

First of all, these notes will cover only a small subset of the available commands and utilities, and will cover most of those in a shallow fashion.

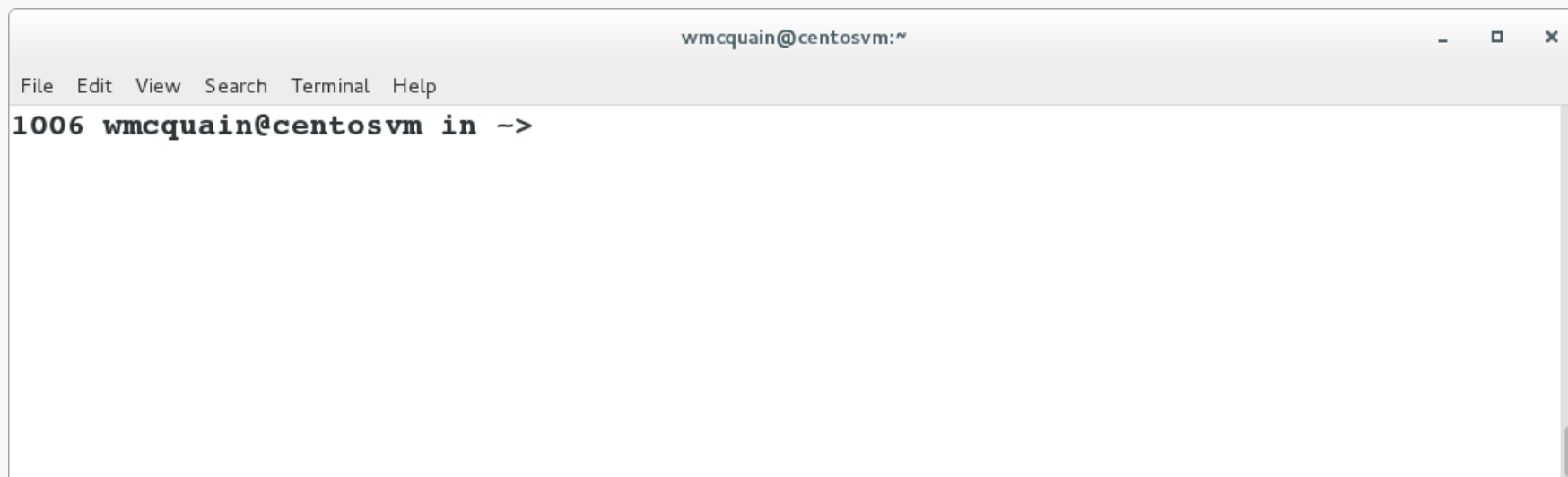
Read the relevant material in Sobell!

If you want to follow along with the examples that follow, and you do, open a Linux terminal.

Second, most of the Linux commands have features that are enabled by using command-line switches; check the **man** pages for the commands for details!

The Linux terminal (or command shell) allows you to enter commands and execute programs.

A terminal displays a prompt and a cursor indicating it's waiting for user input:

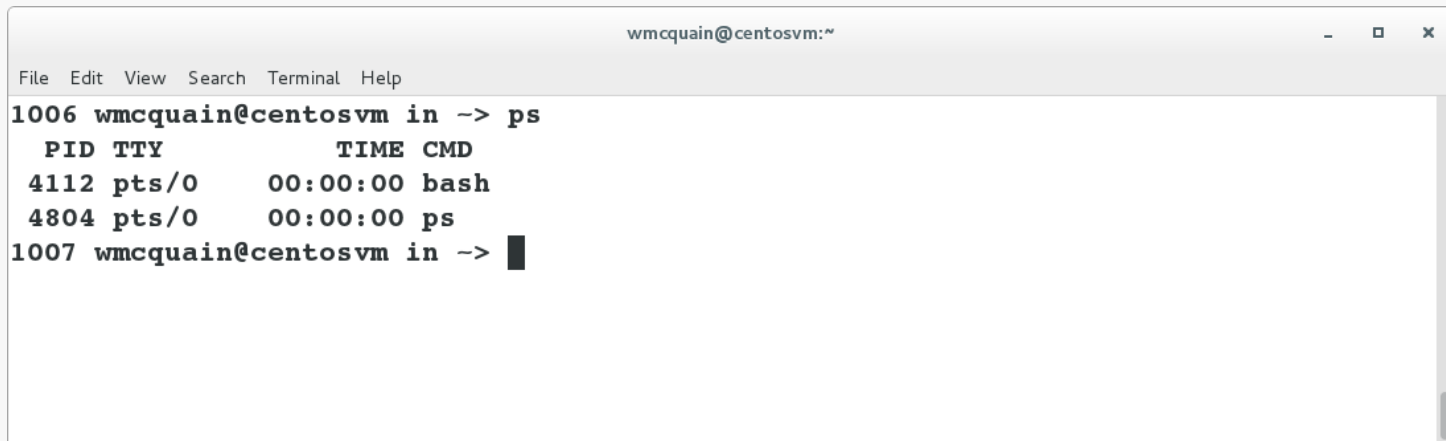
A screenshot of a Linux terminal window. The window title is "wmcquain@centosvm:~". The menu bar contains "File", "Edit", "View", "Search", "Terminal", and "Help". The terminal content shows the prompt "1006 wmcquain@centosvm in ~->" with a cursor at the end of the line.

```
wmcquain@centosvm:~  
File Edit View Search Terminal Help  
1006 wmcquain@centosvm in ~->
```

The prompt itself is configurable; precisely how depends on the particular type of shell you are running.

It is likely that by default you will run the *bash* shell.

The **ps** command displays information about processes the shell is currently running:



```
wmcquain@centosvm:~  
File Edit View Search Terminal Help  
1006 wmcquain@centosvm in -> ps  
  PID TTY          TIME CMD  
 4112 pts/0        00:00:00 bash  
 4804 pts/0        00:00:00 ps  
1007 wmcquain@centosvm in -> █
```

We see that two processes are executing, **bash** and **ps**.

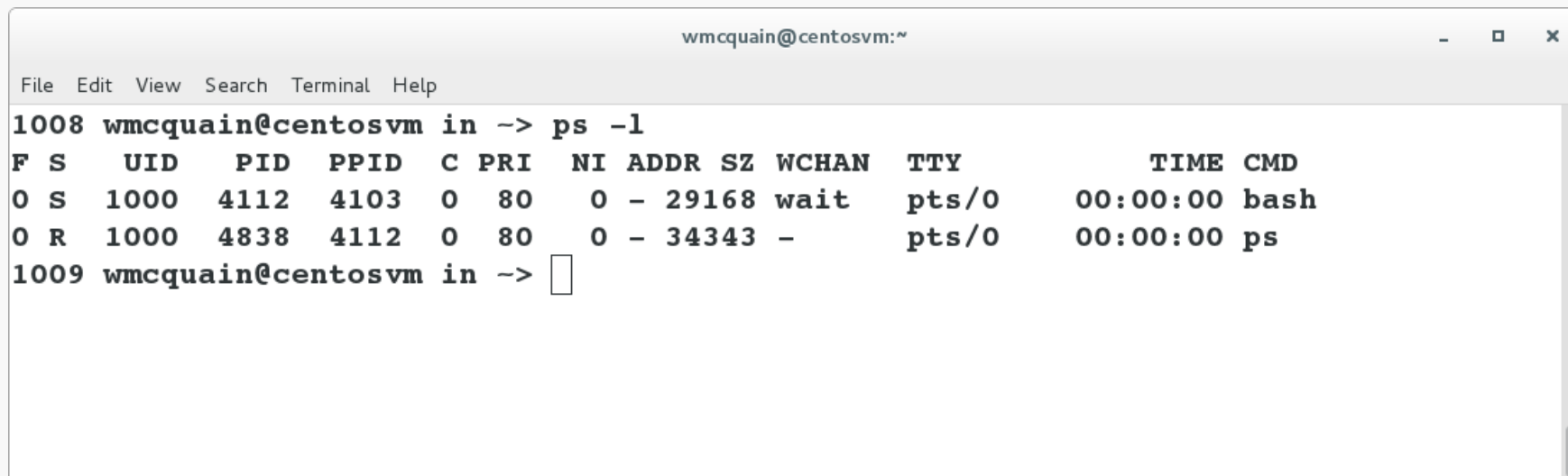
Moreover, we see that:

- each is assigned a unique numeric identifier called a process ID or PID
- each is associated with a terminal (TTY) named pts/0

Try executing **ps** a second time... you'll notice that the PID for **bash** is the same as before but the PID for **ps** has changed.

Why? (That's two questions.)

Try running **ps** with the **-l** (that's ell, not one) switch:

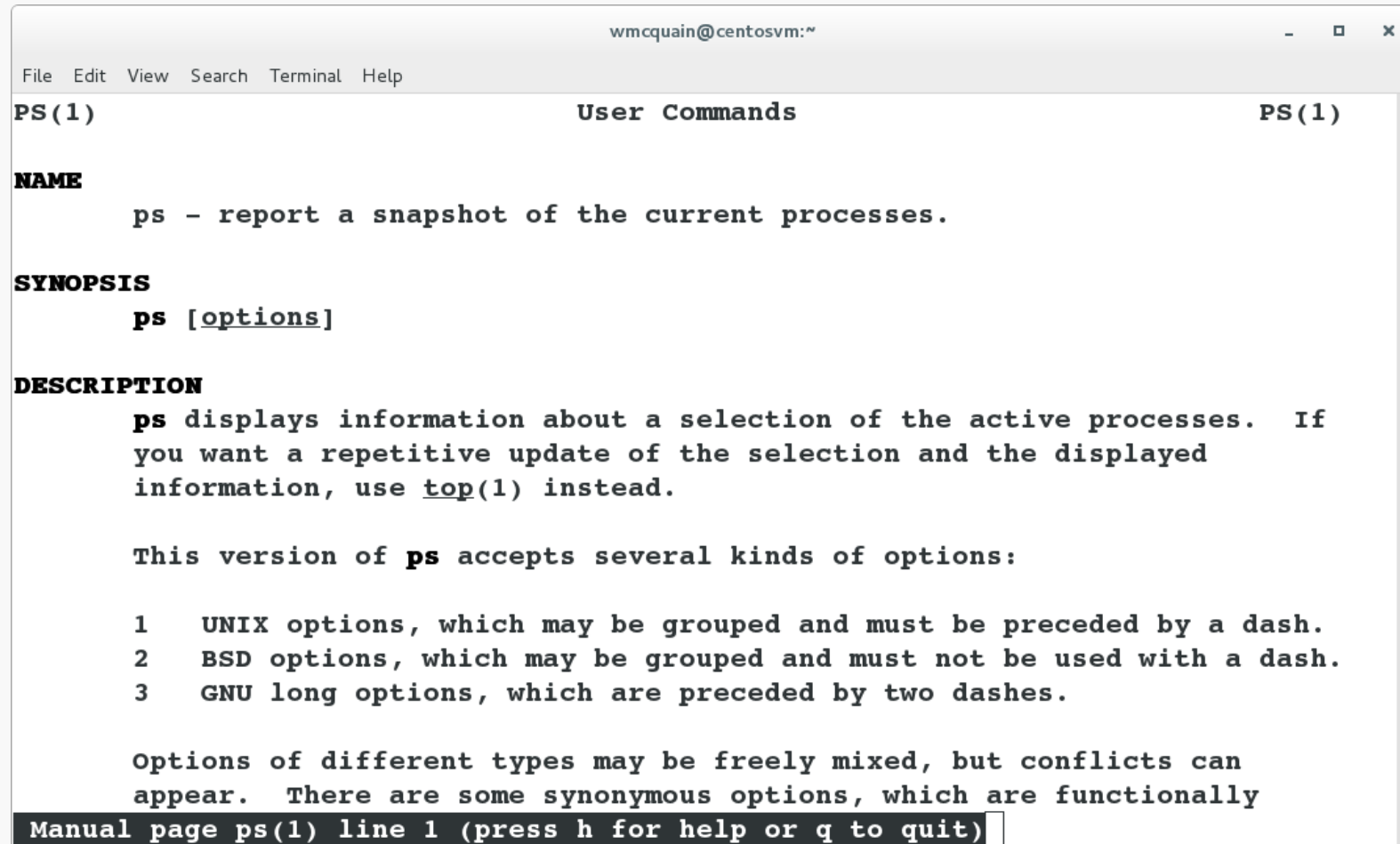


```
wmcquain@centosvm:~  
File Edit View Search Terminal Help  
1008 wmcquain@centosvm in ~-> ps -l  
F S    UID    PID  PPID  C PRI  NI ADDR SZ WCHAN  TTY          TIME CMD  
0 S    1000   4112  4103  0  80   0 -  29168 wait  pts/0        00:00:00 bash  
0 R    1000   4838  4112  0  80   0 -  34343 -    pts/0        00:00:00 ps  
1009 wmcquain@centosvm in ~-> 
```

