```

Common Options

- `-a` change the access time of the file (SVR4 only)
- `-c` don’t create the file if it doesn’t already exist
- `-f` force the touch, regardless of read/write permissions
- `-m` change the modification time of the file (SVR4 only)
- `-t` time use the time specified, not the current time (SVR4 only)

When setting the "-t time" option it should be in the form:

```
[[CC]YY]MMDDhhmm[.SS]
```

where:

- `CC` first two digits of the year
- `YY` second two digits of the year
- `MM` month, 01-12
- `DD` day of month, 01-31
- `hh` hour of day, 00-23
- `mm` minute, 00-59
- `SS` second, 00-61

The date_time options has the form:

```
MMDDhhmm[YY]
```

where these have the same meanings as above.

The date cannot be set to be before 1969 or after January 18, 2038.

Examples

To create a file:

```
% touch filename
```
8.1.6 wc - count words in a file

`wc` stands for "word count"; the command can be used to count the number of lines, characters, or words in a file.

**Syntax**

```
wc [options] file
```

**Common Options**

- `-c` count bytes
- `-m` count characters (SVR4)
- `-l` count lines
- `-w` count words

If no options are specified it defaults to "-lwc".

**Examples**

Given the file `users`:

```
  jdoe  John Doe  4/15/96
  lsmit  Laura Smith  3/12/96
  pchen  Paul Chen  1/5/96
  jhsu  Jake Hsu  4/17/96
  sphilip  Sue Phillip  4/2/96
```

the result of using a `wc` command is as follows:

```
% wc users
   5   20   121 users
```

The first number indicates the number of lines in the file, the second number indicates the number of words in the file, and the third number indicates the number of characters.

Using the `wc` command with one of the options (`-l`, lines; `-w`, words; or `-c`, characters) would result in only one of the above. For example, "`wc -l users`" yields the following result:

```
  5 users
```
8.1.7 ln - link to another file

The `ln` command creates a "link" or an additional way to access (or gives an additional name to) another file.

**Syntax**

```
ln [options] source [target]
```

If not specified `target` defaults to a file of the same name in the present working directory.

**Common Options**

- `-f` force a link regardless of target permissions; don’t report errors (SVR4 only)
- `-s` make a symbolic link

**Examples**

A **symbolic link** is used to create a new path to another file or directory. If a group of users, for example, is accustomed to using a command called `chkmag`, but the command has been rewritten and is now called `chkit`, creating a symbolic link so the users will automatically execute `chkit` when they enter the command `chkmag` will ease transition to the new command.

A symbolic link would be done in the following way:

```
% ln -s chkit chkmag
```

The long listing for these two files is now as follows:

```
16 -rwxr-x---  1 lindadb  acs      15927 Apr 23 04:10 chkit
1 lrwxrwxrwx  1 lindadb  acs        5 Apr 23 04:11 chkmag -> chkit
```

Note that while the permissions for `chkmag` are open to all, since it is linked to `chkit`, the permissions, group and owner characteristics for `chkit` will be enforced when `chkmag` is run.

With a symbolic link, the link can exist without the file or directory it is linked to existing first.

A **hard link** can only be done to another file on the same file system, but not to a directory (except by the superuser). A hard link creates a new directory entry pointing to the same inode as the original file. The file linked to must exist before the hard link can be created. The file will not be deleted until all the hard links to it are removed. To link the two files above with a hard link to each other do:

```
% ln chkit chkmag
```

Then a long listing shows that the **inode** number (742) is the same for each:

```
% ls -il chkit chkmag
```

```
742 -rwxr-x---  2 lindadb acs      15927 Apr 23 04:10 chkit
742 -rwxr-x---  2 lindadb acs      15927 Apr 23 04:10 chkmag
```
8.1.8 sort - sort file contents

The sort command is used to order the lines of a file. Various options can be used to choose the order as well as the field on which a file is sorted. Without any options, the sort compares entire lines in the file and outputs them in ASCII order (numbers first, upper case letters, then lower case letters).

Syntax

```
sort [options] [+pos1 [ -pos2 ]] file
```

Common Options

- `-b` ignore leading blanks ( <space> & <tab> ) when determining starting and ending characters for the sort key
- `-d` dictionary order, only letters, digits, <space> and <tab> are significant
- `-f` fold upper case to lower case
- `-k` keydef sort on the defined keys (not available on all systems)
- `-i` ignore non-printable characters
- `-n` numeric sort
- `-o` outfile output file
- `-r` reverse the sort
- `-t` char use char as the field separator character
- `-u` unique; omit multiple copies of the same line (after the sort)
- `+pos1 [-pos2]` (old style) provides functionality similar to the "-k keydef" option.

For the +/-position entries pos1 is the starting word number, beginning with 0 and pos2 is the ending word number. When -pos2 is omitted the sort field continues through the end of the line. Both pos1 and pos2 can be written in the form w.c, where w is the word number and c is the character within the word. For c 0 specifies the delimiter preceding the first character, and 1 is the first character of the word. These entries can be followed by type modifiers, e.g. n for numeric, b to skip blanks, etc.

The keydef field of the "-k" option has the syntax:

```
start_field [type] [.end_field [type] ]
```

where:

- `start_field, end_field` define the keys to restrict the sort to a portion of the line
- `type` modifies the sort, valid modifiers are given the single characters (bdfiMnr)
  from the similar sort options, e.g. a type b is equivalent to "-b", but applies only to the specified field
Other Useful Commands

Examples

In the file users:

<table>
<thead>
<tr>
<th>Name</th>
<th>First Name</th>
<th>Last Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>jdoe</td>
<td>John Doe</td>
<td></td>
<td>4/15/96</td>
</tr>
<tr>
<td>lsmith</td>
<td>Laura Smith</td>
<td></td>
<td>3/12/96</td>
</tr>
<tr>
<td>pchen</td>
<td>Paul Chen</td>
<td></td>
<td>1/5/96</td>
</tr>
<tr>
<td>jhsu</td>
<td>Jake Hsu</td>
<td></td>
<td>4/17/96</td>
</tr>
<tr>
<td>sphilip</td>
<td>Sue Phillip</td>
<td></td>
<td>4/2/96</td>
</tr>
</tbody>
</table>

sort users yields the following:

<table>
<thead>
<tr>
<th>Name</th>
<th>First Name</th>
<th>Last Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>jdoe</td>
<td>John Doe</td>
<td></td>
<td>4/15/96</td>
</tr>
<tr>
<td>jhsu</td>
<td>Jake Hsu</td>
<td></td>
<td>4/17/96</td>
</tr>
<tr>
<td>lsmith</td>
<td>Laura Smith</td>
<td></td>
<td>3/12/96</td>
</tr>
<tr>
<td>pchen</td>
<td>Paul Chen</td>
<td></td>
<td>1/5/96</td>
</tr>
<tr>
<td>sphilip</td>
<td>Sue Phillip</td>
<td></td>
<td>4/2/96</td>
</tr>
</tbody>
</table>

If, however, a listing sorted by last name is desired, use the option to specify which field to sort on (fields are numbered starting at 0):

% sort +2 users:

<table>
<thead>
<tr>
<th>Name</th>
<th>First Name</th>
<th>Last Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>pchen</td>
<td>Paul Chen</td>
<td></td>
<td>1/5/96</td>
</tr>
<tr>
<td>jdoe</td>
<td>John Doe</td>
<td></td>
<td>4/15/96</td>
</tr>
<tr>
<td>jhsu</td>
<td>Jake Hsu</td>
<td></td>
<td>4/17/96</td>
</tr>
<tr>
<td>sphilip</td>
<td>Sue Phillip</td>
<td></td>
<td>4/2/96</td>
</tr>
<tr>
<td>lsmith</td>
<td>Laura Smith</td>
<td></td>
<td>3/12/96</td>
</tr>
</tbody>
</table>

To sort in reverse order:

% sort -r users:

<table>
<thead>
<tr>
<th>Name</th>
<th>First Name</th>
<th>Last Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>sphilip</td>
<td>Sue Phillip</td>
<td></td>
<td>4/2/96</td>
</tr>
<tr>
<td>pchen</td>
<td>Paul Chen</td>
<td></td>
<td>1/5/96</td>
</tr>
<tr>
<td>lsmith</td>
<td>Laura Smith</td>
<td></td>
<td>3/12/96</td>
</tr>
<tr>
<td>jhsu</td>
<td>Jake Hsu</td>
<td></td>
<td>4/17/96</td>
</tr>
<tr>
<td>jdoe</td>
<td>John Doe</td>
<td></td>
<td>4/15/96</td>
</tr>
</tbody>
</table>
A particularly useful sort option is the -u option, which eliminates any duplicate entries in a file while ordering the file. For example, the file todays.logins:

```
sphillip
ejchen
jdoe
lkeres
jmarsch
ageorge
lkeres
proy
jchen
```

shows a listing of each username that logged into the system today. If we want to know how many unique users logged into the system today, using sort with the -u option will list each user only once. (The command can then be piped into "wc -l" to get a number):

```
% sort -u todays.logins
ageorge
jchen
jdoe
jmarsch
lkeres
proy
sphillip
```
8.1.9 tee - copy command output

*tee* sends standard in to specified files and also to standard out. It’s often used in command pipelines.

**Syntax**

```
tee [options] [file[s]]
```

**Common Options**

- `-a`  append the output to the files
- `-i`  ignore interrupts

**Examples**

In this first example the output of *who* is displayed on the screen and stored in the file *users.file*:

```
brigadier: condron [55]> who | tee users.file
condron  ttyp0   Apr 22 14:10   (lcondron-pc.acs.)
frank    ttyp1   Apr 22 16:19   (nyssa)
condron  ttyp9   Apr 22 15:52   (lcondron-mac.acs)
```

```
brigadier: condron [56]> cat users.file
condron  ttyp0   Apr 22 14:10   (lcondron-pc.acs.)
frank    ttyp1   Apr 22 16:19   (nyssa)
condron  ttyp9   Apr 22 15:52   (lcondron-mac.acs)
```

In this next example the output of *who* is sent to the files *users.a* and *users.b*. It is also piped to the *wc* command, which reports the line count.

```
brigadier: condron [57]> who | tee users.a users.b | wc -l
3
```

```
brigadier: condron [58]> cat users.a
condron  ttyp0   Apr 22 14:10   (lcondron-pc.acs.)
frank    ttyp1   Apr 22 16:19   (nyssa)
condron  ttyp9   Apr 22 15:52   (lcondron-mac.acs)
```

```
brigadier: condron [59]> cat users.b
condron  ttyp0   Apr 22 14:10   (lcondron-pc.acs.)
frank    ttyp1   Apr 22 16:19   (nyssa)
condron  ttyp9   Apr 22 15:52   (lcondron-mac.acs)
```
In the following example a long directory listing is sent to the file `files.long`. It is also piped to the `grep` command which reports which files were last modified in August.

