UNIX Intro and Basic C shell Scripting

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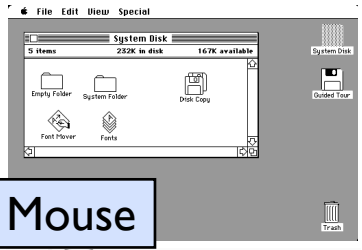
This talk introduces the audience to the basic use of the UNIX/Linux command line tools and to basic C shell scripting.

Why the command line?

Old-school Command Line Interface

>?



Mouse

Touch

???

First, some words of motivation:

In a time of increasingly advanced and often *usefully* simplified interfaces, why use something as old and seemingly retrograde as the command line?

The fact remains that when it comes to power, flexibility, speed and automation (“scriptability”), the command line is still the best human-computer interface we have. Its old-school look and feel belies a truly powerful set of tools for doing scientific computing.

The main disadvantage of this interface is its still-steep learning curve. This talk is here to soften that slope and to enable you to begin learning on your own by introducing a few basic concepts and examples.

Rigor is secondary here: command line, unix shell, terminal, etc. All these words technically refer to disparate concepts that you may in time wish to distinguish from one another. But for the purposes of this talk, if you are entering text commands at a text-only prompt, that is all you need to worry about.

(For the curious, we will focus on the tcsh shell, and I am demonstrating this in the Mac OS X Terminal program.)

Why the command line?

Old-school Command Line Interface

- Power
- Flexibility
- Speed
- Scriptability

Outline

This talk will proceed by practical example. I will expand on relevant concepts as they come up.

Intro to Linux & command line

1. Intro – making `rm` (to delete files) safer
2. Grab-bag of basic commands & info
3. Command options. `grep` and `find`

Intro to scripting

4. A sample backup script
5. Output redirection & pipes
6. Input parameters
7. Looping
8. Conditional statements

Unix/Linux/GNU and all related topics can be dry enough as it is. This is why this talk essentially skips general expository material as much as possible. We'll dive in by example right away. The general concepts of how the command line works will be discussed when they come up.

As such, this talk is organized informally by what I deemed useful for a first-time or near-first-time user. The basic idea is to get you comfortable "moving around" the command line and to get you writing scripts asap. The fine details, you'll pick up along the way.

Part I

Intro to Linux & command line

Example 1: making `rm` safer

- A big obstable in the early part of this learning curve is fear of breaking something
- First step to not breaking stuff: not accidentally deleting stuff
- The `rm` (remove) command deletes files or directories... but there's no "Recycle Bin"!
- Commands/programs/files introduced:
  - **`ls`** (list files)
  - **`rm`** (delete files)
  - **`man`** (diplay manual pages)
  - **`alias`** (replace typed command by another)
  - **`pico`** (text editor)
  - `~/.cshrc` (shell configuration file)

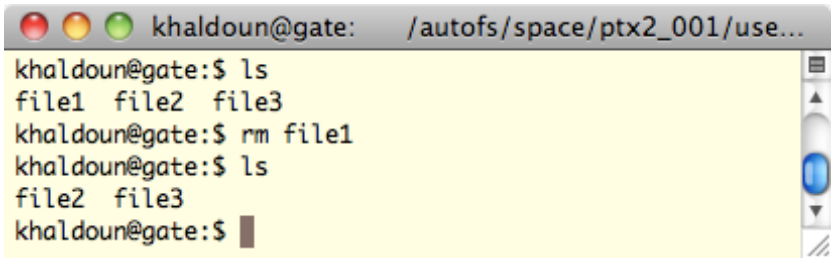
Example 1: The command line grants the user more power than most other interfaces, but as a result it also grants more power to break things. It's important to feel comfortable when learning to use the command line, so it's best to minimize the chance that anything will go wrong.

rm (short for "remove") is the command to delete a file or files (possibly including folders depending on command line options – see later slides). It is a problematic command at first because it acts right away without confirmation ("Are you sure you want to...") and without a recycle bin. It's best to correct this behavior so as to make it safer by adding a confirmation. At the very least, you'll feel more comfortable knowing that you're much less likely to delete anything accidentally.