Don't worry about the meaning of all that just yet, but do notice that the results of the **ps** command were altered by the use of a “switch” on the command line.

This is typical of Linux commands and many user programs.

The **man** (manual) command can be used to obtain more information about Linux commands:



```
wmcquain@centosvm:~  
File Edit View Search Terminal Help  
PS(1) User Commands PS(1)  
NAME  
ps - report a snapshot of the current processes.  
SYNOPSIS  
ps [options]  
DESCRIPTION  
ps displays information about a selection of the active processes. If you want a repetitive update of the selection and the displayed information, use top(1) instead.  
  
This version of ps accepts several kinds of options:  
  
1 UNIX options, which may be grouped and must be preceded by a dash.  
2 BSD options, which may be grouped and must not be used with a dash.  
3 GNU long options, which are preceded by two dashes.  
  
Options of different types may be freely mixed, but conflicts can appear. There are some synonymous options, which are functionally  
Manual page ps(1) line 1 (press h for help or q to quit)
```

The **man** pages are often the first resort for discovering options. Try running **man man**...

The screenshot shows a Mozilla Firefox browser window displaying the website tldp.org. The browser's address bar shows the URL and a search field. The website header features the title "The Linux Documentation Project" with a penguin logo and language options for Español, Français, and Italian. A date stamp "2017-08-23" is visible in the top right corner.

The left sidebar contains several navigation menus:

- LDP Worldwide**
 - Mirrors
 - Non-English info
 - Translation effort
 - Translated Guides
 - Translated HOWTOs
 - Printed books
 - Main site
- LDP Information**
 - FAQ
 - Manifesto / license
 - History
 - Volunteers/Staff
 - Job Descriptions
 - Mailing lists
 - IRC
 - Feedback
- Author / Contribute**
 - LDP Author Guide
 - Contribute / Help
 - Resources
 - How To Submit
 - Git repository
 - Downloads
 - Contacts
- LDP Site Sponsor**
 - hosted by

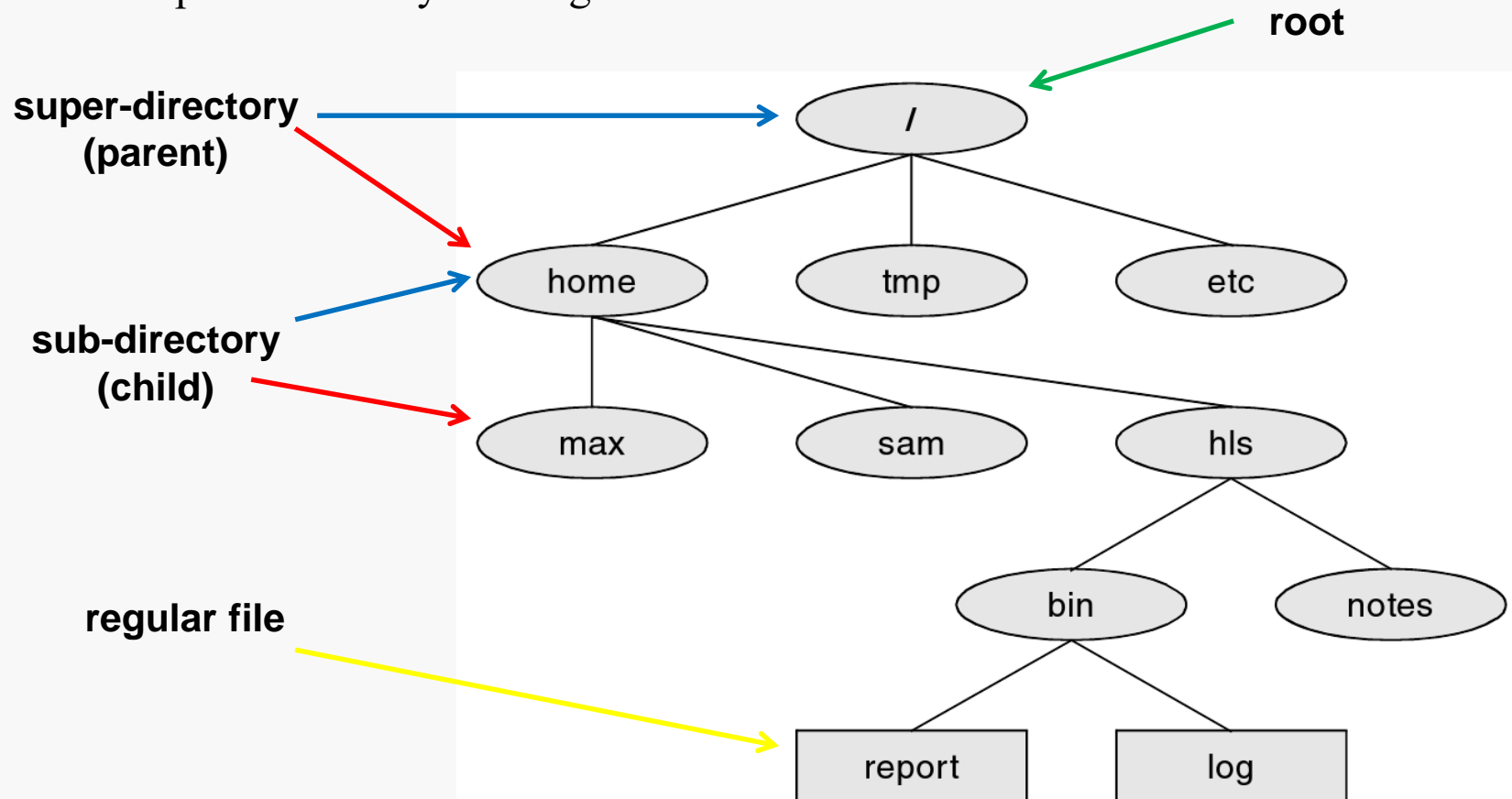
The main content area is organized into sections:

- Workshop**
 - LDP Wiki:** The LDP Wiki is the entry point for any work in progress. Links: [Members](#) | [Authors](#) | [Visitors](#)
- Documents**
 - HOWTOs:** subject-specific help. Links: [latest updates](#) | [main index](#) | [browse by category](#)
 - Guides:** longer, in-depth books. Link: [latest updates / main index](#)
 - FAQs:** Frequently Asked Questions. Link: [latest updates / main index](#)
 - man pages:** help on individual commands (20060810)
 - Linux Gazette:** online magazine
- Search / Resources**
 - Search input field with "go" button
 - Links
 - OMF search
- Announcements / Miscellaneous**
 - Document Updates**
 - A link to HOWTOs that have been [recently updated](#).

The file system is a set of data structures that organizes collections of files.

Files are grouped into *directories* (although directories are themselves files).

Here's one possible file system organization:



Each file and directory has a name:

- names are case-sensitive
- names within the same directory must be unique
- the use of characters other than letters, digits, underscores and periods tends to cause extra work when using many commands

File names are often of the form `<name.ext>`, such as `BashTerminal.jpg`.

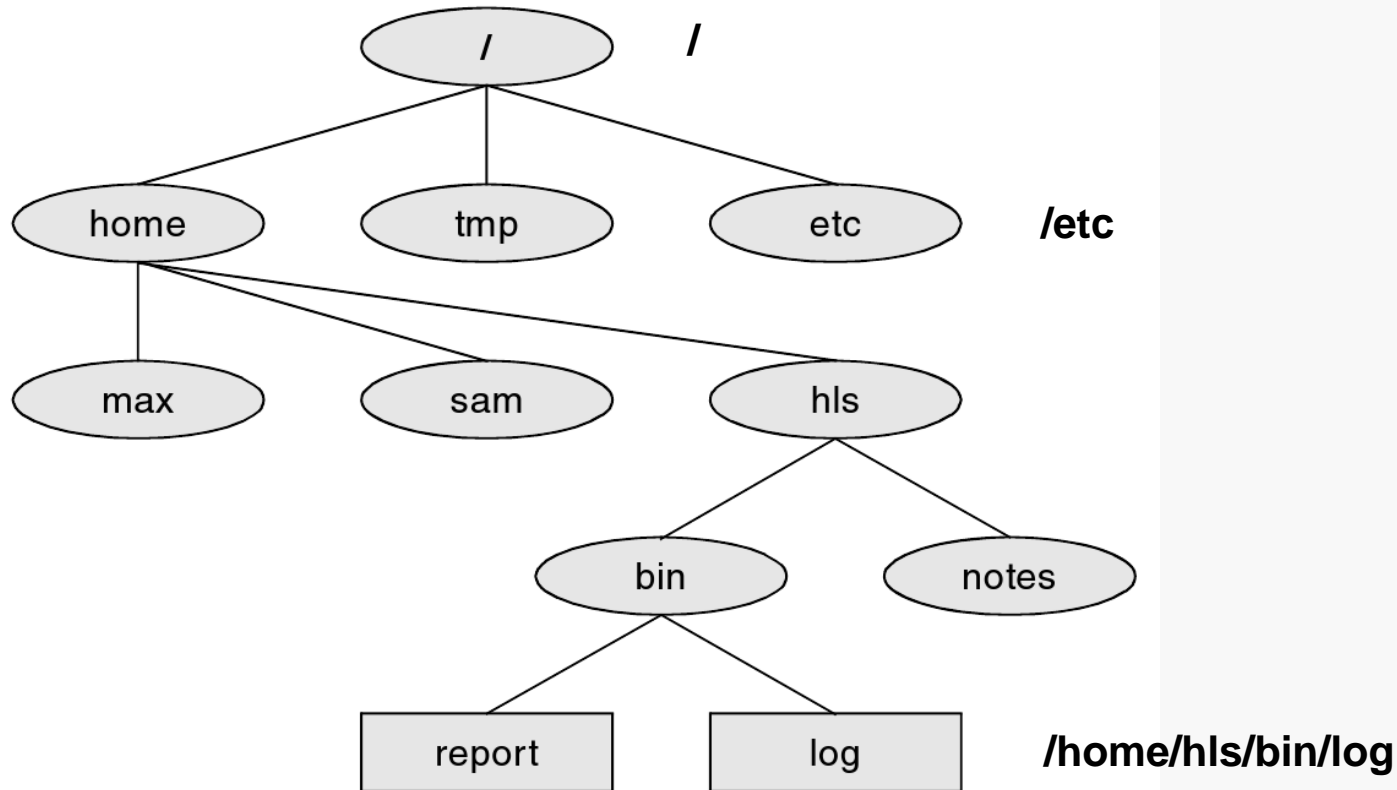
While file extensions are not mandatory, it is standard (and good) practice to employ them.