```
brigadier: condron [60]> ls -l | tee files.long | grep Aug
  1 drwxr-sr-x  2 condron       512 Aug  8  1995 News/
  2 -rw-r--r--  1 condron      1076 Aug  8  1995 magnus.cshrc
  2 -rw-r--r--  1 condron      1252 Aug  8  1995 magnus.login
brigadier: condron [63]> cat files.long
  total 34
  2 -rw-r--r--  1 condron      1253 Oct 10  1995 #.login#
  1 drwx------  2 condron       512 Oct 17  1995 Mail/
  1 drwxr-sr-x  2 condron       512 Aug  8  1995 News/
  5 -rw-r--r--  1 condron      4299 Apr 21 00:18 editors.txt
  2 -rw-r--r--  1 condron      1076 Aug  8  1995 magnus.cshrc
  2 -rw-r--r--  1 condron      1252 Aug  8  1995 magnus.login
  7 -rw-r--r--  1 condron      6436 Apr 21 23:50 resources.txt
  4 -rw-r--r--  1 condron      3094 Apr 18 18:24 telnet.ftp
  1 drwxr-sr-x  2 condron       512 Apr 21 23:56 uc/
  1 -rw-r--r--  1 condron      1002 Apr 22 00:14 uniq.tee.txt
  1 -rw-r--r--  1 condron      1001 Apr 20 15:05 uniq.tee.txt~
  7 -rw-r--r--  1 condron      6194 Apr 15 20:18 unixgrep.txt
```
8.1.10 uniq - remove duplicate lines

uniq filters duplicate adjacent lines from a file.

Syntax

```
uniq [options] [+|-n] file [file.new]
```

Common Options

- `-d` one copy of only the repeated lines
- `-u` select only the lines not repeated
- `+n` ignore the first `n` characters
- `-s n` same as above (SVR4 only)
- `-n` skip the first `n` fields, including any blanks (`<space>` & `<tab>`)  
- `-f fields` same as above (SVR4 only)

Examples

Consider the following file and example, in which `uniq` removes the 4th line from `file` and places the result in a file called `file.new`.

```
{unix prompt 1} cat file
  1 2 3 6
  4 5 3 6
  7 8 9 0
  7 8 9 0
{unix prompt 2} uniq file file.new
{unix prompt 3} cat file.new
  1 2 3 6
  7 8 9 0
```

Below, the `-n` option of the `uniq` command is used to skip the first 2 fields in `file`, and filter out lines which are duplicates from the 3rd field onward.

```
{unix prompt 4} uniq -2 file
  1 2 3 6
  7 8 9 0
```
8.1.11 strings - find ASCII strings

To search a binary file for printable, ASCII, strings use the strings command. It searches for any sequence of 4 or more ASCII characters terminated by a <newline> or null character. I find this command useful for searching for file names and possible error messages within compiled programs that I don’t have source code for.

Syntax

    strings [options] file

Common Options

- **-n number**  
  use number as the minimum string length, rather than 4 (SVR4 only)

- **-number**  
  same as above

- **-t format**  
  precede the string with the byte offset from the start of the file, where format is one of:  
  - d = decimal,
  - o = octal,
  - x = hexadecimal (SVR4 only)

- **-o**  
  precede the string with the byte offset in decimal (BSD only)

Examples

    % strings /bin/cut
    SUNW_OST_OSCMD
    no delimiter specified
    invalid delimiter
    b:c:d:f:ns
    cut: -n may only be used with -b
    cut: -d may only be used with -f
    cut: -s may only be used with -f
    no list specified
    cut: cannot open %s
    invalid range specifier
    too many ranges specified
    ranges must be increasing
    invalid character in range
    Internal error processing input
    invalid multibyte character
    unable to allocate enough memory
    unable to allocate enough memory
    cut:
    usage: cut -b list [-n] [filename ...]
    cut -c list [filename ...]
    cut -f list [-d delim] [-s] [filename]
8.1.12 file - file type
This program, `file`, examines the selected file and tries to determine what type of file it is. It does this by reading the first few bytes of the file and comparing them with the table in `/etc/magic`. It can determine ASCII text files, tar formatted files, compressed files, etc.

Syntax
```
file [options] [-m magic_file] [-f file_list] file
```

Common Options
- `-c` check the magic file for errors in format
- `-f file_list` `file_list` contains a list of files to examine
- `-h` don’t follow symbolic links (SVR4 only)
- `-L` follow symbolic links (BSD only)
- `-m magic_file` use `magic_file` as the magic file instead of `/etc/magic`

Examples
Below we list the output from the command "`file filename`" for some representative files.

```
/etc/magic: ascii text
/usr/local/bin/gzip: Sun demand paged SPARC executable dynamically linked
/usr/bin/cut: ELF 32-bit MSB executable SPARC Version 1, dynamically linked, stripped
source.tar: USTAR tar archive
source.tar.Z: compressed data block compressed 16 bits
```

8.1.13 tr - translate characters
The `tr` command translates characters from stdin to stdout.

Syntax
```
tr [options] string1 [string2]
```

With no options the characters in `string1` are translated into the characters in `string2`, character by character in the string arrays. The first character in `string1` is translated into the first character in `string2`, etc.

A range of characters in a string is specified with a hyphen between the upper and lower characters of the range, e.g. to specify all lower case alphabetic characters use `[a-z]`.

Repeated characters in `string2` can be represented with the `[x*n]` notation, where character `x` is repeated `n` times. If `n` is 0 or absent it is assumed to be as large as needed to match `string1`. 
Characters can include \texttt{octal} (BSD and SVR4) and \texttt{character} (SVR4 only) notation. Here "\texttt{octal}" is replaced by the one, two, or three octal integer sequence encoding the ASCII character and "\texttt{character}" can be one of:

\begin{itemize}
\item b \hspace{1cm} back space
\item f \hspace{1cm} form feed
\item n \hspace{1cm} new line
\item r \hspace{1cm} carriage return
\item t \hspace{1cm} tab
\item v \hspace{1cm} vertical tab
\end{itemize}

The SVR4 version of \texttt{tr} allows the operand "\texttt{:class:}" in the string field where \texttt{class} can take on character classification values, including:

\begin{itemize}
\item \texttt{alpha} \hspace{1cm} alphabetic characters
\item \texttt{lower} \hspace{1cm} lower case alphabetic characters
\item \texttt{upper} \hspace{1cm} upper case alphabetic characters
\end{itemize}

### Common Options

\begin{itemize}
\item \texttt{-c} \hspace{1cm} complement the character set in \texttt{string1}
\item \texttt{-d} \hspace{1cm} delete the characters in \texttt{string1}
\item \texttt{-s} \hspace{1cm} squeeze a string of repeated characters in \texttt{string1} to a single character
\end{itemize}

### Examples

The following examples will use as input the file, a list of P. G. Wodehouse Jeeves & Wooster books.

\begin{itemize}
\item The Inimitable Jeeves [1923]
\item Carry On, Jeeves [1925]
\item Very Good, Jeeves [1930]
\item Thank You, Jeeves [1934]
\item Right Ho, Jeeves [1934]
\item The Code of the Woosters [1938]
\item Joy in the Morning [1946]
\item The Mating Season [1949]
\item Ring for Jeeves [1953]
\item Jeeves and the Feudal Spirit [1954]
\item Jeeves in the Offing [1960]
\item Stiff Upper Lip, Jeeves [1963]
\item Much Obliged, Jeeves [1971]
\item Aunts Aren't Gentlemen [1974]
\end{itemize}

To translate all lower case alphabetic characters to upper case we could use either of:

\begin{itemize}
\item tr \texttt{'[a-z]' '[A-Z]'}
\item tr \texttt{'[[:lower:]:]' '[[:upper:]:]'}
\end{itemize}
Other Useful Commands

Since `tr` reads from stdin we first `cat` the file and pipe the output to `tr`, as in:

```bash
% cat wodehouse | tr `'[a-z]' `[A-Z]'`

THE INIMITABLE JEEVES [1923]       THE MATING SEASON [1949]
CARRY ON, JEEVES [1925]            RING FOR JEEVES [1953]
THANK YOU, JEEVES [1934]           JEEVES IN THE OFFING [1960]
RIGHT HO, JEEVES [1934]            STIFF UPPER LIP, JEEVES [1963]
```

We could delete all numbers with:

```bash
% cat wodehouse | tr -d ' [0-9]'`

The Inimitable Jeeves []       The Mating Season []
Carry On, Jeeves []            Ring for Jeeves []
Very Good, Jeeves []           Jeeves and the Feudal Spirit []
Thank You, Jeeves []           Jeeves in the Offing []
Right Ho, Jeeves []            Stiff Upper Lip, Jeeves []
The Code of the Woosters []     Much Obliged, Jeeves []
Joy in the Morning []          Aunts Aren't Gentlemen []
```

To squeeze all multiple occurrences of the characters e, r, and f:

```bash
% cat wodehouse | tr -s `erf`

The Inimitable Jeeves [1923]       The Mating Season [1949]
Carry On, Jeeves [1925]            Ring for Jeeves [1953]
Right Ho, Jeeves [1934]            Stiff Upper Lip, Jeeves [1963]
```
8.1.14 find - find files

The `find` command will recursively search the indicated directory tree to find files matching a type or pattern you specify. `find` can then list the files or execute arbitrary commands based on the results.

**Syntax**

```
fnd directory [search options] [actions]
```

**Common Options**

For the time search options the notation in days, `n` is:

- `+n` more than `n` days
- `n` exactly `n` days
- `-n` less than `n` days

Some file characteristics that `find` can search for are:

- `time` that the file was last accessed or changed
  - `-atime n` access time, true if accessed `n` days ago
  - `-ctime n` change time, true if the files status was changed `n` days ago
  - `-mtime n` modified time, true if the files data was modified `n` days ago
- `-newer filename` true if newer than `filename`
- `-type type` type of file, where `type` can be:
  - `b` block special file
  - `c` character special file
  - `d` directory
  - `l` symbolic link
  - `p` named pipe (fifo)
  - `f` regular file
- `-fstype type` type of file system, where `type` can be any valid file system type, e.g.: `ufs` (Unix File System) and `nfs` (Network File System)
- `-user username` true if the file belongs to the user `username`
- `-group groupname` true if the file belongs to the group `groupname`
- `-perm [-]mode` permissions on the file, where `mode` is the octal modes for the `chmod` command. When `mode` is precede by the minus sign only the bits that are set are compared.
- `-exec command` execute `command`. The end of `command` is indicated by and escaped semicolon (`;`). The `command` argument, `{}`, replaces the current path name.
- `-name filename` true if the file is named `filename`. Wildcard pattern matches are allowed if the meta-character is escaped from the shell with a backslash (`\`).
- `-ls` always true. It prints a long listing of the current pathname.
- `-print` print the pathnames found (default for SVR4, not for BSD)
Complex expressions are allowed. Expressions should be grouped within parenthesis (escaping the parenthesis with a backslash to prevent the shell from interpreting them). The exclamation symbol (!) can be used to **negate** an expression. The operators: `-a` (**and**) and `-o` (**or**) are used to group expressions.

**Examples**

`find` will recursively search through sub-directories, but for the purpose of these examples we will just use the following files:

- `14 -rw-r--r-- 1 frank staff 6682 Feb 5 10:04 library`
- `6 -r--r----- 1 frank staff 3034 Mar 16 1995 netfile`
- `34 -rw-r--r-- 1 frank staff 17351 Feb 5 10:04 standard`
- `2 -rwxr-xr-x 1 frank staff 386 Apr 26 09:51 tr25`

To find all files newer than the file, library:

```
% find . -newer library -print
./tr25
./standard
```

To find all files with general read or execute permission set, and then to change the permissions on those files to disallow this:

```
% find . \( -perm -004 -o -perm -001 \) -exec chmod o-rx {} \; -exec ls -al {} \;
-rw-r----- 1 frank staff 6682 Feb 5 10:04 ./library
-rwxr-x--- 1 frank staff 386 Apr 26 09:51 ./tr25
-rw-r----- 1 frank staff 17351 Feb 5 10:04 ./standard
```

In this example the parentheses and semicolons are escaped with a backslash to prevent the shell from interpreting them. The curly brackets are automatically replaced by the results from the previous search and the semicolon ends the command.

We could search for any file name containing the string "ar" with:

```
% find . -name \*ar\* -ls
326584 7 -rw-r----- 1 frank staff 6682 Feb 5 10:04 ./library
326585 17 -rw-r----- 1 frank staff 17351 Feb 5 10:04 ./standard
```

where the `-ls` option prints out a long listing, including the inode numbers.
8.2 File Archiving, Compression and Conversion

TABLE 8.2 File Archiving, Compression and Conversion Commands

<table>
<thead>
<tr>
<th>Command/Syntax</th>
<th>What it will do</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dd</code> <code>[if=infile] [of=outfile] [operand=value]</code></td>
<td>copy a file, converting between ASCII and EBCDIC or swapping byte order, as specified</td>
</tr>
<tr>
<td><code>gzip/gunzip/zcat</code> [options] <code>file.gz</code></td>
<td>compress or uncompress a file. Compressed files are stored with a .gz ending</td>
</tr>
<tr>
<td><code>od</code> [options] <code>file</code></td>
<td>octal dump a binary file, in octal, ASCII, hex, decimal, or character mode.</td>
</tr>
<tr>
<td><code>tar</code> key[options] <code>[file(s)]</code></td>
<td>tape archiver--refer to man pages for details on creating, listing, and retrieving from archive files. Tar files can be stored on tape or disk.</td>
</tr>
<tr>
<td><code>uudecode</code> <code>file</code></td>
<td>decode a uuencoded file, recreating the original file</td>
</tr>
</tbody>
</table>
| `uuencode` `file` `new_name` | encode binary file to 7-bit ASCII, useful when sending via email, to be decoded as new_name at destination |}

8.2.1 File Compression

The `compress` command is used to reduce the amount of disk space utilized by a file. When a file has been compressed using the `compress` command, a suffix of .Z is appended to the file name. The ownership modes and access and modification times of the original file are preserved. `uncompress` restores the files originally compressed by `compress`.

Syntax

```
compress [options] [file]
uncompress [options] [file.Z]
zcat [file.Z]
```

Common Options

- `-c` write to standard output and don’t create or change any files
- `-f` force compression of a file, even if it doesn’t reduce the size of the file or if the target file (file.Z) already exists.

`zcat` writes to standard output. It is equivalent to "uncompress -c".
Examples

Given the files:

```
96 -rw-r--r--   1 lindadb   acs   45452 Apr 24 09:13 logins.beauty
184 -rw-r--r--   1 lindadb   acs   90957 Apr 24 09:13 logins.bottom
152 -rw-r--r--   1 lindadb   acs   75218 Apr 24 09:13 logins.photon
168 -rw-r--r--   1 lindadb   acs   85970 Apr 24 09:13 logins.top
```

These can be compressed with:

```
% compress logins.*
```

which creates the files:

```
24 -rw-r--r--   1 lindadb   acs    8486 Apr 24 09:13 logins.beauty.Z
40 -rw-r--r--   1 lindadb   acs   16407 Apr 24 09:13 logins.bottom.Z
24 -rw-r--r--   1 lindadb   acs   10909 Apr 24 09:13 logins.photon.Z
32 -rw-r--r--   1 lindadb   acs   16049 Apr 24 09:13 logins.top.Z
```

The original files are lost.

To display a compressed file, the `zcat` command is used:

```
% zcat logins.beauty.Z | head
```

```
beauty:01/22/94:#total logins,4338:#different UIDs,2290
beauty:01/23/94:#total logins,1864:#different UIDs,1074
beauty:01/24/94:#total logins,2317:#different UIDs,1242
beauty:01/25/94:#total logins,3673:#different UIDs,2215
beauty:01/26/94:#total logins,3532:#different UIDs,2216
beauty:01/27/94:#total logins,3096:#different UIDs,1984
beauty:01/28/94:#total logins,3724:#different UIDs,2212
beauty:01/29/94:#total logins,3460:#different UIDs,2161
beauty:01/30/94:#total logins,1408:#different UIDs,922
beauty:01/31/94:#total logins,2175:#different UIDs,1194
```

A display of the file using commands other than `zcat` yields an unreadable, binary, output.

The `uncompress` command is used to return the file to its original format:

```
% uncompress logins.*.Z ; ls -als logins.*
```

```
96 -rw-r--r--   1 lindadb   acs   45452 Apr 24 09:13 logins.beauty
184 -rw-r--r--   1 lindadb   acs   90957 Apr 24 09:13 logins.bottom
152 -rw-r--r--   1 lindadb   acs   75218 Apr 24 09:13 logins.photon
168 -rw-r--r--   1 lindadb   acs   85970 Apr 24 09:13 logins.top
```
In addition to the standard Unix *compress, uncompress, zcat* utilities there are a set of GNU ones freely available. These do an even better job of compression using a more efficient algorithm. The GNU programs to provide similar functions to those above are often installed as *gzip, gunzip, and zcat*, respectively. Files compressed with gzip are given the endings *.gz* or *.gz*. GNU software can be obtained via anonymous ftp from *ftp://ftp.gnu.org/pub/gnu*.

### 8.2.2 tar - archive files

The *tar* command combines files into one device or filename for archiving purposes. The *tar* command does not compress the files; it merely makes a large quantity of files more manageable.

**Syntax**

```
tar [options] [directory file]
```

**Common Options**

- `c` create an archive (begin writing at the start of the file)
- `t` table of contents list
- `x` extract from an archive
- `v` verbose
- `f` archive file name
- `b` archive block size

*tar* will accept its options either with or without a preceding hyphen (-). The archive file can be a disk file, a tape device, or standard input/output. The latter are represented by a hyphen.

**Examples**

Given the files and size indications below:

- 45 logs.beauty
- 89 logs.bottom
- 74 logs.photon
- 84 logs.top

*tar* can combine these into one file, *logfile.tar*:

```
% tar -cf logfile.tar logs.* ; ls -s logfile.tar
304 logfile.tar
```

Many anonymous FTP archive sites on the Internet store their packages in compressed tar format, so the files will end in *tar.Z* or *tar.gz*. To extract the files from these files you would first uncompress them, or use the appropriate zcat command and pipe the output into tar, e.g.:

```
% zcat archive.tar.Z | tar -xvf -
```

where the hyphen at the end of the *tar* command indicates that the file is taken from *stdin*.
8.2.3 uuencode/uudecode - encode a file

To encode a binary file into 7-bit ASCII use the `uuencode` command. To decode the file back to binary use the `uudecode` command. The `uu` in the names comes because they are part of the Unix-to-Unix CoPy (UUCP) set of commands. The `uuencode` and `uudecode` commands are commonly used when sending binary files through e-mail. In e-mail there’s no guarantee that 8-bit binary files will be transferred cleanly. So to ensure delivery you should encode the binary file, either directly, on the command line and then include the encoded file, or indirectly, by letting your MIME mailer program do it for you. In a similar manner, the user decodes the file on the receiving end.

Syntax

```
    uuencode [ source_file ]  pathname_to_uudecode_to [ > new_file ]
```

```
    uudecode [ -p ] encoded_file
```

Common Options

- `p` 
  send output to standard output, rather than to the default file

Examples

The first line of encoded file includes the permission `modes` and `name` that `uudecode` will use when decoding the file. The file begins and ends with the `begin` and `end` keywords, respectively, e.g.:

```
begin 555 binary_filename
M?T5,1@$' 0 " ( ! %"W #0 5"< T "
M!0 H !4 % 8 T $ - "@ H 4 P
M -0 !$ ! ! ! ! %"
M%P !0A< % $ 4(8 -"& W& W% < 0
M @ !0B T( @ ) @ !P O=7-R+VQ8B]L9"YS
M;RXQ ?< 'Y VP "O !VP )8 &6 !G0
M %[ U0 %G !3 :< #Q %Q !
MEP :P !_ ' @ !PP ( P
M N0 =H _0 $D Y < #F /L
M01 $' $ & ! P #0A@ 4(8
M' 0 !E !@ , T(@ %"( ) @ $
M 0 ( ;@ $ ' -"N !0K@ /H
M $ # ' , ! P #1J 4:@ #8 !
M !Y 0 , TH %* !=X 0
M@ @ # -X !3^ "E, $ (4 !
M 4> )0 0 ". P
; %0 P )@ $
end
```
8.2.4 dd - block copy and convert

The dd command allows you to copy from raw devices, such as disks and tapes, specifying the input and output block sizes. dd was originally known as the disk-to-disk copy program. With dd you can also convert between different formats, for example, EBCDIC to ASCII, or swap byte order, etc.

Syntax

```
dd [if=input_device] [of=output_device] [operand=value]
```

Common Options

- `if=input_device` the input file or device
- `of=output_device` the output file or device

If the input or output devices are not specified they default to standard input and standard output, respectively.

Operands can include:

- `ibs=n` input block size (defaults to 512 byte blocks)
- `obs=n` output block size (defaults to 512 byte blocks)
- `bs=n` sets both input and output block sizes
- `files=n` copy n input files
- `skip=n` skip n input blocks before starting to copy
- `count=n` only copy n input blocks
- `conv=value[value]` where value can include:
  - `ascii` convert EBCDIC to ASCII
  - `ebcdic` convert from ASCII to EBCDIC
  - `lcase` convert upper case characters to lower case
  - `ucase` convert lower case characters to upper case
  - `swab` swap every pair of bytes of input data
  - `noerror` don’t stop processing on an input error
  - `sync` pad every input block to the size of ibs, appending null bytes as needed

Block sizes are specified in bytes and may end in k, b, or w to indicate 1024 (kilo), 512 (block), or 2 (word), respectively.
Examples

To copy files from one tape drive to another:

```
% dd if=/dev/rmt/0 of=/dev/rmt/1
 20+0 records in
 20+0 records out
```

To copy files written on a tape drive on a big endian machine, written with a block size of 20 blocks, to a file on a little endian machine that now has the tape inserted in its drive, we would need to swap pairs of bytes, as in:

```
% dd if=/dev/rmt/0 of=new_file ibs=20b conv=swab
 1072+0 records in
 21440+0 records out
```

Upon completion `dd` reports the number of whole blocks and partial blocks for both the input and output files.

8.2.5 od - octal dump of a file

`od` dumps a file to stdout in different formats, including octal, decimal, floating point, hex, and character format.

Syntax