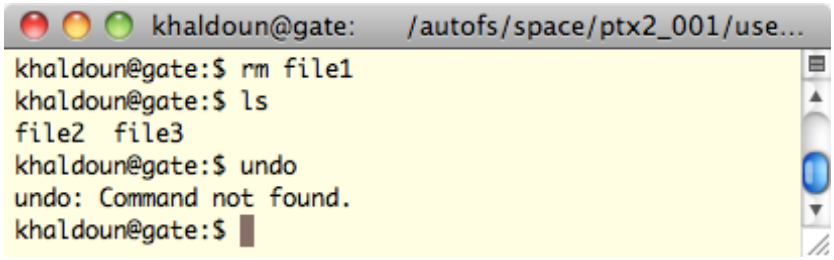
While this may get tedious after you get comfortable with the command line, it's also a useful example to demonstrate a few basic commands.

Example 1: making `rm` safer

Type `ls` to list the contents of the current directory (folder)



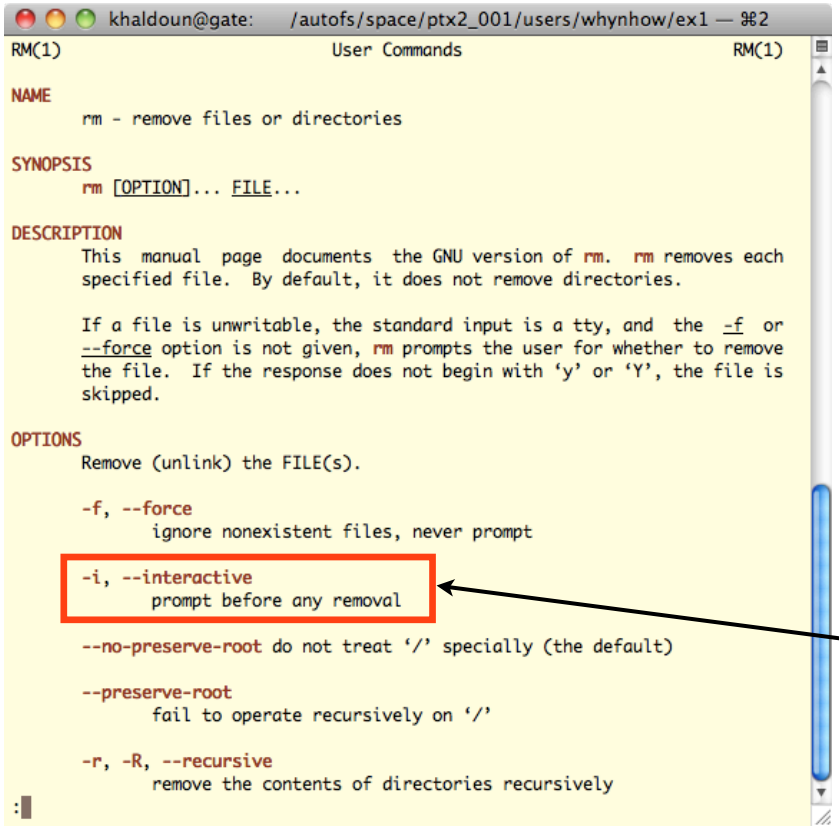
Type `rm file1` to delete `file1` forever.
Note that the next `ls` shows that `file1` is gone.



No undo here!

Note: always press ENTER or RETURN to execute the command(s) you've just typed. ENTER is not carriage return (next line)! Think before you validate :)