You are required to use appropriate file extensions in this course.

It is bad practice to employ extensions incorrectly. Common ones include:

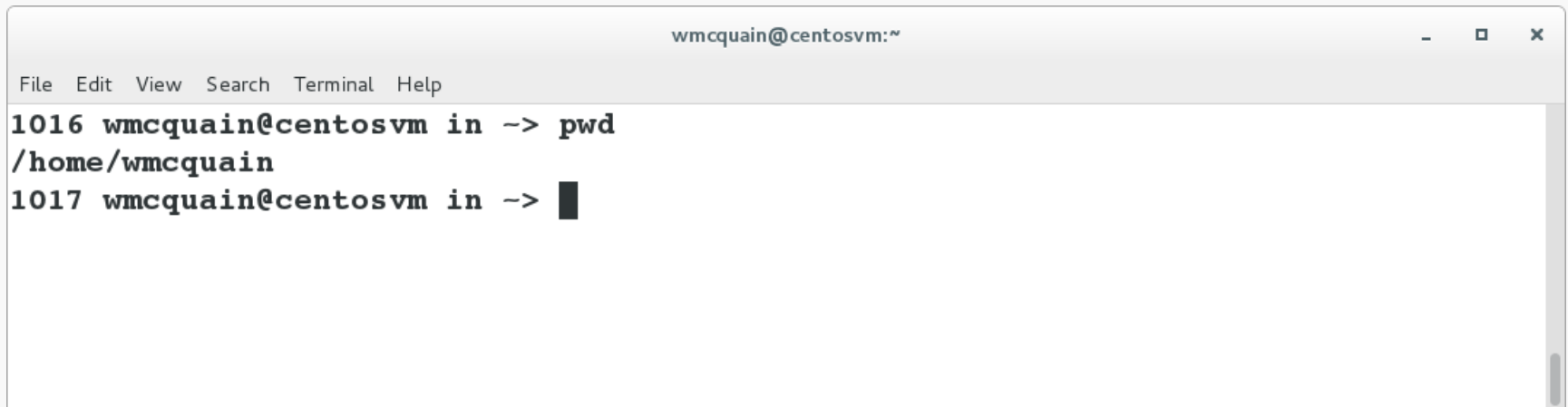
- `c` C language source files
- `h` C language header files
- `txt` plain text files
- `gz` file compressed with **gzip**
- `tar` archive file created with **tar**
- `html` hypertext markup language file

Each file (and directory) can be specified by a unique *absolute pathname*:



When you open a terminal, by default you will be in your *home directory*.

Typically, this will be `/home/<userid>`, but you can check the path to your current directory by using the **pwd** command:

A terminal window titled 'wmcquain@centosvm:~' with a menu bar (File, Edit, View, Search, Terminal, Help). The terminal shows the command 'pwd' being executed, resulting in the output '/home/wmcquain'.

```
wmcquain@centosvm:~  
File Edit View Search Terminal Help  
1016 wmcquain@centosvm in -> pwd  
/home/wmcquain  
1017 wmcquain@centosvm in -> █
```

The **ls** command lists the files in the current directory:

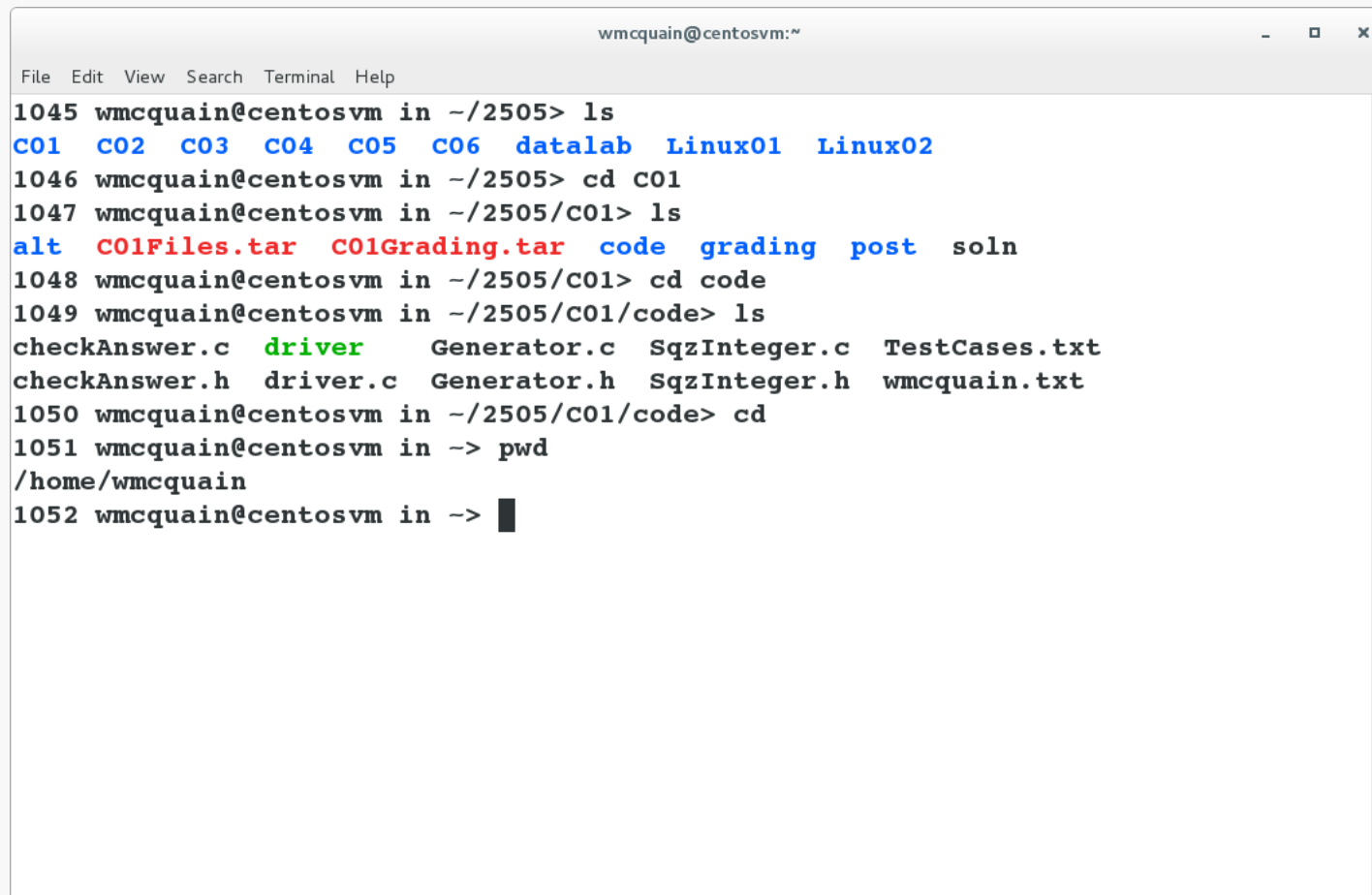
```
wmcquain@centosvm:~/bin
File Edit View Search Terminal Help
1036 wmcquain@centosvm in ~/bin> ls
2505Summer16.jar      distributetars.sh  logisim-generic-2.7.1.jar  unpackjars.sh
3114Summer2016.jar  filter.sh          Mars4_4.jar               unpacktars2.sh
backtoshare.sh       flatten.sh         Mars4_5.jar               unpacktars.sh
backup.sh            Harvester.jar     package.sh                 unpackzips.sh
distributefiles.sh  howmany.sh        rmdupes3.sh               zipdirs.sh
1037 wmcquain@centosvm in ~/bin> ls -l
total 14656
-rwxrw----. 1 wmcquain comporg 308335 Jul 1 2016 2505Summer16.jar
-rwxrw----. 1 wmcquain comporg 308335 Jul 1 2016 3114Summer2016.jar
-rwxrwx---. 1 wmcquain comporg 2598 Jul 5 11:03 backtoshare.sh
-rwxrw----. 1 wmcquain wmcquain 2786 Jun 29 2015 backup.sh
-rwxrwx---. 1 wmcquain wmcquain 1929 Feb 6 2016 distributefiles.sh
-rwxr----- 1 wmcquain wmcquain 2596 Nov 18 2014 distributetars.sh
-rwxrw----. 1 wmcquain wmcquain 6350 May 1 11:21 filter.sh
-rwxrw----. 1 wmcquain wmcquain 1968 Feb 4 2017 flatten.sh
-rwxrw----. 1 wmcquain comporg 3487 Jun 9 13:54 Harvester.jar
-rwxrw----. 1 wmcquain wmcquain 1380 Jun 29 2015 howmany.sh
-rwxrwx---. 1 wmcquain wmcquain 6933898 Jan 31 2017 logisim-generic-2.7.1.jar
-rwxrwx---. 1 wmcquain wmcquain 3212322 Nov 10 2014 Mars4_4.jar
-rwxrwx---. 1 wmcquain wmcquain 4169142 Aug 13 2015 Mars4_5.jar
-rwxrwx---. 1 wmcquain comporg 1502 Aug 4 22:41 package.sh
-rwxrw----. 1 wmcquain wmcquain 2449 Feb 23 2014 rmdupes3.sh
-rwxrwx---. 1 wmcquain comporg 2918 Jun 25 2016 unpackjars.sh
```

You can display a map of the directory tree rooted at your current directory:

```
wmcquain@centosvm:~/2505
File Edit View Search Terminal Help
1040 wmcquain@centosvm in ~/2505> ls
C01 C02 C03 C04 C05 C06 datalab Linux01 Linux02
1041 wmcquain@centosvm in ~/2505> tree
.
|-- C01
|   |-- alt
|   |   |-- altdriver
|   |   |-- checkAnswer.h
|   |   |-- checkAnswer.o
|   |   |-- driver.c
|   |   |-- SqzInteger.c
|   |   `-- SqzInteger.h
|   |-- C01Files.tar
|   |-- C01Grading.tar
|   |-- code
|   |   |-- checkAnswer.c
|   |   |-- checkAnswer.h
|   |   |-- driver
|   |   |-- driver.c
|   |   |-- Generator.c
|   |   |-- Generator.h
|   |   |-- SqzInteger.c
|   |   |-- SqzInteger.h
|   |   |-- TestCases.txt
```

The tree program may not be installed by default; we'll cover software package installation a bit later.