```
od [options] file
```

Common Options

- `-b` octal dump
- `-d|-D` decimal (-d) or long decimal (-D) dump
- `-s|-S` signed decimal (-s) and signed long decimal (-S) dump
- `-f|-F` floating point (-f) or long (double) floating point (-F) dump
- `-x|-X` hex (-x) or long hex (-X) dump
- `-c|-C` character (single byte) or long character dump (single or multi-byte characters, as determined by locale settings) dump
- `-v` verbose mode
Examples

To look at the actual contents of the following file, a list of P. G. Wodehouse’s Lord Emsworth novels.

    Something Fresh [1915]
    Leave it to Psmith [1923]
    Summer Lightning [1929]
    Heavy Weather [1933]
    Blandings Castle and Elsewhere [1935]
    Uncle Fred in the Springtime [1939]
    Full Moon [1947]

    Uncle Dynamite [1948]
    Pigs Have Wings [1952]
    Cocktail Time [1958]
    Service with a Smile [1961]
    Galahad at Blandings [1965]
    A Pelican at Blandings [1969]
    Sunset at Blandings [1977]

we could do:

% od -c wodehouse

    0000000   S   o   m   e   t   h   i   n   g       F   r   e   s   h
    0000020   [   1   9   1   5   ]  \t   U   n   c   l   e       D   y   n
    0000040   a   m   i   t   e       [   1   9   4   8   ]  \n   L   e   a
    0000060   v   e   i   t   t   o       P   s   m   i   t   h
    0000100   [   1   9   2   3   ]  \t   P   i   g   s       H   a   v
    0000120   e       W   i   n   g   s       [   1   9   5   2   ]  \n   S   u
    0000140   m   m   e       L   i   g   h   t   n   i   n   g
    0000160   [   1   9   2   9   ]  \t   C   o   c   k   t   a   i   T
    0000200   i   m   e       [   1   9   5   8   ]  \n   H   e   a
    0000220   v   e   r   y       W   e   a   t   h   e   r
    0000240   [   1   9   3   3   ]  \t
    0000260   S   e   r   v   i   c   e       w   i   t   h   a   S
    0000280   m   i   l   e       [   1   9   6   1   ]  \n   B   l   a
    0000300   n   C   a   s   t   l   e   a   n   d
    0000320   E   l   s   e   w   h   e   r   e
    0000340   [   1   9   3   5   ]  \t   G   a   l   a   h   a
    0000360   d   a   t   B   l   a
    0000400   n   d   i   n   g   s
    0000420   [   1   9   6   5   ]  \n   U   n
    0000440   n   C   e
    0000460   l   F   r   e   d   i   n
    0000480   t   h   e
    0000500   S   p   r   i
    0000520   n   g   t   i
    0000540   m   e   [   1   9   3   9   ]  \t   A   P   e
    0000560   l   i   c   a
    0000580   n   a
    0000600   t   B
    0000620   i
    0000640   n
    0000660   g   s
    0000680   [   1   9   6   9   ]  \n
0000694
8.3 Remote Connections

### 8.3.1 TELNET and FTP - remote login and file transfer protocols

**TELNET** and **FTP** are Application Level Internet protocols. The TELNET and FTP protocol specifications have been implemented by many different sources, including The National Center for Supercomputer Applications (NCSA), and many other public domain and shareware sources.

The programs implementing the **TELNET** protocol are usually called *telnet*, but not always. Some notable exceptions are *tn3270*, *WinQVT*, and *QWS3270*, which are also TELNET protocol implementations. TELNET is used for remote login to other computers on the Internet.

The programs implementing the **FTP** protocol are usually called *ftp*, but there are exceptions to that too. A program called *Fetch*, distributed by Dartmouth College, *WS_FTP*, written and distributed by John Junod, and *Ftp tool*, written by Mike Sullivan, are FTP protocol implementations with graphic user interfaces. There’s an enhanced FTP version, *ncftp*, that allows additional features, written by Mike Gleason. Also, FTP protocol implementations are often included in TELNET implementation programs, such as the ones distributed by NCSA. FTP is used for transferring files between computers on the Internet.

*rlogin* is a remote login service that was at one time exclusive to Berkeley 4.3 BSD UNIX. Essentially, it offers the same functionality as *telnet*, except that it passes to the remote computer information about the user's login environment. Machines can be configured to allow connections from trusted hosts without prompting for the users’ passwords. A more secure version of this protocol is the Secure SHell, **SSH**, software written by Tatu Ylonen and available via ftp://ftp.net.ohio-state.edu/pub/security/ssh.

From a Unix prompt, these programs are invoked by typing the command (program name) and the (Internet) name of the remote machine to which to connect. You can also specify various options, as allowed, for these commands.
Remote Connections

Syntax

\texttt{telnet} [options] [ remote\_host [ port\_number ] ]
\texttt{tn3270} [options] [ remote\_host [ port\_number ] ]
\texttt{ftp} [options] [ remote\_host ]

Common Options

<table>
<thead>
<tr>
<th>ftp</th>
<th>telnet</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>-d</td>
<td>-d</td>
<td>set debugging mode on</td>
</tr>
<tr>
<td>-d</td>
<td>-d</td>
<td>same as above (SVR4 only)</td>
</tr>
<tr>
<td>-i</td>
<td></td>
<td>turn off interactive prompting</td>
</tr>
<tr>
<td>-n</td>
<td></td>
<td>don’t attempt auto-login on connection</td>
</tr>
<tr>
<td>-v</td>
<td></td>
<td>verbose mode on</td>
</tr>
<tr>
<td>-l</td>
<td>user</td>
<td>connect with username, \texttt{user}, on the remote host (SVR4 only)</td>
</tr>
<tr>
<td>-s</td>
<td></td>
<td>8-bit data path (SVR4 only)</td>
</tr>
</tbody>
</table>

\texttt{telnet} and \texttt{tn3270} allow you the option of specifying a port number to connect to on the remote host. For both commands it defaults to port number 23, the telnet port. Other ports are used for debugging of network services and for specialized resources.

Examples

telnet oscar.us.ohio-state.edu
tn3270 ohstmvs1.acs.ohio-state.edu
ftp magnus.acs.ohio-state.edu

The remote machine will query you for your login identification and your password. Machines set up as archives for software or information distribution often allow anonymous ftp connections. You \texttt{ftp} to the remote machine and login as \texttt{anonymous} (the login \texttt{ftp} is equivalent on many machines), that is, when asked for your "login" you would type \texttt{anonymous}.

Once you have successfully connected to a remote computer with \texttt{telnet} and \texttt{rlogin} (and assuming terminal emulation is appropriate) you will be able to use the machine as you always do.

Once you have successfully connected to a remote computer with \texttt{ftp}, you will be able to transfer a file "up" to that computer with the \texttt{put} command, or "down" from that computer with the \texttt{get} command. The syntax is as follows:

\texttt{put local-file-name remote-file-name}
\texttt{get local-file-name remote-file-name}
Other commands are available in ftp as well, depending on the specific "local" and "remote" FTP implementations. The help command will display a list of available commands. The help command will also display the purpose of a specific command. Examples of valid commands are shown below:

```
help            display list of available commands
help mget       display the purpose of the mget command ("get multiple files")
pwd             present working directory
ls or dir       directory list
cd              change directory
cd              local change directory
open            specify the machine you wish to connect with
user            specify your login id (in cases where you are not prompted)
quit            quit out of the FTP program
```

8.3.2 finger - get information about users

finger displays the .plan file of a specific user, or reports who is logged into a specific machine. The user must allow general read permission on the .plan file.

Syntax

```
finger [options] [user[@hostname]]
```

Common Options

```
-l              force long output format
-m              match username only, not first or last names
-s              force short output format
```

Examples

brigadier: condron [77]> finger workshop@nyssa

This is a sample .plan file for the nyssa id, workshop.
This id is being used this week by Frank Fiamingo, Linda DeBula, and Linda Condron, while we teach a pilot version of the new Unix workshop we developed for UTS.

Hope yer learnin' somethin'.
Frank, Linda, & Linda

brigadier: condron [77]> finger

<table>
<thead>
<tr>
<th>Login</th>
<th>Name</th>
<th>TTY</th>
<th>Idle</th>
<th>When</th>
<th>Where</th>
</tr>
</thead>
<tbody>
<tr>
<td>condron</td>
<td>Linda S Condron</td>
<td>p0</td>
<td></td>
<td>Sun 18:13</td>
<td>lcondron-mac.acs</td>
</tr>
<tr>
<td>frank</td>
<td>Frank G. Fiamingo</td>
<td>p1</td>
<td></td>
<td>Mon 16:19</td>
<td>nyssa</td>
</tr>
</tbody>
</table>
8.3.3 Remote commands

A number of Unix machines can be connected together to form a local area network. When this is the case, it often happens that a user of one machine has valid login access to several of the other machines in the local network. There are Unix commands available to such users which provide convenience in carrying out certain common operations. Because these commands focus on communications with remote hosts in the local network, the command names begin with the letter "r": `rlogin`, `rsh`, and `rcp`. The remote access capability of these commands is supported (optionally) by the dotfile, `~/.rhosts`, for individual users and by the system-wide file `/etc/hosts.equiv`. For security reasons these may be restricted on some hosts.

The `rlogin` command allows remote login access to another host in the local network. `rlogin` passes information about the local environment, including the value of the `TERM` environment variable, to the remote host.

The `rsh` command provides the ability to invoke a Unix shell on a remote host in the local network for the purpose of executing a shell command there. This capability is similar to the "shell escape" function commonly available from within such Unix software systems as editors and email.

The `rcp` command provides the ability to copy files from the local host to a remote host in the local network.

**Syntax**

```
\text{rlogin} \ [\ -l \ \text{username} \ ] \ \text{remote}\_\text{host}
\text{rsh} \ [\ -l \ \text{username} \ ] \ \text{remote}\_\text{host} \ [\ \text{command} \ ]
\text{rcp} \ [\ \text{[user}1\text{@host}1::]\text{original}\_\text{filename} \ [\ \text{[user}2\text{@host}2::]\text{new}\_\text{filename} \ ]
```

where the parts in brackets ([]) are optional. `rcp` does not prompt for passwords, so you must have permission to execute remote commands on the specified machines as the selected user on each machine.

**Common Options**

`-l \text{username}`  
connect as the user, \text{username}, on the remote host (\text{rlogin} & \text{rsh})

The `.rhosts` file, if it exists in the user's home directory on the remote host, permits `rlogin`, `rsh`, or `rcp` access to that remote host without prompting for a password for that account. The `.rhosts` file contains an entry for each remote host and username from which the owner of the `.rhosts` file may wish to connect. Each entry in the `.rhosts` file is of the form:

```
\text{remote}\_\text{host} \ \text{remote}\_\text{user}
```

where listing the remote_user is optional. For instance, if Heather Jones wants to be able to connect to machine1 (where her username is heather) from machine2 (where her username is jones), or from machine 3 (where her username is heather, the same as for machine1), she could create a `.rhosts` file in her home directory on machine1. The contents of this file could be:
machine2 jones
machine3

--or--

machine2 jones
machine3 heather

On a system-wide basis the file /etc/hosts.equiv serves the same purpose for all users, except the super-user. Such a file with the contents:

remote_machine

allows any user from remote_machine to remote connect to this machine without a password, as the same username on this machine.

An /etc/hosts.equiv file with the contents:

remote_machine remote_user

allows remote_user, on remote_machine, to remote connect to this machine as any local user, except the super-user.

/etc/hosts.equiv and ~/.rhosts files should be used with caution.

The Secure SHell (SSH) versions of the rcp, rsh, and rlogin programs are freely available and provide much greater security.
9.1 Shell Scripts

You can write shell programs by creating scripts containing a series of shell commands. The first line of the script should start with `#!/` which indicates to the kernel that the script is directly executable. You immediately follow this with the name of the shell, or program (spaces are allowed), to execute, using the full path name. Generally you can count on having up to 32 characters, possibly more on some systems, and can include one option. So to set up a Bourne shell script the first line would be:

```
#!/ /bin/sh
```

or for the C shell:

```
#!/ /bin/csh -f
```

where the "-f" option indicates that it should not read your `.cshrc`. Any blanks following the magic symbols, `#!`, are optional.

You also need to specify that the script is executable by setting the proper bits on the file with `chmod`, e.g.:

```
% chmod +x shell_script
```

Within the scripts `#` indicates a comment from that point until the end of the line, with `#!` being a special case if found as the first characters of the file.

9.2 Setting Parameter Values

Parameter values, e.g. `param`, are assigned as:

```
Bourne shell                C shell
param=value                 set param = value
```

where `value` is any valid string, and can be enclosed within quotations, either single (`'value'`) or double (`"value"`), to allow spaces within the string value. When enclosed with backquotes (`'value'`) the string is first evaluated by the shell and the result is substituted. This is often used to run a command, substituting the command output for `value`, e.g.:
$ day='date +%a'
$ echo $day
Wed

After the parameter values has been assigned the current value of the parameter is accessed using the
$param, or ${param}, notation.

### 9.3 Quoting

We quote strings to control the way the shell interprets any parameters or variables within the string. We can use single (') and double ("") quotes around strings. Double quotes define the string, but allow variable substitution. Single quotes define the string and prevent variable substitution. A backslash (\) before a character is said to escape it, meaning that the system should take the character literally, without assigning any special meaning to it. These quoting techniques can be used to separate a variable from a fixed string. As an example lets use the variable, var, that has been assigned the value bat, and the constant string, man. If I wanted to combine these to get the result "batman" I might try:

```bash
$varman
```

but this doesn’t work, because the shell will be trying to evaluate a variable called varman, which doesn’t exist. To get the desired result we need to separate it by quoting, or by isolating the variable with curly braces ({}), as in:

```
"$var"man       - quote the variable
$var""man       - separate the parameters
$var"man"      - quote the constant
$var"man       - separate the parameters
$var\man       - quote the constant
$var\man"      - separate the parameters
${var}man      - isolate the variable
```

These all work because ", , \\, {, and } are not valid characters in a variable name.

We could not use either of

```bash
'$var'\man
\$varman
```

because it would prevent the variable substitution from taking place.

When using the curly braces they should surround the variable only, and not include the $, otherwise, they will be included as part of the resulting string, e.g.:

```bash
% echo ${var}man
{bat}man
9.4 Variables

There are a number of variables automatically set by the shell when it starts. These allow you to reference arguments on the command line.

These shell variables are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Usage</th>
<th>sh</th>
<th>csh</th>
</tr>
</thead>
<tbody>
<tr>
<td>$#</td>
<td>number of arguments on the command line</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>$-</td>
<td>options supplied to the shell</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>$?</td>
<td>exit value of the last command executed</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>$$</td>
<td>process number of the current process</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>$!</td>
<td>process number of the last command done in background</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>$n</td>
<td>argument on the command line, where n is from 1 through 9, reading left to right</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>$0</td>
<td>the name of the current shell or program</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>$*</td>
<td>all arguments on the command line (&quot;$1 $2 ... $9&quot;)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>$@</td>
<td>all arguments on the command line, each separately quoted (&quot;$1&quot; &quot;$2&quot; ... &quot;$9&quot;)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>$argv[n]</td>
<td>selects the nth word from the input list</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>${argv[n]}</td>
<td>same as above</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>$#argv</td>
<td>report the number of words in the input list</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

We can illustrate these with some simple scripts. First for the Bourne shell the script will be:

```bash
#!/bin/sh
echo "#$::" $#
echo " $#::" $#
echo ' $:::' $-
echo ' $:::' $-
echo ' $:::' $?
echo ' $:::' $$
echo ' $:::' $$
echo ' $:::' $!
echo ' $:::' $!
echo ' $:::' $3
echo ' $:::' $0
echo ' $:::' $0
echo ' $:::' $*
```

TABLE 9.1 Shell Variables

We can illustrate these with some simple scripts. First for the Bourne shell the script will be:

```bash
#!/bin/sh
echo "$#::" $#
echo "$#::" $#
echo ' $:::' $-
echo ' $:::' $-
echo ' $:::' $?
echo ' $:::' $$
echo ' $:::' $$
echo ' $:::' $!
echo ' $:::' $!
echo ' $:::' $3
echo ' $:::' $0
echo ' $:::' $0
echo ' $:::' $*
```
When executed with some arguments it displays the values for the shell variables, e.g.:

```
$ ./variables.sh one two three four five
  5: 5
  $#: 5
  $+: 
  $? : 0
  $$ : 12417
  $! : 
  $3 : three
  $0 : ./variables.sh
  $*: one two three four five
  $@ : one two three four five
```

As you can see, we needed to use single quotes to prevent the shell from assigning special meaning to $$. The double quotes, as in the first echo statement, allowed substitution to take place.

Similarly, for the C shell variables we illustrate variable substitution with the script:

```csh
#!/bin/csh -f
echo "$$:" $$
echo "$3:" $3
echo "$0:" $0
echo "$*: $*
echo "$argv[2]: $argv[2]
echo "$argv[4]: $argv[4]
```

which when executed with some arguments displays the following:

```
% ./variables.csh one two three four five
  $$ : 12419
  $3 : three
  $0 : ./variables.csh
  $*: one two three four five
  $argv[2]: two
  $argv[4]: four
  $#argv: 5
```
9.5 Parameter Substitution

You can reference parameters abstractly and substitute values for them based on conditional settings using the operators defined below. Again we will use the curly braces ({} ) to isolate the variable and its operators.

- \$parameter substitute the value of parameter for this string
- ${parameter} same as above. The brackets are helpful if there’s no separation between this parameter and a neighboring string.
- $parameter= sets parameter to null.
- ${parameter-default} if parameter is not set, then use default as the value here. The parameter is not reset.
- ${parameter=default} if parameter is not set, then set it to default and use the new value
- ${parameter+newval} if parameter is set, then use newval, otherwise use nothing here. The parameter is not reset.
- ${parameter?message} if parameter is not set, then display message. If parameter is set, then use its current value.

There are no spaces in the above operators. If a colon (:) is inserted before the -, =, +, or ? then a test if first performed to see if the parameter has a non-null setting.

The C shell has a few additional ways of substituting parameters:

- $list[n] selects the nth word from list
- ${list[n]} same as above
- $#list report the number of words in list
- $?parameter return 1 if parameter is set, 0 otherwise
- ${?parameter} same as above
- $< read a line from stdin

The C shell also defines the array, $argv[n] to contain the n arguments on the command line and $#argv to be the number of arguments, as noted in Table 9.1.
To illustrate some of these features we’ll use the test script below.

```bash
#!/bin/sh

param0=$0

if [ -n "$1" ]; then
    param1=$1
fi

if [ -n "$2" ]; then
    param2=$2
fi

if [ -n "$3" ]; then
    param3=$3
fi

echo 0: $param0

if [ -n "$1" ]; then
    echo "1: \${param1-1}: \c" ; echo $param1
else
    echo "1: \c" ; echo $param1
fi

if [ -n "$2" ]; then
    echo "2: \${param2=2}: \c" ; echo $param2
else
    echo "2: \c" ; echo $param2
fi

if [ -n "$3" ]; then
    echo "3: \${param3+3}: \c" ; echo $param3
else
    echo "3: \c" ; echo $param3
fi
```

In the script we first test to see if the variable exists, if so we set a parameter to its value. Below this we report the values, allowing substitution.

In the first run through the script we won’t provide any arguments:

```
$ ./parameter.sh
0: ./parameter.sh  # always finds $0
1: 1:             # substitute 1, but don’t assign this value
2: 2: 2           # substitute 2 and assign this value
3: :              # don’t substitute
```

In the second run through the script we’ll provide the arguments:

```
$ ./parameter one two three
0: ./parameter.sh  # always finds $0
1: one: one        # don’t substitute, it already has a value
2: two: two        # don’t substitute, it already has a value
3: 3: three        # substitute 3, but don’t assign this value
```
9.6 Here Document

A here document is a form of quoting that allows shell variables to be substituted. It’s a special form of redirection that starts with $<$WORD$>$ and ends with WORD as the only contents of a line. In the Bourne shell you can prevent shell substitution by escaping WORD by putting a \ in front of it on the redirection line, i.e. $<$\WORD$>$, but not on the ending line. To have the same effect the C shell expects the \ in front of WORD at both locations.

The following scripts illustrate this,

for the Bourne shell:

```bash
#!/bin/sh
does=does
not=""
cat << EOF
This here document
$does $not
do variable substitution
EOF
cat << \EOF
This here document
$does $not
do variable substitution
\EOF
```

Both produce the output:

```
This here document
does
do variable substitution
This here document
$does $not
do variable substitution
```

In the top part of the example the shell variables $does and $not are substituted. In the bottom part they are treated as simple text strings without substitution.

and for the C shell:

```bash
#!/bin/csh -f
set does = does
set not = ""
cat << EOF
This here document
$does $not
do variable substitution
EOF
cat << \EOF
This here document
$does $not
do variable substitution
\EOF
```
9.7 Interactive Input

Shell scripts will accept interactive input to set parameters within the script.

9.7.1 Sh

Sh uses the built-in command, `read`, to read in a line, e.g.:

```bash
read param
```

We can illustrate this with the simple script:

```bash
#!/bin/sh
echo "Input a phrase \c" # This is /bin/echo which requires "\c" to prevent <newline>
read param
echo param=$param
```

When we run this script it prompts for input and then echoes the results:

```
$ ./read.sh
Input a phrase hello frank # I type in hello frank <return>
param=hello frank
```

9.7.2 Csh

Csh uses the `$<` symbol to read a line from stdin, e.g.:

```csh
set param = $<
```

The spaces around the equal sign are important. The following script illustrates how to use this.

```csh
#!/bin/csh -f
echo -n "Input a phrase " # This built-in echo requires -n to prevent <newline>
set param = $<
echo param=$param
```

Again, it prompts for input and echoes the results:

```
% ./read.csh
Input a phrase hello frank # I type in hello frank <return>
param=hello frank
```
9.8 Functions

The Bourne shell has functions. These are somewhat similar to aliases in the C shell, but allow you more flexibility. A function has the form:

```
fcn () { command; }
```

where the space after {, and the semicolon (;) are both required; the latter can be dispensed with if a <newline> precedes the }. Additional spaces and <newline>’s are allowed. We saw a few examples of this in the sample .profile in an earlier chapter, where we had functions for `ls` and `ll`:

```
ls() { /bin/ls -sbF "$@";}
ll() { ls -al "$@";}
```

The first one redefines `ls` so that the options `-sbF` are always supplied to the standard `/bin/ls` command, and acts on the supplied input, `"$@"`. The second one takes the current value for `ls` (the previous function) and tacks on the `-al` options.