You can use the **cd** command to change your current (or *working*) directory:



```
wmcquain@centosvm:~  
File Edit View Search Terminal Help  
1045 wmcquain@centosvm in ~/2505> ls  
C01 C02 C03 C04 C05 C06 datalab Linux01 Linux02  
1046 wmcquain@centosvm in ~/2505> cd C01  
1047 wmcquain@centosvm in ~/2505/C01> ls  
alt C01Files.tar C01Grading.tar code grading post soln  
1048 wmcquain@centosvm in ~/2505/C01> cd code  
1049 wmcquain@centosvm in ~/2505/C01/code> ls  
checkAnswer.c driver Generator.c SqzInteger.c TestCases.txt  
checkAnswer.h driver.c Generator.h SqzInteger.h wmcquain.txt  
1050 wmcquain@centosvm in ~/2505/C01/code> cd  
1051 wmcquain@centosvm in -> pwd  
/home/wmcquain  
1052 wmcquain@centosvm in -> █
```

Using **cd** with no destination moves you back to your home directory:

You can also specify a pathname that's relative to the current (working) directory.

Let's say you're in a directory `~/2505/C01/alt/`:

```
wmcquain@
File Edit View Search Terminal Help
1040 wmcquain@centosvm in ~/2505> ls
C01 C02 C03 C04 C05 C06 datalab
1041 wmcquain@centosvm in ~/2505> tree
.
|-- C01
|   |-- alt
|       |-- altdriver
|       |-- checkAnswer.h
|       |-- checkAnswer.o
|       |-- driver.c
|       |-- SqzInteger.c
|       |-- SqzInteger.h
|   |-- C01Files.tar
|   |-- C01Grading.tar
|   |-- code
|       |-- checkAnswer.c
|       |-- checkAnswer.h
|       |-- driver
|       |-- driver.c
|       |-- Generator.c
|       |-- Generator.h
|       |-- SqzInteger.c
|       |-- SqzInteger.h
|       |-- TestCases.txt
```

../C01Grading.tar

../code/checkAnswer.c

There are two special directory names:

- `.` refers to the current directory
- `..` refers to the parent of the current directory

mkdir: creates a new subdirectory of the current directory

rmdir: deletes a empty subdirectory

rm -Rf: deletes a subdirectory and all its contents (recursive, very dangerous!)

```
wmcquain@centosvm:~/2505/notes
File Edit View Search Terminal Help
1063 wmcquain@centosvm in ~/2505/notes> ls
T02
1064 wmcquain@centosvm in ~/2505/notes> mkdir temp
1065 wmcquain@centosvm in ~/2505/notes> ls
T02 temp
1066 wmcquain@centosvm in ~/2505/notes> ls temp
1067 wmcquain@centosvm in ~/2505/notes> rmdir temp
1068 wmcquain@centosvm in ~/2505/notes> ls
T02
1069 wmcquain@centosvm in ~/2505/notes> ls T02
Slide02.png Slide04.png Slide06.png Slide11.png Slide13.png
Slide03.png Slide05.png Slide10.png Slide12.png
1070 wmcquain@centosvm in ~/2505/notes> rmdir T02/
rmdir: failed to remove 'T02/': Directory not empty
1071 wmcquain@centosvm in ~/2505/notes> 
```

You can create a copy of a file with the **cp** command.

Assume we're in a directory containing a file named **inloop.c**:

cp inloop.c inloop2.c

makes a copy of **inloop.c** named **inloop2.c** in the same directory

cp inloop.c ..

makes a copy of **inloop.c** with the same name in the parent directory

cp inloop.c ../inloop2.c

makes a copy of **inloop.c**, named **inloop2.c**, in the parent directory

As before, assume we're in a directory containing a file named **infloop.c**:

```
mv infloop.c infiniteloop.c
```

changes the name of the file **infloop.c** to **infinitefloop.c**

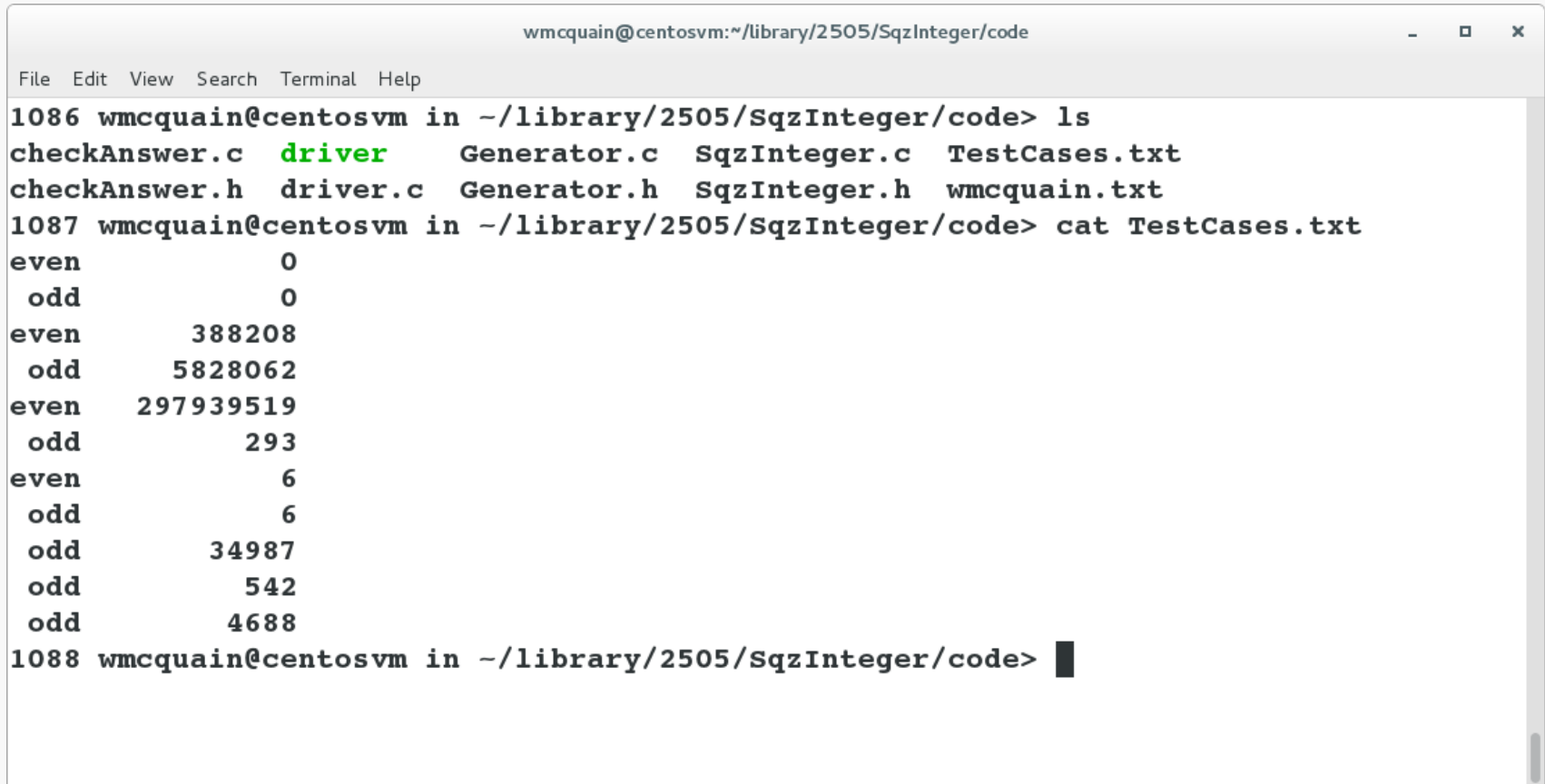
```
mv infloop.c ../attic
```

moves the file **infloop.c** to the subdirectory of the parent named **attic**

```
mv infloop.c ../infinitefloop.c
```

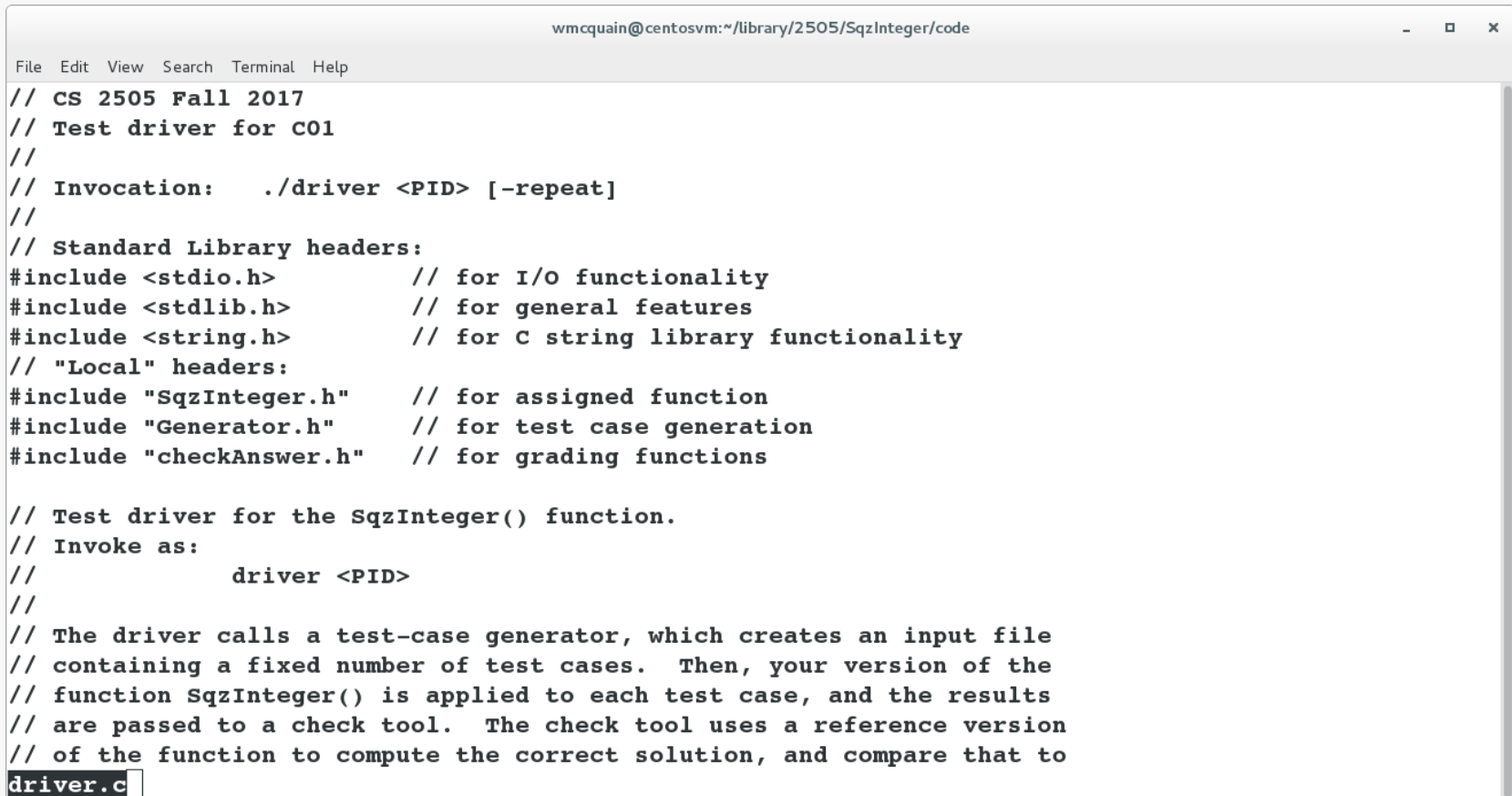
removes the file **infloop.c** from this directory, and creates a copy named **infinitefloop.c** in the parent directory

You can use the **cat** command to display the contents of a file to the terminal:



```
wmcquain@centosvm:~/library/2505/SqzInteger/code
File Edit View Search Terminal Help
1086 wmcquain@centosvm in ~/library/2505/SqzInteger/code> ls
checkAnswer.c driver Generator.c SqzInteger.c TestCases.txt
checkAnswer.h driver.c Generator.h SqzInteger.h wmcquain.txt
1087 wmcquain@centosvm in ~/library/2505/SqzInteger/code> cat TestCases.txt
even          0
  odd          0
even        388208
  odd        5828062
even    297939519
  odd         293
even          6
  odd          6
  odd        34987
  odd         542
  odd        4688
1088 wmcquain@centosvm in ~/library/2505/SqzInteger/code> █
```

You can use the **less** command to display the contents of a file to the terminal, one screenful at a time; here we entered **less driver.c**:

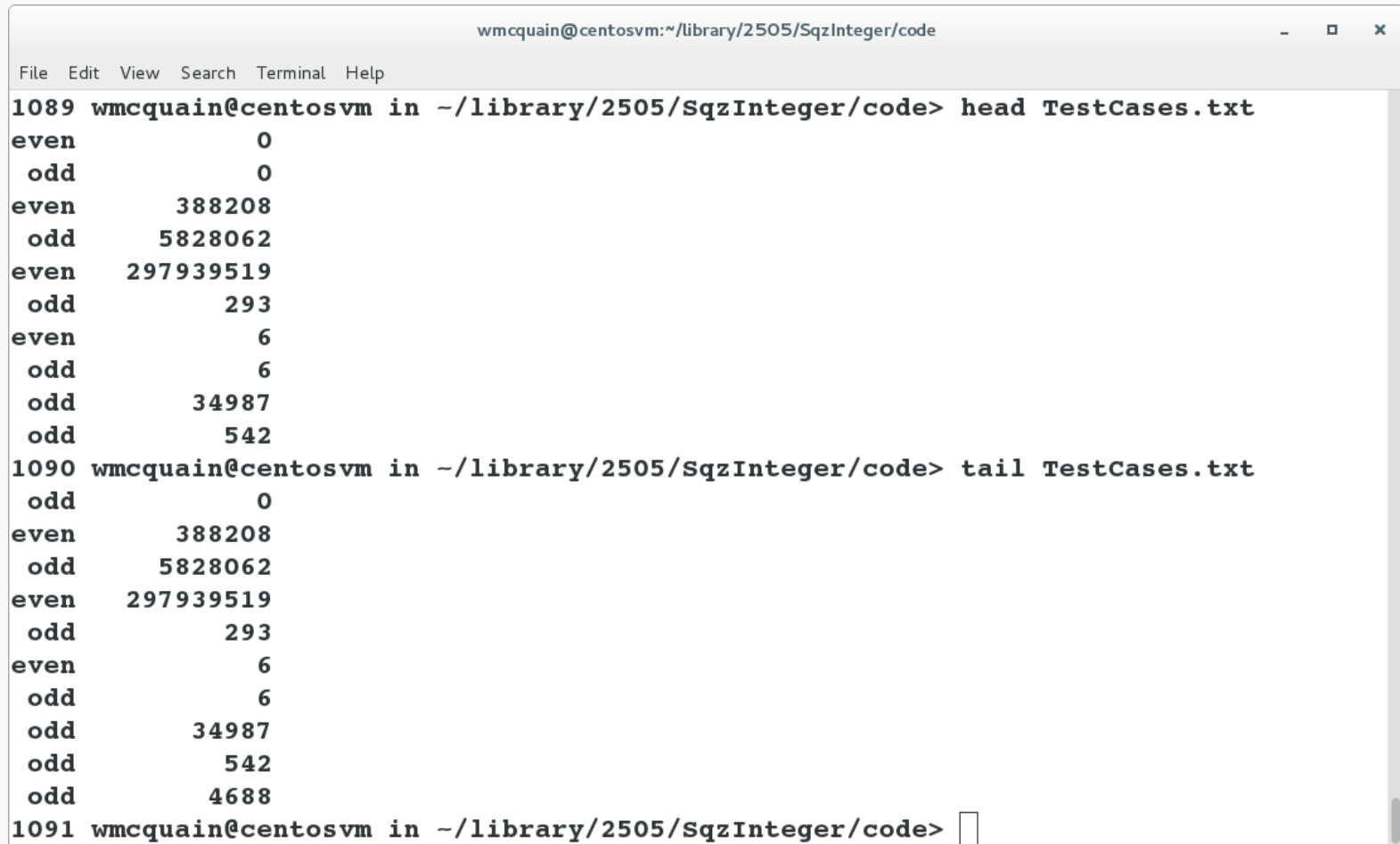
A terminal window titled 'wmcquain@centosvm:~/library/2505/SqzInteger/code' showing the contents of a C file named 'driver.c'. The code is displayed in a monospaced font. The window has a menu bar with 'File', 'Edit', 'View', 'Search', 'Terminal', and 'Help'. The code includes comments and preprocessor directives for standard and local headers, and a test driver function.

```
wmcquain@centosvm:~/library/2505/SqzInteger/code
File Edit View Search Terminal Help
// CS 2505 Fall 2017
// Test driver for C01
//
// Invocation:  ./driver <PID> [-repeat]
//
// Standard Library headers:
#include <stdio.h>          // for I/O functionality
#include <stdlib.h>        // for general features
#include <string.h>        // for C string library functionality
// "Local" headers:
#include "SqzInteger.h"    // for assigned function
#include "Generator.h"     // for test case generation
#include "checkAnswer.h"  // for grading functions

// Test driver for the SqzInteger() function.
// Invoke as:
//          driver <PID>
//
// The driver calls a test-case generator, which creates an input file
// containing a fixed number of test cases.  Then, your version of the
// function SqzInteger() is applied to each test case, and the results
// are passed to a check tool.  The check tool uses a reference version
// of the function to compute the correct solution, and compare that to
driver.c
```

Just hit **<space>** or **f** to advance, **b** to back up, and **q** to quit.

You can view the first (or last) few lines of a file by using the **head** (or **tail**) command:



```
wmcquain@centosvm:~/library/2505/SqzInteger/code
File Edit View Search Terminal Help
1089 wmcquain@centosvm in ~/library/2505/SqzInteger/code> head TestCases.txt
even          0
  odd          0
even        388208
  odd        5828062
even    297939519
  odd         293
even          6
  odd          6
  odd        34987
  odd         542
1090 wmcquain@centosvm in ~/library/2505/SqzInteger/code> tail TestCases.txt
  odd          0
even        388208
  odd        5828062
even    297939519
  odd         293
even          6
  odd          6
  odd        34987
  odd         542
  odd         4688
1091 wmcquain@centosvm in ~/library/2505/SqzInteger/code> 
```

You can control how many lines are shown; see the **man** page.

The **wc** command reports the number of lines, "words", and bytes in a file:

```
wmcquain@centosvm:~/library/2505/SqzInteger/code
File Edit View Search Terminal Help
1023 wmcquain@centosvm in ~/library/2505/SqzInteger/code> wc driver
  21   223 13749 driver
1024 wmcquain@centosvm in ~/library/2505/SqzInteger/code> wc *
  67   222  1493 checkAnswer.c
  20    88   614 checkAnswer.h
  21   223 13749 driver
 161   984  6407 driver.c
 126   424  2677 Generator.c
  14    61   363 Generator.h
  40   168   982 SqzInteger.c
  26   149   851 SqzInteger.h
  11    22   187 TestCases.txt
  21    84   978 wmcquain.txt
 507  2425 28301 total
1025 wmcquain@centosvm in ~/library/2505/SqzInteger/code> █
```

The **grep** command can be used to display lines of a file that match a pattern:

```
wmcquain@centosvm:~/2505/C01/code
File Edit View Search Terminal Help
1111 wmcquain@centosvm in ~/2505/C01/code> ls -l
total 32
-rw-rw----. 1 wmcquain wmcquain 1493 Aug  2 20:44 checkAnswer.c
-rw-rw----. 1 wmcquain wmcquain  614 Aug  2 20:44 checkAnswer.h
-rw-rw----. 1 wmcquain wmcquain 6407 Aug 18 14:02 driver.c
-rw-rw----. 1 wmcquain wmcquain 2677 Aug  2 20:41 Generator.c
-rw-rw----. 1 wmcquain wmcquain  363 Aug  2 20:41 Generator.h
-rw-rw----. 1 wmcquain wmcquain  982 Aug  2 20:45 SqzInteger.c
-rw-rw----. 1 wmcquain wmcquain  851 Aug  2 20:36 SqzInteger.h
1112 wmcquain@centosvm in ~/2505/C01/code> grep -n return driver.c
47:      return 1;
67:      return 2;
76:      return 3;
89:      // return NULL if it fails to read any input. That will force the
94:      // read into Line; sscanf() will return 0 if nothing was read.
124:     // strcmp() compares two (C-style) character strings; it returns
159:     // Traditionally, return 0 on successful termination.
160:     return 0;
1113 wmcquain@centosvm in ~/2505/C01/code> 
```