Functions are very useful in shell scripts. The following is a simplified version of one I use to automatically backup up system partitions to tape.

```
#!/bin/sh
# Cron script to do a complete backup of the system
HOST=`/bin/uname -n`
admin=frank
Mt=/bin/mt
Dump=/usr/sbin/ufsdump
Mail=/bin/mailx
device=/dev/rmt/0n
Rewind="$Mt -f $device rewind"
Offline="$Mt -f $device rewoffl"
# Failure - exit
failure () {
    $Mail -s "Backup Failure - $HOST" $admin << EOF_failure
    $HOST
    Cron backup script failed. Apparently there was no tape in the device.
    EOF_failure
    exit 1
}
# Dump failure - exit
dumpfail () {

```

```
$Mail -s "Backup Failure - $HOST" $admin << EOF_dumpfail
$HOST
Cron backup script failed. Initial tape access was okay, but dump failed.
EOF_dumpfail
exit 1
}

# Success
success () {
$Mail -s "Backup completed successfully - $HOST" $admin << EOF_success
$HOST
Cron backup script was apparently successful. The /etc/dumpdates file is:
`/bin/cat /etc/dumpdates`
EOF_success
}

# Confirm that the tape is in the device
$Rewind || failure
$Dump 0uf $device / || dumpfail
$Dump 0uf $device /usr || dumpfail
$Dump 0uf $device /home || dumpfail
$Dump 0uf $device /var || dumpfail
($Dump 0uf $device /var/spool/mail || dumpfail) && success
$Offline

This script illustrates a number of topics that we’ve looked at in this document. It starts by setting various parameter values. $HOST is set from the output of a command, $admin is the administrator of the system, $Mt, $Dump, and $Mail are program names, device is the special device file used to access the tape drive, $Rewind and $Offline contain the commands to rewind and off-load the tape drive, respectively, using the previously referenced Mt and the necessary options. There are three functions defined: $failure, $dumpfail, and $success. The functions in this script all use a here document to form the contents of the function. We also introduce the logical OR (||) and AND (&&) operators here; each is position between a pair of commands. For the OR operator, the second command will be run only if the first command does not complete successfully. For the AND operator, the second command will be run only if the first command does complete successfully.

The main purpose of the script is done with the Dump commands, i.e. backup the specified file systems. First an attempt is made to rewind the tape. Should this fail, || $failure, the $failure function is run and we exit the program. If it succeeds we proceed with the backup of each partition in turn, each time checking for successful completion (|| $dumpfail). Should it not complete successfully we run the $dumpfail subroutine and then exit. If the last backup succeeds we proceed with the $success function ((...) && $success). Lastly, we rewind the tape and take it offline so that no other user can accidently write over our backup tape.
9.9 Control Commands

9.9.1 Conditional if

The conditional if statement is available in both shells, but has a different syntax in each.

9.9.1.1 Sh

```
if condition1
  then
    command list if condition1 is true
  [elif condition2
    then command list if condition2 is true]
  [else
    command list if condition1 is false]
fi
```

The conditions to be tested for are usually done with the test, or / command (see Section 8.9.6). The if and then must be separated, either with a <newline> or a semicolon (;).

```
#!/bin/sh
if [ $# -ge 2 ]
  then
    echo $2
  elif [ $# -eq 1 ]; then
    echo $1
  else
    echo No input
fi
```

There are required spaces in the format of the conditional test, one after [ and one before ]. This script should respond differently depending upon whether there are zero, one or more arguments on the command line. First with no arguments:

```
$ ./if.sh
  No input
```

Now with one argument:

```
$ ./if.sh one
  one
```

And now with two arguments:

```
$ ./if.sh one two
  two
```
9.9.1.2 Csh

if (condition) command
-or-
if (condition1) then
    command list if condition1 is true
[else if (condition2) then
    command list if condition2 is true]
[else
    command list if condition1 is false]
endif

The if and then must be on the same line.

#!/bin/csh -f
if ( $#argv >= 2 ) then
    echo $2
else if ( $#argv == 1 ) then
    echo $1
else
    echo No input
endif

Again, this script should respond differently depending upon whether I have zero, one or more arguments on the command line. First with no arguments:

% ./if.csh
     No input

Now with one argument:

% ./if.csh one
     one

And now with two arguments:

% ./if.csh one two
     two
9.9.2 Conditional switch and case

To choose between a set of string values for a parameter use *case* in the Bourne shell and *switch* in the C shell.

9.9.2.1 Sh

*case* parameter *in*

```
  pattern1([pattern1a]) command list1;;
  pattern2) command list2
    command list2a;;
  pattern3) command list3;;
  *) ;;
```

* esac

You can use any valid filename meta-characters within the patterns to be matched. The `;;` ends each choice and can be on the same line, or following a `<newline>`, as the last command for the choice. Additional alternative patterns to be selected for a particular case are separated by the vertical bar, `|`, as in the first pattern line in the example above. The wildcard symbols: `?` to indicate any one character and `*` to match any number of characters, can be used either alone or adjacent to fixed strings.

This simple example illustrates how to use the conditional case statement.

```
#!/bin/sh

case $1 in
  aa|ab) echo A
    ;;
  b?) echo "B \c"
    echo $1;;
  c*) echo C;;
  *) echo D;;

esac
```

So when running the script with the arguments on the left, it will respond as on the right:

```
    aa          A
    ab          A
    ac          D
    bb          B bb
    bbb         D
    c           C
    cc          C
    fff         D
```
9.9.2.2 Csh

`switch` (parameter)
`case` pattern1:
   command list1
   `[breaksw]

`case` pattern2:
   command list2
   `[breaksw]

default:
   command list for default behavior
   `[breaksw]

`endsw`

`breaksw` is optional and can be used to break out of the switch after a match to the string value of the parameter is made. `Switch` doesn’t accept `"|"` in the pattern list, but it will allow you to string several `case` statements together to provide a similar result. The following C shell script has the same behavior as the Bourne shell `case` example above.

```csh
#!/bin/csh -f
switch ($1)
   case aa:
   case ab:
      echo A
      breaksw
   case b?:
      echo -n "B 
      echo $1
      breaksw
   case c*:
      echo C
      breaksw
   default:
      echo D
endsw
```
9.9.3 for and foreach

One way to loop through a list of string values is with the *for* and *foreach* commands.

9.9.3.1 Sh

```
for variable [in list_of_values]
do
    command list
done
```

The *list_of_values* is optional, with *@* assumed if nothing is specified. Each value in this list is sequentially substituted for *variable* until the list is emptied. Wildcards can be used and are applied to file names in the current directory. Below we illustrate the for loop in copying all files ending in *.old* to similar names ending in *.new*. In these examples the *basename* utility extracts the base part of the name so that we can exchange the endings.

```
#!/bin/sh
for file in *.old
do
    newf=`basename $file .old`
cp $file $newf.new
done
```

9.9.3.2 Csh

```
foreach file (*.old)
    set newf = `basename $file .old`
    cp $file $newf.new
end
```

The equivalent C shell script to copy all files ending in *.old* to *.new* is:

```
#!/bin/csh -f
foreach file (*.old)
    set newf = `basename $file .old`
    cp $file $newf.new
end
```
9.9.4 while

The *while* commands let you loop as long as the condition is true.

9.9.4.1 Sh

```
while condition
do
    command list
    [break]
    [continue]
done
```

A simple script to illustrate a *while* loop is:

```
#!/bin/sh
while [ $# -gt 0 ]
do
    echo $1
    shift
done
```

This script takes the list of arguments, echoes the first one, then shifts the list to the left, losing the original first entry. It loops through until it has shifted all the arguments off the argument list.

```
$ ./while.sh one two three
one
two
three
```
9.9.4.2 Csh

while (condition)
    command list
    [break]
    [continue]
end

If you want the condition to always be true specify 1 within the conditional test.

A C shell script equivalent to the one above is:

```csh
#!/bin/csh -f
while ($#argv != 0 )
    echo $argv[1]
    shift
end
```

9.9.5 until

This looping feature is only allowed in the Bourne shell.

until condition
do
    command list while condition is false
done

The condition is tested at the start of each loop and the loop is terminated when the condition is true. A script equivalent to the while examples above is:

```sh
#!/bin/sh
until [ $# -le 0 ]
do
    echo $1
    shift
done
```

Notice, though, that here we’re testing for less than or equal, rather than greater than or equal, because the until loop is looking for a false condition.

Both the until and while loops are only executed if the condition is satisfied. The condition is evaluated before the commands are executed.
9.9.6 test

Conditional statements are evaluated for true or false values. This is done with the test, or its equivalent, the \[/ operators. If the condition evaluates to true, a zero (TRUE) exit status is set, otherwise a non-zero (FALSE) exit status is set. If there are no arguments a non-zero exit status is set. The operators used by the Bourne shell conditional statements are given below.

For filenames the options to test are given with the syntax:

-option filename

The options available for the test operator for files include:

-\[ -r \] true if it exists and is readable
-\[ -w \] true if it exists and is writable
-\[ -x \] true if it exists and is executable
-\[ -f \] true if it exists and is a regular file (or for csh, exists and is not a directory)
-\[ -d \] true if it exists and is a directory
-\[ -h \] or \[-L \] true if it exists and is a symbolic link
-\[ -c \] true if it exists and is a character special file (i.e. the special device is accessed one character at a time)
-\[ -b \] true if it exists and is a block special file (i.e. the device is accessed in blocks of data)
-\[ -p \] true if it exists and is a named pipe (fifo)
-\[ -u \] true if it exists and is setuid (i.e. has the set-user-id bit set, s or S in the third bit)
-\[ -g \] true if it exists and is setgid (i.e. has the set-group-id bit set, s or S in the sixth bit)
-\[ -k \] true if it exists and the sticky bit is set (a t in bit 9)
-\[ -s \] true if it exists and is greater than zero in size

There is a test for file descriptors:

-\[ -t [file_descriptor] \] true if the open file descriptor (default is 1, stdin) is associated with a terminal

There are tests for strings:

-\[ -z string \] true if the string length is zero
-\[ -n string \] true if the string length is non-zero
-\[ string1 = string2 \] true if string1 is identical to string2
-\[ string1 != string2 \] true if string1 is non identical to string2
-\[ string \] true if string is not NULL
There are integer comparisons:

- `n1 -eq n2` true if integers n1 and n2 are equal
- `n1 -ne n2` true if integers n1 and n2 are not equal
- `n1 -gt n2` true if integer n1 is greater than integer n2
- `n1 -ge n2` true if integer n1 is greater than or equal to integer n2
- `n1 -lt n2` true if integer n1 is less than integer n2
- `n1 -le n2` true if integer n1 is less than or equal to integer n2

The following logical operators are also available:

- `!` negation (unary)
- `-a` and (binary)
- `-o` or (binary)
- `()` expressions within the () are grouped together. You may need to quote the () to prevent the shell from interpreting them.
9.9.7 C Shell Logical and Relational Operators

The C shell has its own set of built-in logical and relational expression operators. In descending order of precedence they are:

- Group expressions with ()
- Inversion (one’s complement)
- Logical negation
- Multiply, divide, modulus
- Add, subtract
- Bitwise shift left, bitwise shift right
- Less than or equal
- Greater than or equal
- Less than
- Greater than
- Equal
- Not equal
- Match a string
- Don’t match the string
- Bitwise AND
- Bitwise XOR (exclusive or)
- Bitwise OR
- Logical AND
- Logical OR
- True (1) if command terminates with a zero exit status, false (0) otherwise.

The C shell also allows file type and permission inquiries with the operators:

- `r` return true (1) if it exists and is readable, otherwise return false (0)
- `w` true if it exists and is writable
- `x` true if it exists and is executable
- `f` true if it exists and is a regular file (or for csh, exists and is not a directory)
- `d` true if it exists and is a directory
- `e` true if the file exists
- `o` true if the user owns the file
- `z` true if the file has zero length (empty)
There are numerous text processing utilities available with Unix, as is noted throughout this document (e.g., ed, ex, sed, awk, the grep family, and the roff family). Among the editors, the standard "visual" (or fullscreen) editor on Unix is vi. It comprises a super-set, so to speak, of ed and ex (the Unix line editors) capabilities.

Vi is a modal editor. This means that it has specific modes that allow text insertion, text deletion, and command entering. You leave the insert mode by typing the <escape> key. This brings you back to command mode. The line editor, ex, is incorporated within vi. You can switch back and forth between full-screen and line mode as desired. In vi mode type Q to go to ex mode. In ex mode at the : prompt type vi to return to vi mode. There is also a read-only mode of vi, which you can invoke as view.

Another editor that is common on Unix systems, especially in college and university environments, is emacs (which stands for "editing macros"). While vi usually comes with the Unix operating system, emacs usually does not. It is distributed by The Free Software Foundation. It is arguably the most powerful editor available for Unix. It is also a very large software system, and is a heavy user of computer system resources.

The Free Software Foundation and the GNU Project (of which emacs is a part) were founded by Richard Stallman and his associates, who believe (as stated in the GNU Manifesto) that sharing software is the "fundamental act of friendship among programmers." Their General Public License guarantees your rights to use, modify, and distribute emacs (including its source code), and was specifically designed to prevent anyone from hoarding or turning a financial profit from emacs or any software obtained through the Free Software Foundation. Most of their software, including emacs, is available at ftp://ftp.gnu.org/pub/gnu/ and http://www.gnu.org/.

Both vi and emacs allow you to create start-up files that you can populate with macros to control settings and functions in the editors.
10.1 Configuring Your vi Session

To configure the vi environment certain options can be set with the line editor command :set during a vi editing session. Alternatively, frequently used options can be set automatically when vi is invoked, by use of the .exrc file. This file can also contain macros to map keystrokes into functions using the map function. Within vi these macros can be defined with the :map command. Control characters can be inserted by first typing <control>-V (^V), then the desired control character. The options available in vi include, but are not limited to, the following. Some options are not available on every Unix system.

:set all display all option settings
:set ignorecase ignore the case of a character in a search
:set list display tabs and carriage returns
:set nolist turn off list option
:set number display line numbers
:set nonumber turn off line numbers
:set showmode display indication that insert mode is on
:set noshowmode turn off showmode option
:set wrapmargin=n turn on word-wrap n spaces from the right margin
:set wrapmargin=0 turn off wrapmargin option
:set warn display "No write since last change"
:set nowarn turn off "write" warning

The following is a sample .exrc file:

set wrapmargin=10
set number
set list
set warn
set ignorecase
map K {!}fmt -80 # reformat this paragraph, {!}, using fmt to 80 characters per line
map ^Z :!spell # invoke spell, :, to check a word spelling (return to vi with ^D)
10.2 Configuring Your emacs Session

Configuring the emacs environment amounts to making calls to LISP functions. Emacs is infinitely customizable by means of emacs variables and built-in functions and by using Emacs LISP programming. Settings can be specified from the minibuffer (or command line) during an emacs session. Alternatively, frequently used settings can be established automatically when emacs is invoked, by use of a .emacs file. Though a discussion of Emacs LISP is beyond the scope of this document, a few examples of common emacs configurations follow.

To set or toggle emacs variables, or to use emacs built-in functions, use the <escape> key ("Meta" is how emacs refers to it), followed by the letter x, then by the variable or function and its arguments.

- M-x what-line what line is the cursor on?
- M-x auto-fill-mode turn on word-wrap
- M-x auto-fill-mode turn off word-wrap
- M-x set-variable<return>
  fill-column<return> set line-length to
  45 45 characters
- M-x set-variable<return>
  auto-save-interval<return> save the file automatically after every
  300 300 keystrokes
- M-x goto-line<return>16 move the cursor to line 16
- M-x help-for-help invoke emacs help when C-h has been bound to the
  backspace key

The following is a sample .emacs file:

```lisp
(message "Loading ~/.emacs...")
(setq text-mode-hook 'turn-on-auto-fill) ; turn on word-wrap
(setq fill-column 45) ; line-length=45 chars
(setq auto-save-interval 300) ; save after every 300 keystrokes
(global-set-key \C-h 'backward-delete-char-untabify) ; Bind (or map) the rubout (control-h) function to the backspace key
(global-set-key \C-x? 'help-for-help) ; Bind the emacs help function to the keystroke sequence "C-x ?".
(global-set-key \C-x? 'help-for-help) ; To jump to line 16, type M-#<return>16
(global-set-key \M-# 'goto-line) ; To find out what line you are on, type M-n
(global-set-key \M-n 'what-line)
(message "~//.emacs loaded.")
(message ")")```

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10.3 vi Quick Reference Guide

All commands in vi are preceded by pressing the escape key. Each time a different command is to be entered, the escape key needs to be used. Except where indicated, vi is case sensitive.

**Cursor Movement Commands:**
- \( n \) indicates a number, and is optional
- \( n \)h left (n) space(s)
- \( n \)j down (n) space(s)
- \( n \)k up (n) space(s)
- \( n \)l right (n) space(s)

(\( \wedge \) indicates control key; case does not matter)
- \( \wedge \)F forward one screen
- \( \wedge \)B back one screen
- \( \wedge \)D down half screen
- \( \wedge \)U up half screen

**Inserting Text:**
- i insert text before the cursor
- a append text after the cursor (does not overwrite other text)
- I insert text at the beginning of the line
- A append text to the end of the line
- r replace the character under the cursor with the next character typed
- R Overwrite characters until the end of the line (or until escape is pressed to change command)
- o (alpha o) open new line after the current line to type text
- O (alpha O) open new line before the current line to type text

**Deleting Text:**
- dd deletes current line
- \( n \)dd deletes (n) line(s)
- \( n \)dw deletes (n) word(s)
- D deletes from cursor to end of line
- x deletes current character
- \( n \)x deletes (n) character(s)
- X deletes previous character

**Change Commands:**
- \( n \)cc changes (n) characters on line(s) until end of the line (or until escape is pressed)
- cw changes characters of word until end of the word (or until escape is pressed)
- \( n \)cw changes characters of the next (n) words
- c$ changes text to the end of the line
- ct(x) changes text to the letter (x)
- C changes remaining text on the current line (until stopped by escape key)

**File Manipulation:**
- :w (file) writes changes to file (default is current file)
- :wq writes changes to current file and quits edit session
- :w! writes changes to current file and overwrites file (default is current file)
- :q quits edit session w/no changes made
- :q! quits edit session and discards changes
- :n edits next file in argument list
- :f (name) changes name of current file to (name)
- :r (file) reads contents of file into current edit at the current cursor position (insert a file)
- :! (command) shell escape
- :r!(command) inserts result of shell command at cursor position
- ZZ write changes to current file and exit
10.4 emacs Quick Reference Guide

Emacs commands are accompanied either by simultaneously holding down the control key (indicated by C-) or by first hitting the escape key (indicated by M-).

### Essential Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-h</td>
<td>help</td>
</tr>
<tr>
<td>C-x u</td>
<td>undo</td>
</tr>
<tr>
<td>C-x C-g</td>
<td>get out of current operation or command</td>
</tr>
<tr>
<td>C-x C-s</td>
<td>save the file</td>
</tr>
<tr>
<td>C-x C-c</td>
<td>close Emacs</td>
</tr>
</tbody>
</table>

### Cursor movement

<table>
<thead>
<tr>
<th>Command</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-f</td>
<td>forward one character</td>
</tr>
<tr>
<td>C-b</td>
<td>back one character</td>
</tr>
<tr>
<td>C-p</td>
<td>previous line</td>
</tr>
<tr>
<td>C-n</td>
<td>next line</td>
</tr>
<tr>
<td>C-a</td>
<td>beginning of line</td>
</tr>
<tr>
<td>C-e</td>
<td>end of line</td>
</tr>
<tr>
<td>C-l</td>
<td>center current line on screen</td>
</tr>
<tr>
<td>C-v</td>
<td>scroll forward</td>
</tr>
<tr>
<td>M-v</td>
<td>scroll backward</td>
</tr>
<tr>
<td>M-f</td>
<td>forward one word</td>
</tr>
<tr>
<td>M-b</td>
<td>back one word</td>
</tr>
<tr>
<td>M-a</td>
<td>beginning of sentence</td>
</tr>
<tr>
<td>M-e</td>
<td>end of sentence</td>
</tr>
<tr>
<td>M-{</td>
<td>beginning of paragraph</td>
</tr>
<tr>
<td>M-}</td>
<td>end of paragraph</td>
</tr>
<tr>
<td>M-&lt;</td>
<td>beginning of buffer</td>
</tr>
<tr>
<td>M-&gt;</td>
<td>end of buffer</td>
</tr>
</tbody>
</table>

### Other Important Functions

<table>
<thead>
<tr>
<th>Command</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-(n)</td>
<td>repeat the next command (n) times</td>
</tr>
<tr>
<td>C-d</td>
<td>delete a character</td>
</tr>
<tr>
<td>M-d</td>
<td>delete a word</td>
</tr>
<tr>
<td>C-k</td>
<td>kill line</td>
</tr>
<tr>
<td>M-k</td>
<td>kill sentence</td>
</tr>
<tr>
<td>C-s</td>
<td>search forward</td>
</tr>
<tr>
<td>C-r</td>
<td>search in reverse</td>
</tr>
<tr>
<td>M-%</td>
<td>query replace</td>
</tr>
<tr>
<td>M-c</td>
<td>capitalize word</td>
</tr>
<tr>
<td>M-u</td>
<td>uppercase word</td>
</tr>
<tr>
<td>M-l</td>
<td>lowercase word</td>
</tr>
<tr>
<td>C-t</td>
<td>transpose characters</td>
</tr>
<tr>
<td>M-t</td>
<td>transpose words</td>
</tr>
<tr>
<td>C-@</td>
<td>mark beginning of region</td>
</tr>
<tr>
<td>C-w</td>
<td>cut--wipe out everything from mark to point</td>
</tr>
<tr>
<td>C-y</td>
<td>paste--yank deleted text into current location</td>
</tr>
<tr>
<td>M-q</td>
<td>reformat paragraph</td>
</tr>
<tr>
<td>M-g</td>
<td>reformat each paragraph in region</td>
</tr>
<tr>
<td>M-x auto-fill-mode</td>
<td>turn on word wrap</td>
</tr>
<tr>
<td>M-x set-variable &lt;return&gt; fill-column &lt;return&gt; 45</td>
<td>set length of lines to 45 characters</td>
</tr>
<tr>
<td>M-x goto-line &lt;return&gt; 16</td>
<td>move cursor to line 16</td>
</tr>
<tr>
<td>M-w</td>
<td>copy region marked</td>
</tr>
<tr>
<td>C-x C-f</td>
<td>find file and read it</td>
</tr>
<tr>
<td>C-x C-v</td>
<td>find and read alternate file</td>
</tr>
<tr>
<td>C-x i</td>
<td>insert file at cursor position</td>
</tr>
<tr>
<td>C-x C-s</td>
<td>save file</td>
</tr>
<tr>
<td>C-x C-w</td>
<td>write buffer to a different file</td>
</tr>
<tr>
<td>C-x C-c</td>
<td>exit emacs, and be prompted to save</td>
</tr>
</tbody>
</table>
CHAPTER 11

Unix Command Summary

11.1 Unix Commands

In the table below we summarize the more frequently used commands on a Unix system. In this table, as in general, for most Unix commands, file, could be an actual file name, or a list of file names, or input/output could be redirected to or from the command.