The **grep** command can also be used to examine a collection of files:

```
wmcquain@centosvm:~/2505/C01/code
File Edit View Search Terminal Help
1114 wmcquain@centosvm in ~/2505/C01/code> ls
checkAnswer.c  driver.c      Generator.h  SqzInteger.h
checkAnswer.h  Generator.c  SqzInteger.c
1115 wmcquain@centosvm in ~/2505/C01/code> grep -n fprintf *.c
checkAnswer.c:20:      fprintf(fp, "Correct!      ");
checkAnswer.c:24:      fprintf(fp, "Alas, wrong:  ");
checkAnswer.c:26:      fprintf(fp, "%12"PRIu32, origValue);
checkAnswer.c:28:      fprintf(fp, "    even  ");
checkAnswer.c:31:      fprintf(fp, "    odd   ");
checkAnswer.c:33:      fprintf(fp, "%12"PRIu32, stuAnswer);
checkAnswer.c:36:      fprintf(fp, "    should be %"PRIu32, refAnswer);
checkAnswer.c:38:      fprintf(fp, "\n");
driver.c:136:          fprintf(results, "Unrecognized action flag: %s\n", actionFlag)
;
driver.c:149:          fprintf(results, "Score:  %3"PRIu32" / %3"PRIu32"\n", totalScore, to
talPts);
Generator.c:125:       fprintf(Out, "%4s  %10d\n", Flag, N);
1116 wmcquain@centosvm in ~/2505/C01/code> 
```


The **pipe** symbol (`|`) connects standard output from one command to standard input for the next command:

```
wmcquain@centosvm:~/library/2505/SqzInteger/code
File Edit View Search Terminal Help
1036 wmcquain@centosvm in ~/library/2505/SqzInteger/code> ls
checkAnswer.c driver Generator.c SqzInteger.c TestCases.txt
checkAnswer.h driver.c Generator.h SqzInteger.h wmcquain.txt
1037 wmcquain@centosvm in ~/library/2505/SqzInteger/code> ls | wc
    10     10    121
1038 wmcquain@centosvm in ~/library/2505/SqzInteger/code> 
```


The output a program writes to standard output (the terminal) can be sent to a file by using an **output redirection operator** (> or >>):

```
wmcquain@centosvm:~/library/2505/SqzInteger/code
File Edit View Search Terminal Help
1042 wmcquain@centosvm in ~/library/2505/SqzInteger/code> ls
checkAnswer.c driver Generator.c SqzInteger.c TestCases.txt
checkAnswer.h driver.c Generator.h SqzInteger.h wmcquain.txt
1043 wmcquain@centosvm in ~/library/2505/SqzInteger/code> ls -l > files.txt
1044 wmcquain@centosvm in ~/library/2505/SqzInteger/code> head files.txt
total 56
-rw-rw----. 1 wmcquain comporg 1493 Aug 22 21:04 checkAnswer.c
-rw-rw----. 1 wmcquain comporg 614 Aug 22 21:04 checkAnswer.h
-rwxrwx----. 1 wmcquain comporg 13749 Aug 22 21:04 driver
-rw-rw----. 1 wmcquain comporg 6407 Aug 22 21:04 driver.c
-rw-rw----. 1 wmcquain comporg 0 Aug 24 20:35 files.txt
-rw-rw----. 1 wmcquain comporg 2677 Aug 22 21:04 Generator.c
-rw-rw----. 1 wmcquain comporg 363 Aug 22 21:04 Generator.h
-rw-rw----. 1 wmcquain comporg 982 Aug 22 21:04 SqzInteger.c
-rw-rw----. 1 wmcquain comporg 851 Aug 22 21:04 SqzInteger.h
1045 wmcquain@centosvm in ~/library/2505/SqzInteger/code> 
```

The contents of a file can be sent, as standard input, to a program by using an **input redirection operator** (< or <<):

A terminal window titled 'wmcquain@centosvm:~/library/2505/SqzInteger/code' with a menu bar (File, Edit, View, Search, Terminal, Help). The terminal shows the command 'wc < files.txt' being executed, which outputs '12 101 690'. The prompt '1051 wmcquain@centosvm in ~/library/2505/SqzInteger/code>' is followed by a cursor.

```
wmcquain@centosvm:~/library/2505/SqzInteger/code
File Edit View Search Terminal Help
1050 wmcquain@centosvm in ~/library/2505/SqzInteger/code> wc < files.txt
 12 101 690
1051 wmcquain@centosvm in ~/library/2505/SqzInteger/code> █
```

You can obtain information about a file with the **file** command:

```
wmcquain@centosvm:~/2505/C01/code
File Edit View Search Terminal Help
1123 wmcquain@centosvm in ~/2505/C01/code> ls
checkAnswer.c driver Generator.c SqzInteger.c TestCases.txt
checkAnswer.h driver.c Generator.h SqzInteger.h wmcquain.txt
1124 wmcquain@centosvm in ~/2505/C01/code> file TestCases.txt
TestCases.txt: ASCII text
1125 wmcquain@centosvm in ~/2505/C01/code> file driver
driver: ELF 64-bit LSB executable, x86-64, version 1 (SYSV), dynamically linked (use
s shared libs), for GNU/Linux 2.6.32, BuildID[sha1]=dea893278362719fb481691010cd5632
bebf18b3, not stripped
1126 wmcquain@centosvm in ~/2505/C01/code>
```

There are three types of users:

- *owner (aka user)*
- *group*
- *other (aka world)*

A user may attempt to access an ordinary file in three ways:

- *read from*
- *write to*
- *execute*

Use **ls -l** to view the file permissions:

```
1143 wmcquain@centosvm in ~/2505> ls -l C04/code
total 48
-rw-rw----. 1 wmcquain comporg 4653 Aug 7 21:45 comparator.c
-rwxr-xr-x. 1 wmcquain comporg 13340 Aug 7 21:45 compare
-rw-rw----. 1 wmcquain comporg 2612 Aug 7 21:45 driver.c
-rw-rw----. 1 wmcquain comporg 451 Aug 10 19:30 Intersection.h
-rw-rw----. 1 wmcquain comporg 1944 Aug 7 21:45 Intersection.o
drwxrwxr--. 1 wmcquain comporg 3073 Aug 7 21:45 tmpbackup
```

File type

File permissions (owner group other)

Number of links to file

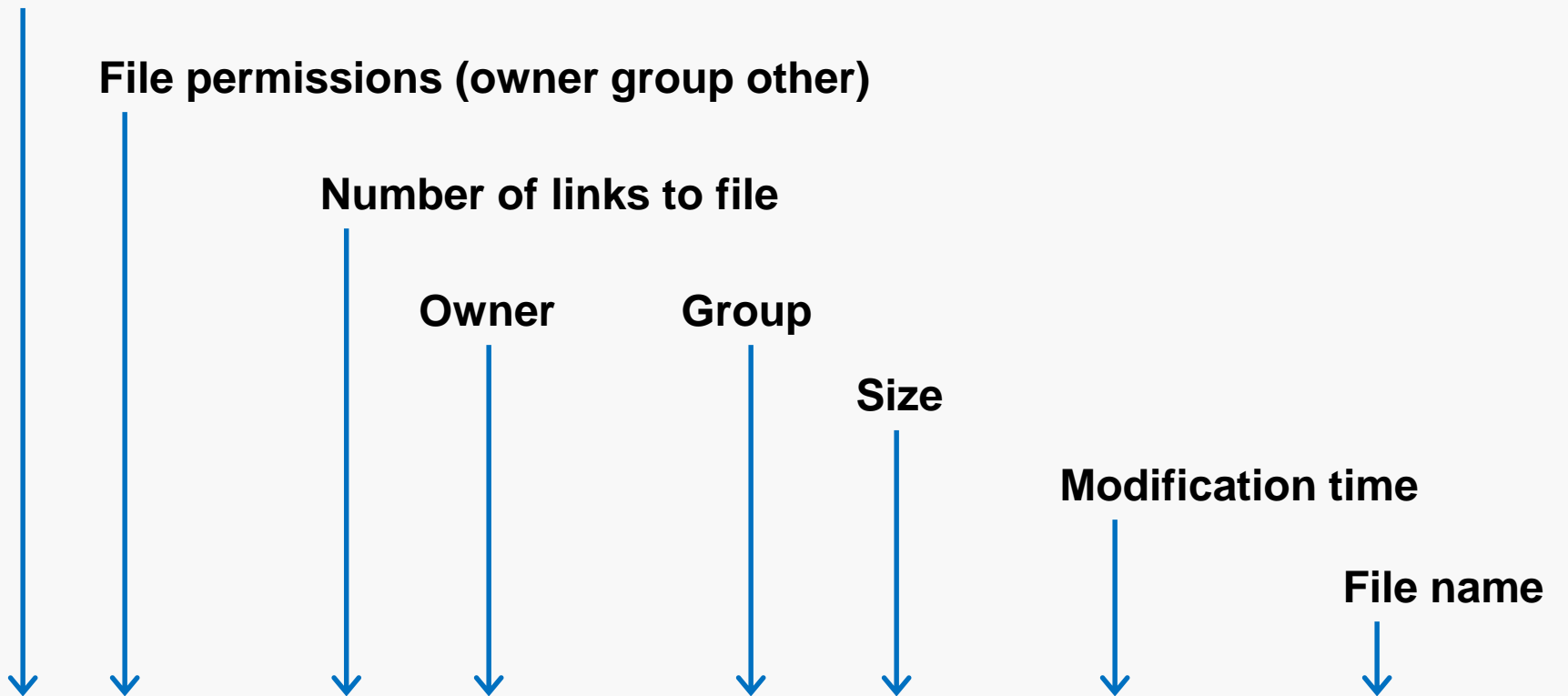
Owner

Group

Size

Modification time

File name



```
-rwxr-xr-x. 1 wmcquain comporg 13340 Aug 7 21:45 compare
drwxrwxr--. 1 wmcquain comporg 3073 Aug 7 21:45 tmpbackup
```

Use the **chmod** command to set or alter traditional file permissions:

```
1143 wmcquain@centosvm in ~/2505> ls -l C04/code/comparator.c
-rw-rw----. 1 wmcquain comporg 4653 Aug  7 21:45 comparator.c

1144 wmcquain@centosvs in ~/2505> chmod g-rw C04/code/comparator.c

1143 wmcquain@centosvm in ~/2505> ls -l C04/code/comparator.c
-rw-----. 1 wmcquain comporg 4653 Aug  7 21:45 comparator.c
```

chmod also allows the use of numeric arguments:

- 0** no access permissions
- 1** execute permissions
- 2** write to permissions
- 4** read from permissions

So, **chmod 740** would set
owner permissions to **r w x**
group permissions to **r- -**
other permissions to **- - -**

WHY?

Binary representations:

none	0	000
x	1	001
w	2	010
r	4	100

Now notice that **7 = 111** which is the logical OR of **001** and **010** and **100**

And, **740** thus specifies permissions **7** for the owner, **4** for the group and **0** for others.

When working on a shared environment, like the rlogin cluster, it is vital that you make sure that your access permissions are set correctly.

As a general rule, you will rely on the default access permissions, which are controlled via shell configuration files we will discuss later.