<table>
<thead>
<tr>
<th>Command/Syntax</th>
<th>What it will do</th>
</tr>
</thead>
<tbody>
<tr>
<td>awk/nawk [options] file</td>
<td>scan for patterns in a file and process the results</td>
</tr>
<tr>
<td>cat [options] file</td>
<td>concatenate (list) a file</td>
</tr>
<tr>
<td>cd [directory]</td>
<td>change directory</td>
</tr>
<tr>
<td>chgrp [options] group file</td>
<td>change the group of the file</td>
</tr>
<tr>
<td>chmod [options] file</td>
<td>change file or directory access permissions</td>
</tr>
<tr>
<td>chown [options] owner file</td>
<td>change the ownership of a file; can only be done by the superuser</td>
</tr>
<tr>
<td>chsh (passwd -e/-s) username login_shell</td>
<td>change the user’s login shell (often only by the superuser)</td>
</tr>
<tr>
<td>cmp [options] file1 file2</td>
<td>compare two files and list where differences occur (text or binary files)</td>
</tr>
<tr>
<td>compress [options] file</td>
<td>compress file and save it as file.Z</td>
</tr>
<tr>
<td>cp [options] file1 file2</td>
<td>copy file1 into file2; file2 shouldn't already exist. This command creates or overwrites file2.</td>
</tr>
<tr>
<td>cut (options) [file(s)]</td>
<td>cut specified field(s)/character(s) from lines in file(s)</td>
</tr>
<tr>
<td>date [options]</td>
<td>report the current date and time</td>
</tr>
<tr>
<td>dd [if=infile] [of=outfile] [operand=value]</td>
<td>copy a file, converting between ASCII and EBCDIC or swapping byte order, as specified</td>
</tr>
<tr>
<td>diff [options] file1 file2</td>
<td>compare the two files and display the differences (text files only)</td>
</tr>
<tr>
<td>df [options] [resource]</td>
<td>report the summary of disk blocks and inodes free and in use</td>
</tr>
<tr>
<td>du [options] [directory or file]</td>
<td>report amount of disk space in use</td>
</tr>
<tr>
<td>echo [text string]</td>
<td>echo the text string to stdout</td>
</tr>
<tr>
<td>ed or ex [options] file</td>
<td>Unix line editors</td>
</tr>
<tr>
<td>emacs [options] file</td>
<td>full-screen editor</td>
</tr>
<tr>
<td>expr arguments</td>
<td>evaluate the arguments. Used to do arithmetic, etc. in the shell.</td>
</tr>
<tr>
<td>file [options] file</td>
<td>classify the file type</td>
</tr>
</tbody>
</table>
## Unix Commands

<table>
<thead>
<tr>
<th>Command/Syntax</th>
<th>What it will do</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>find</code> directory [options] [actions]</td>
<td>find files matching a type or pattern</td>
</tr>
<tr>
<td><code>finger</code> [options] <code>user[@hostname]</code></td>
<td>report information about users on local and remote machines</td>
</tr>
<tr>
<td><code>ftp</code> [options] <code>host</code></td>
<td>transfer file(s) using file transfer protocol</td>
</tr>
<tr>
<td><code>grep</code> [options] <code>search string</code></td>
<td>search the argument (in this case probably a file) for all occurrences of the search string, and list them.</td>
</tr>
<tr>
<td><code>egrep</code> [options] <code>search string</code></td>
<td>search the argument (in this case probably a file) for all occurrences of the search string, and list them.</td>
</tr>
<tr>
<td><code>fgrep</code> [options] <code>search string</code></td>
<td>search the argument (in this case probably a file) for all occurrences of the search string, and list them.</td>
</tr>
<tr>
<td><code>gzip</code> [options] <code>file</code></td>
<td>compress or uncompress a file. Compressed files are stored with a <code>.gz</code> ending</td>
</tr>
<tr>
<td><code>gunzip</code> [options] <code>file</code></td>
<td>compress or uncompress a file. Compressed files are stored with a <code>.gz</code> ending</td>
</tr>
<tr>
<td><code>zcat</code> [options] <code>file</code></td>
<td>compress or uncompress a file. Compressed files are stored with a <code>.gz</code> ending</td>
</tr>
<tr>
<td><code>head</code> [-number] <code>file</code></td>
<td>display the first 10 (or number of) lines of a file</td>
</tr>
<tr>
<td><code>hostname</code></td>
<td>display or set (super-user only) the name of the current machine</td>
</tr>
<tr>
<td><code>kill</code> [options] [-SIGNAL] <code>[pid#] [%job]</code></td>
<td>send a signal to the process with the process id number (pid#) or job control number (%n). The default signal is to kill the process.</td>
</tr>
<tr>
<td><code>ln</code> [options] <code>source_file</code> <code>target</code></td>
<td>link the <code>source_file</code> to the <code>target</code></td>
</tr>
<tr>
<td><code>lpq</code> [options]</td>
<td>show the status of print jobs</td>
</tr>
<tr>
<td><code>lpstat</code> [options]</td>
<td>show the status of print jobs</td>
</tr>
<tr>
<td><code>lpr</code> [options] <code>file</code></td>
<td>print to defined printer</td>
</tr>
<tr>
<td><code>lp</code> [options] <code>file</code></td>
<td>print to defined printer</td>
</tr>
<tr>
<td><code>lprm</code> [options]</td>
<td>remove a print job from the print queue</td>
</tr>
<tr>
<td><code>cancel</code> [options]</td>
<td>remove a print job from the print queue</td>
</tr>
<tr>
<td><code>ls</code> [options] <code>[directory or file]</code></td>
<td>list directory contents or file permissions</td>
</tr>
<tr>
<td><code>mail</code> [options] <code>[user]</code></td>
<td>simple email utility available on Unix systems. Type a period as the first character on a new line to send message out, question mark for help.</td>
</tr>
<tr>
<td><code>mailx</code> [options] <code>[user]</code></td>
<td>simple email utility available on Unix systems. Type a period as the first character on a new line to send message out, question mark for help.</td>
</tr>
<tr>
<td><code>Mail</code> [options] <code>[user]</code></td>
<td>simple email utility available on Unix systems. Type a period as the first character on a new line to send message out, question mark for help.</td>
</tr>
<tr>
<td><code>man</code> [options] <code>command</code></td>
<td>show the manual (<code>man</code>) page for a command</td>
</tr>
<tr>
<td><code>mkdir</code> [options] <code>directory</code></td>
<td>make a <code>directory</code></td>
</tr>
<tr>
<td><code>more</code> [options] <code>file</code></td>
<td>page through a text file</td>
</tr>
<tr>
<td><code>less</code> [options] <code>file</code></td>
<td>page through a text file</td>
</tr>
<tr>
<td><code>pg</code> [options] <code>file</code></td>
<td>page through a text file</td>
</tr>
<tr>
<td><code>mv</code> [options] <code>file1 file2</code></td>
<td>move <code>file1</code> into <code>file2</code></td>
</tr>
<tr>
<td><code>od</code> [options] <code>file</code></td>
<td>octal dump a binary file, in octal, ASCII, hex, decimal, or character mode.</td>
</tr>
<tr>
<td><code>passwd</code> [options]</td>
<td>set or change your password</td>
</tr>
<tr>
<td><code>paste</code> [options] <code>file</code></td>
<td>paste field(s) onto the lines in <code>file</code></td>
</tr>
<tr>
<td><code>pr</code> [options] <code>file</code></td>
<td>filter the file and print it on the terminal</td>
</tr>
<tr>
<td><code>ps</code> [options]</td>
<td>show status of active processes</td>
</tr>
<tr>
<td>Command/Syntax</td>
<td>What it will do</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------</td>
</tr>
<tr>
<td><code>pwd</code></td>
<td>print working (current) directory</td>
</tr>
<tr>
<td><code>rcp [options] hostname</code></td>
<td>remotely copy files from this machine to another machine</td>
</tr>
<tr>
<td><code>rlogin [options] hostname</code></td>
<td>login remotely to another machine</td>
</tr>
<tr>
<td><code>rm [options] file</code></td>
<td>remove (delete) a file or directory ( <code>-r</code> recursively deletes the directory and its contents) ( <code>-i</code> prompts before removing files)</td>
</tr>
<tr>
<td><code>rmdir [options] directory</code></td>
<td>remove a directory</td>
</tr>
<tr>
<td><code>rsh [options] hostname</code></td>
<td>remote shell to run on another machine</td>
</tr>
<tr>
<td><code>script file</code></td>
<td>saves everything that appears on the screen to file until <code>exit</code> is executed</td>
</tr>
<tr>
<td><code>sed [options] file</code></td>
<td>stream editor for editing files from a script or from the command line</td>
</tr>
<tr>
<td><code>sort [options] file</code></td>
<td>sort the lines of the file according to the options chosen</td>
</tr>
<tr>
<td><code>source file</code></td>
<td>read commands from the file and execute them in the current shell. <code>source</code>: C shell, <code>:</code>: Bourne shell.</td>
</tr>
<tr>
<td><code>strings [options] file</code></td>
<td>report any sequence of 4 or more printable characters ending in <code>&lt;NL&gt;</code> or <code>&lt;NULL&gt;</code>. Usually used to search binary files for ASCII strings.</td>
</tr>
<tr>
<td><code>stty [options] file</code></td>
<td>display the last few lines (or parts) of a file</td>
</tr>
<tr>
<td><code>tar key[options] [file(s)]</code></td>
<td>tape archiver–refer to man pages for details on creating, listing, and retrieving from archive files. Tar files can be stored on tape or disk.</td>
</tr>
<tr>
<td><code>tee [options] file</code></td>
<td>copy stdout to one or more files</td>
</tr>
<tr>
<td><code>telnet [host [port]]</code></td>
<td>communicate with another host using telnet protocol</td>
</tr>
<tr>
<td><code>touch [options] [date] file</code></td>
<td>create an empty file, or update the access time of an existing file</td>
</tr>
<tr>
<td><code>tr [options] string1 string2</code></td>
<td>translate the characters in string1 from stdin into those in string2 in stdout</td>
</tr>
<tr>
<td><code>uncompress file.Z</code></td>
<td>uncompress <code>file.Z</code> and save it as a file</td>
</tr>
<tr>
<td><code>uniq [options] file</code></td>
<td>remove repeated lines in a file</td>
</tr>
<tr>
<td><code>uudecode [file]</code></td>
<td>decode a uuencoded file, recreating the original file</td>
</tr>
<tr>
<td><code>uuencode [file] new_name</code></td>
<td>encode binary file to 7-bit ASCII, useful when sending via email, to be decoded as new_name at destination</td>
</tr>
<tr>
<td><code>vi [options] file</code></td>
<td>visual, full-screen editor</td>
</tr>
<tr>
<td><code>wc [options] [file(s)]</code></td>
<td>display word (or character or line) count for file(s)</td>
</tr>
<tr>
<td><code>whereis [options] command</code></td>
<td>report the binary, source, and man page locations for the command named</td>
</tr>
<tr>
<td><code>which command</code></td>
<td>reports the path to the command or the shell alias in use</td>
</tr>
<tr>
<td><code>who or w</code></td>
<td>report who is logged in and what processes are running</td>
</tr>
<tr>
<td><code>zcat file.Z</code></td>
<td>concatenate (list) uncompressed file to screen, leaving file compressed on disk</td>
</tr>
</tbody>
</table>
CHAPTER 12

A Short Unix Bibliography

12.1 Highly Recommended


12.2 Assorted Others