When in doubt, use **ls -l** to check!

You can create a single file that contains a collection of files, including a directory structure with the **tar** utility:

```
wmcquain@centosvm:~/2505/C01/code
File Edit View Search Terminal Help
1130 wmcquain@centosvm in ~/2505/C01/code> ls
checkAnswer.c  driver.c      Generator.h   SqzInteger.h
checkAnswer.h  Generator.c   SqzInteger.c
1131 wmcquain@centosvm in ~/2505/C01/code> tar cvf C01Code.tar *.c *.h
checkAnswer.c
driver.c
Generator.c
SqzInteger.c
checkAnswer.h
Generator.h
SqzInteger.h
1132 wmcquain@centosvm in ~/2505/C01/code> ls
C01Code.tar  checkAnswer.h  Generator.c  SqzInteger.c
checkAnswer.c  driver.c      Generator.h  SqzInteger.h
1133 wmcquain@centosvm in ~/2505/C01/code>
```

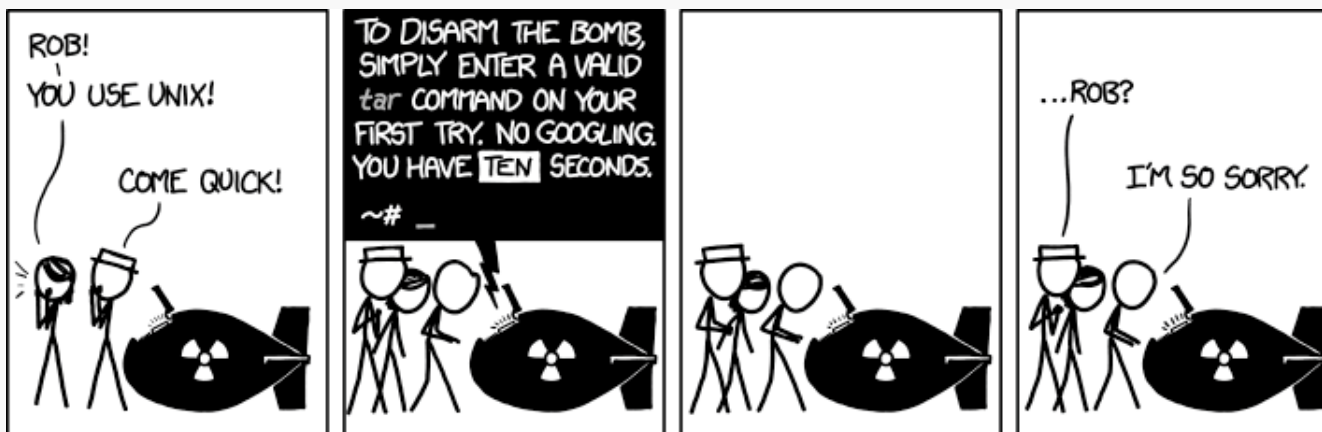
cvf create archive, be verbose, write to a file

Note the name of the new tar file is listed before the target (files to be tar'd up).

DO NOT get that backwards!

As with all commands, your syntax must be precise... but the tar command has the potential to destroy files:

```
wmcquain@centosvm:~/2505/C01/code/temp
File Edit View Search Terminal Help
1147 wmcquain@centosvm in ~/2505/C01/code/temp> ls
C01Code.tar driver.c SqzInteger.c SqzInteger.h
1148 wmcquain@centosvm in ~/2505/C01/code/temp> tar cvf driver.c SqzInteger.c SqzInteger.h C01Code.tar
SqzInteger.c
SqzInteger.h
C01Code.tar
1149 wmcquain@centosvm in ~/2505/C01/code/temp> ls
C01Code.tar driver.c SqzInteger.c SqzInteger.h
1150 wmcquain@centosvm in ~/2505/C01/code/temp> file driver.c
driver.c: POSIX tar archive (GNU)
1151 wmcquain@centosvm in ~/2505/C01/code/temp>
```



xkcd.org

There is a bash shell script on the [Resources](#) page that provides a safer alternative:

A terminal window titled 'wmcquain@centosvm:~/2505/C01/code/temp' with a menu bar (File, Edit, View, Search, Terminal, Help). The terminal shows the following commands and output:

```
1168 wmcquain@centosvm in ~/2505/C01/code/temp> ls
C01Code.tar driver.c SqzInteger.c SqzInteger.h
1169 wmcquain@centosvm in ~/2505/C01/code/temp> safertar.sh driver.c SqzInteger.c SqzInteger.h C01Code.tar
driver.c already exists
driver.c IS NOT a tar file
Do you want to overwrite (destroy) driver.c? Y/N
N
You said: N
1170 wmcquain@centosvm in ~/2505/C01/code/temp> █
```

Download `safertar.sh`, put it in a directory in your path, and make it executable.

This comes with the usual software license...

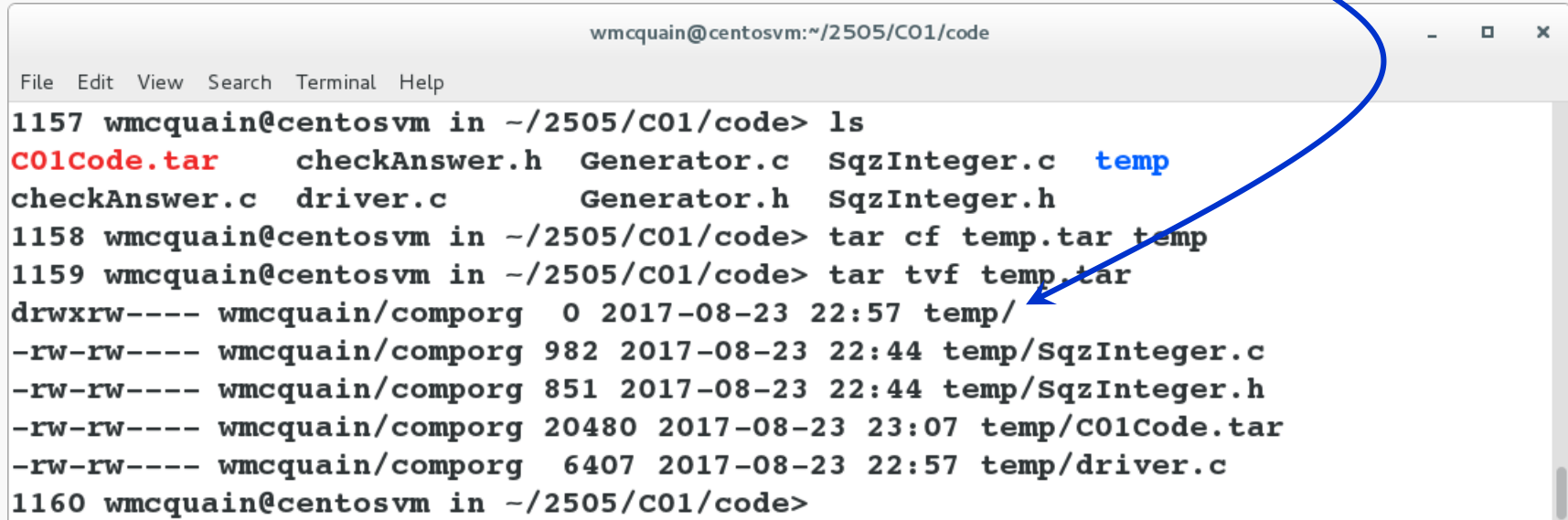
You can check the contents of a tar file:

```
wmcquain@centosvm:~/2505/C01/code/temp
File Edit View Search Terminal Help
1152 wmcquain@centosvm in ~/2505/C01/code/temp> ls
C01Code.tar driver.c SqzInteger.c SqzInteger.h
1153 wmcquain@centosvm in ~/2505/C01/code/temp> tar tvf C01Code.tar
-rw-rw---- wmcquain/comporg 6407 2017-08-23 22:57 driver.c
-rw-rw---- wmcquain/comporg  982 2017-08-23 22:44 SqzInteger.c
-rw-rw---- wmcquain/comporg  851 2017-08-23 22:44 SqzInteger.h
1154 wmcquain@centosvm in ~/2505/C01/code/temp> 
```

This is an example of a *flat* tar file.

That is, there is no directory structure in the tar file.

If you tar a directory tree, the tar file will (by default) contain directory information:

A terminal window titled 'wmcquain@centosvm:~/2505/C01/code' showing the execution of tar commands. The terminal output shows the directory structure of the tar file. A blue arrow points from the text above to the 'temp/' entry in the output.

```
wmcquain@centosvm:~/2505/C01/code
File Edit View Search Terminal Help
1157 wmcquain@centosvm in ~/2505/C01/code> ls
C01Code.tar      checkAnswer.h  Generator.c    SqzInteger.c   temp
checkAnswer.c   driver.c       Generator.h    SqzInteger.h
1158 wmcquain@centosvm in ~/2505/C01/code> tar cf temp.tar temp
1159 wmcquain@centosvm in ~/2505/C01/code> tar tvf temp.tar
drwxrw---- wmcquain/comporg  0 2017-08-23 22:57 temp/
-rw-rw---- wmcquain/comporg 982 2017-08-23 22:44 temp/SqzInteger.c
-rw-rw---- wmcquain/comporg 851 2017-08-23 22:44 temp/SqzInteger.h
-rw-rw---- wmcquain/comporg 20480 2017-08-23 23:07 temp/C01Code.tar
-rw-rw---- wmcquain/comporg 6407 2017-08-23 22:57 temp/driver.c
1160 wmcquain@centosvm in ~/2505/C01/code>
```

Some situations require a flat tar file, some require creating one that preserves a directory structure.

Be sure you pay attention to what's required, and create the correct type of tar.

Use the **x** switch to extract the contents of a **tar** file, and **-C** to specify a destination:

```
wmcquain@centosvm:~/2505/C01/code
File Edit View Search Terminal Help
1161 wmcquain@centosvm in ~/2505/C01/code> mkdir xtemp
1162 wmcquain@centosvm in ~/2505/C01/code> ls
C01Code.tar      checkAnswer.h  Generator.c    SqzInteger.c   temp          xtemp
checkAnswer.c   driver.c       Generator.h    SqzInteger.h   temp.tar
1163 wmcquain@centosvm in ~/2505/C01/code> tar xvf temp.tar -C xtemp
temp/
temp/SqzInteger.c
temp/SqzInteger.h
temp/C01Code.tar
temp/driver.c
1164 wmcquain@centosvm in ~/2505/C01/code> ls xtemp
temp
1165 wmcquain@centosvm in ~/2505

wmcquain@centosvm:~/2505/C01/code
File Edit View Search Terminal Help
1167 wmcquain@centosvm in ~/2505/C01/code> tree xtemp
xtemp
|-- temp
    |-- C01Code.tar
    |-- driver.c
    |-- SqzInteger.c
    `-- SqzInteger.h

1 directory, 4 files
1168 wmcquain@centosvm in ~/2505/C01/code>
```

A compression tool can frequently reduce the amount of space a file occupies:

```
wmcquain@centosvm:~/tmp
File Edit View Search Terminal Help
1062 wmcquain@centosvm in ~/tmp> ll
total 1228
-rw-rw----. 1 wmcquain comporg 1257295 Aug 24 21:06 MobyDick.txt
1063 wmcquain@centosvm in ~/tmp> bzip2 MobyDick.txt
1064 wmcquain@centosvm in ~/tmp> ll
total 380
-rw-rw----. 1 wmcquain comporg 388090 Aug 24 21:06 MobyDick.txt.bz2
1065 wmcquain@centosvm in ~/tmp>
```

A common, older alternative is **gzip**.

Both of these suffer the same limitation: they can compress, but not bundle.

Therefore, it's common to create a tar archive and then compress that.

The **zip** utility also compresses, but will bundle as well:

```
wmcquain@centosvm:~/2505/C01/code
File Edit View Search Terminal Help
1074 wmcquain@centosvm in ~/2505/C01/code> ll
total 32
-rw-rw----. 1 wmcquain wmcquain 1493 Aug  2 20:44 checkAnswer.c
-rw-rw----. 1 wmcquain wmcquain  614 Aug  2 20:44 checkAnswer.h
-rw-rw----. 1 wmcquain wmcquain 6407 Aug 18 14:02 driver.c
-rw-rw----. 1 wmcquain wmcquain 2677 Aug  2 20:41 Generator.c
-rw-rw----. 1 wmcquain wmcquain  363 Aug  2 20:41 Generator.h
-rw-rw----. 1 wmcquain wmcquain  982 Aug  2 20:45 SqzInteger.c
-rw-rw----. 1 wmcquain wmcquain  851 Aug  2 20:36 SqzInteger.h
1075 wmcquain@centosvm in ~/2505/C01/code> zip C01Code.zip *.c *.h
  adding: checkAnswer.c (deflated 60%)
  adding: driver.c (deflated 62%)
  adding: Generator.c (deflated 72%)
  adding: SqzInteger.c (deflated 52%)
  adding: checkAnswer.h (deflated 43%)
  adding: Generator.h (deflated 32%)
  adding: SqzInteger.h (deflated 42%)
1076 wmcquain@centosvm in ~/2505/C01/code> █
```


The degree of compression depends on the nature of the file(s) being compressed:

```
wmcquain@centosvm:~/2505/C01/code
File Edit View Search Terminal Help
1084 wmcquain@centosvm in ~/2505/C01/code> ls -l C01Code.zip
-rw-rw----. 1 wmcquain comporg 6390 Aug 24 21:23 C01Code.zip
1085 wmcquain@centosvm in ~/2505/C01/code> unzip -l C01Code.zip
Archive:  C01Code.zip
  Length      Date    Time    Name
-----
  1493   08-02-2017  20:44   checkAnswer.c
  6407   08-18-2017  14:02   driver.c
  2677   08-02-2017  20:41   Generator.c
   982   08-02-2017  20:45   SqzInteger.c
   614   08-02-2017  20:44   checkAnswer.h
   363   08-02-2017  20:41   Generator.h
   851   08-02-2017  20:36   SqzInteger.h
-----
 13387
          7 files
1086 wmcquain@centosvm in ~/2505/C01/code>
```

Each compression tool has an analog that will uncompress; for example:

```
wmcquain@centosvm:~/2505/C01/code
File Edit View Search Terminal Help
1093 wmcquain@centosvm in ~/2505/C01/code> ls
C01Code.zip      checkAnswer.h  Generator.c    SqzInteger.c  unpacked
checkAnswer.c   driver.c       Generator.h    SqzInteger.h
1094 wmcquain@centosvm in ~/2505/C01/code> unzip C01Code.zip -d unpacked
Archive:  C01Code.zip
  inflating:  unpacked/checkAnswer.c
  inflating:  unpacked/driver.c
  inflating:  unpacked/Generator.c
  inflating:  unpacked/SqzInteger.c
  inflating:  unpacked/checkAnswer.h
  inflating:  unpacked/Generator.h
  inflating:  unpacked/SqzInteger.h
1095 wmcquain@centosvm in ~/2505/C01/code> ls unpacked/
checkAnswer.c  driver.c      Generator.h   SqzInteger.h
checkAnswer.h  Generator.c   SqzInteger.c
1096 wmcquain@centosvm in ~/2505/C01/code> 
```

`rm` does not actually delete file contents from your drive; it just deindexes the file.

You can securely remove a file by using the **`shred`** command, but see Sobell for a discussion of the limitations.

See the discussion of **`dd`** in Sobell for an alternative way to wipe a file.

Many Linux commands support the use of special characters (aka wildcards) to specify a pattern that identifies a set of files:

- ?** matches any single character (in the name of an existing file)
- *** matches zero or more characters (in the name of an existing file)
- []** matches any of the characters within the braces (in the name of an existing file)

***.txt**

matches any file with extension "txt"

foo?.*

matches a file with any extension and name consisting of "foo" followed by a single character

[abc]foo.html

matches a file with extension "html" and name "afoo" or "bfoo" or "cfoo"

scp can be used to copy a file between the local machine and a remote machine (or between two remote machines).

For example, the following command would copy `GettysburgAddress.txt` from my computer to a directory named **documents** on **rlogin**:

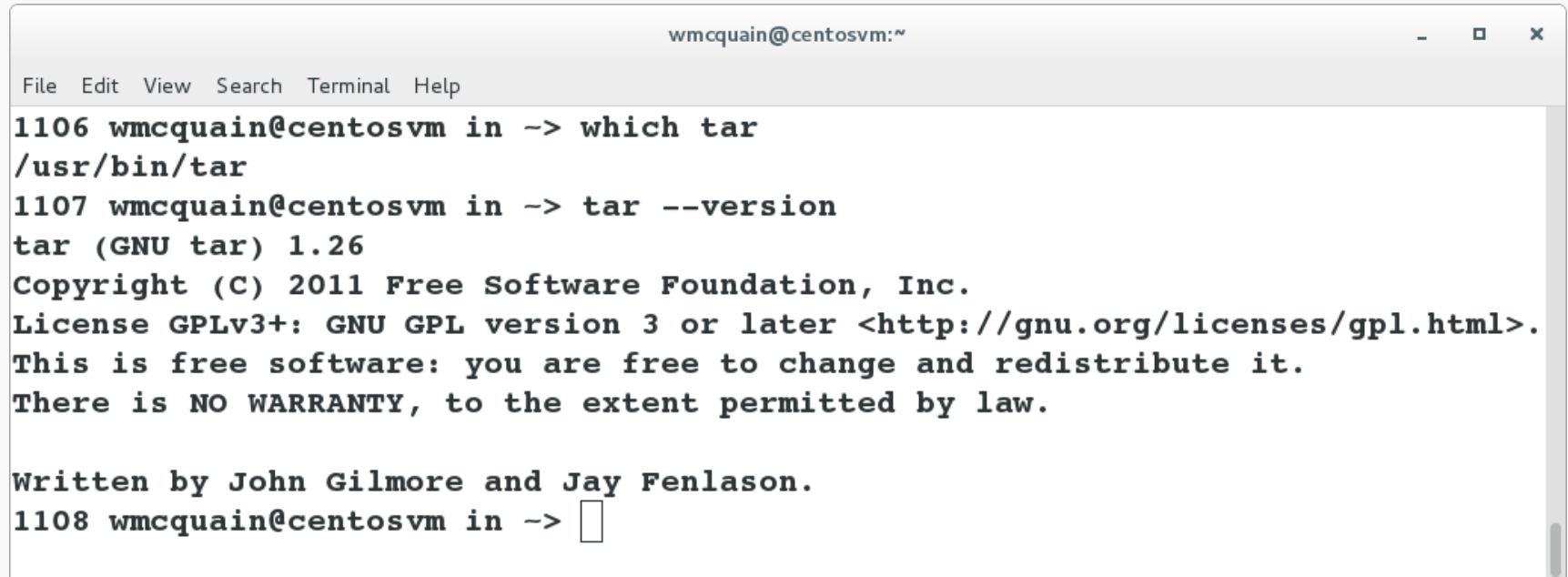
```
scp GettysburgAddress.txt wmcquain@rlogin.cs.vt.edu:documents
```

If you haven't set up password-less login, you'll be prompted for the necessary authentication information.

And the following command would copy `GettysburgAddress.txt` from my rlogin account to my current directory on my machine:

```
scp wmcquain@rlogin.cs.vt.edu:documents/GettysburgAddress.txt .
```

If you're not sure where a command resides, the **which** command will tell you:

A terminal window titled 'wmcquain@centosvm:~' with a menu bar (File, Edit, View, Search, Terminal, Help). The terminal shows the following text:

```
1106 wmcquain@centosvm in -> which tar
/usr/bin/tar
1107 wmcquain@centosvm in -> tar --version
tar (GNU tar) 1.26
Copyright (C) 2011 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>.
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.

Written by John Gilmore and Jay Fenlason.
1108 wmcquain@centosvm in -> 
```

Many Linux applications also support a **--version** switch which can help identify which specific version of an application you're invoking.

By default when you execute a command in a shell, the shell program waits (doesn't provide a prompt and allow entry of another command) until the current command completes (or is otherwise interrupted).

Here, the command is running in the *foreground*:

```
1141 wmcquain@centosvm in ~/tmp> sleeper 5 hi
0    995:  hi
1    997:  hi
2     1:  hi
3     7:  hi
4    15:  hi
```

We may run the command in the *background*:

```
1143 wmcquain@centosvm in ~/tmp> sleeper 5 hi > sleeper.txt &  
[1] 8672
```

```
1144 wmcquain@centosvm in ~/tmp> ps
```

PID	TTY	TIME	CMD
3928	pts/0	00:00:01	bash
8672	pts/0	00:00:00	sleeper
8676	pts/0	00:00:00	ps

```
1145 wmcquain@centosvm in ~/tmp>
```

```
[1]+  Done                  sleeper 5 hi > sleeper.txt
```

```
1145 wmcquain@centosvm in ~/tmp> cat sleeper.txt
```

```
0  270:  hi  
1  272:  hi  
2  276:  hi  
3  282:  hi  
4  290:  hi
```


A (foreground) running process can be killed by using **Ctrl-C**.

A (background) running process or a suspended process can be killed by using the **kill** command:

```
wmcquain@centosvm:~/tmp
File Edit View Search Terminal Help
1152 wmcquain@centosvm in ~/tmp> sleeper 5 hi > sleeper.txt &
[1] 8785
1153 wmcquain@centosvm in ~/tmp> ps
  PID TTY          TIME CMD
 3928 pts/0    00:00:01 bash
  8785 pts/0    00:00:00 sleeper
  8789 pts/0    00:00:00 ps
1154 wmcquain@centosvm in ~/tmp> kill -9 8785
[1]+  Killed                  sleeper 5 hi > sleeper.txt
1155 wmcquain@centosvm in ~/tmp> 
```