Example 1: making `rm` safer



Type `man rm` and hit ENTER to show the manual entry for `rm`

Note the structure:
- -Name
- -Synopsis (usage)
- -Description
- -Options

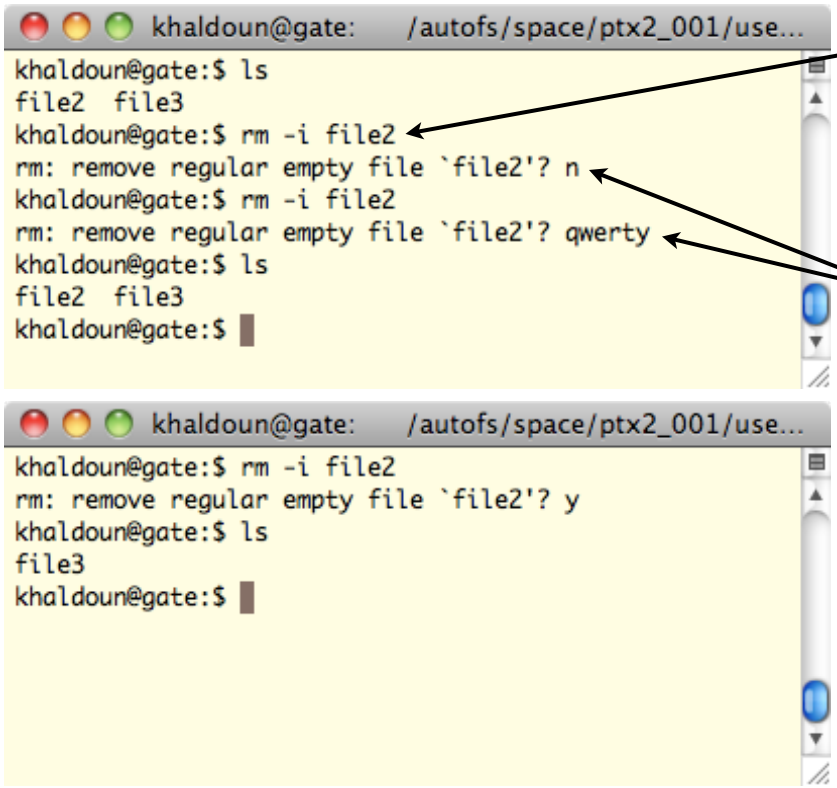
What we're looking for!

Now let's see if we can glean something about `rm` by reading its manual entry. Type `man rm` and hit ENTER. `man` is a terrifically useful resource. Anytime that you are having trouble with a command, or that you're not sure how a particular command works, your first stop is to check whether it has an entry in `man` (not all commands do). If it does, it's often the best way to learn how a command works.

Note: to scroll in `man`, hit SPACE. To scroll backwards hit the letter `b`. To quit and return to the command line, type `q`. To search for a phrase, type `/`, then type the query, then type ENTER. While in search mode, hit `n` to go to the next match, and `p` to go to the previous match.

You can learn more about man by typing `man man` and hitting ENTER.... but sadly, it's not obvious how to navigate from the `man` entry for `man`, which is why I include it here.

Example 1: making `rm` safer

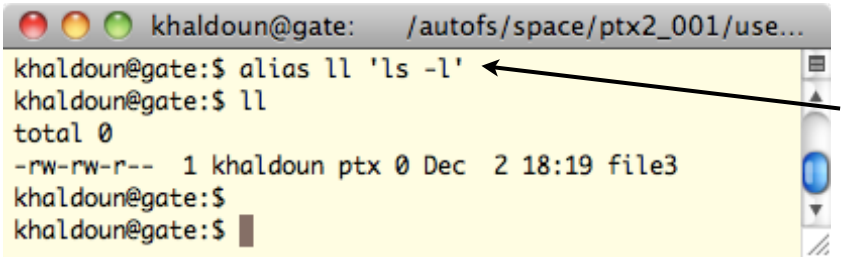


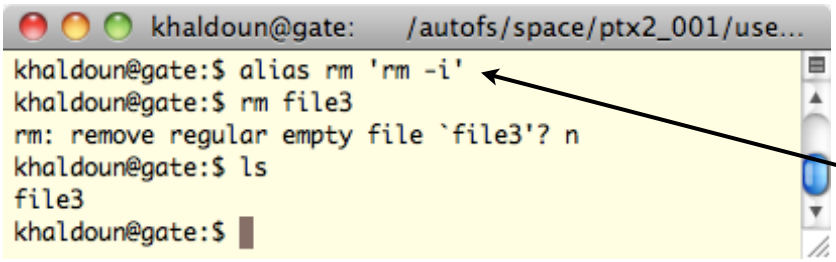
Now if we type `rm -i file2`, the system asks to confirm first.

Any answer other than "`y`" will be interpreted as "no", including just typing ENTER

Note: the confirmation "dialog" will specify the type of file that you're trying to delete. In this case, I created empty files, hence the message you see here.

Example 1: making `rm` safer





Of course remembering to type "`rm -i`" each time isn't exactly useful.

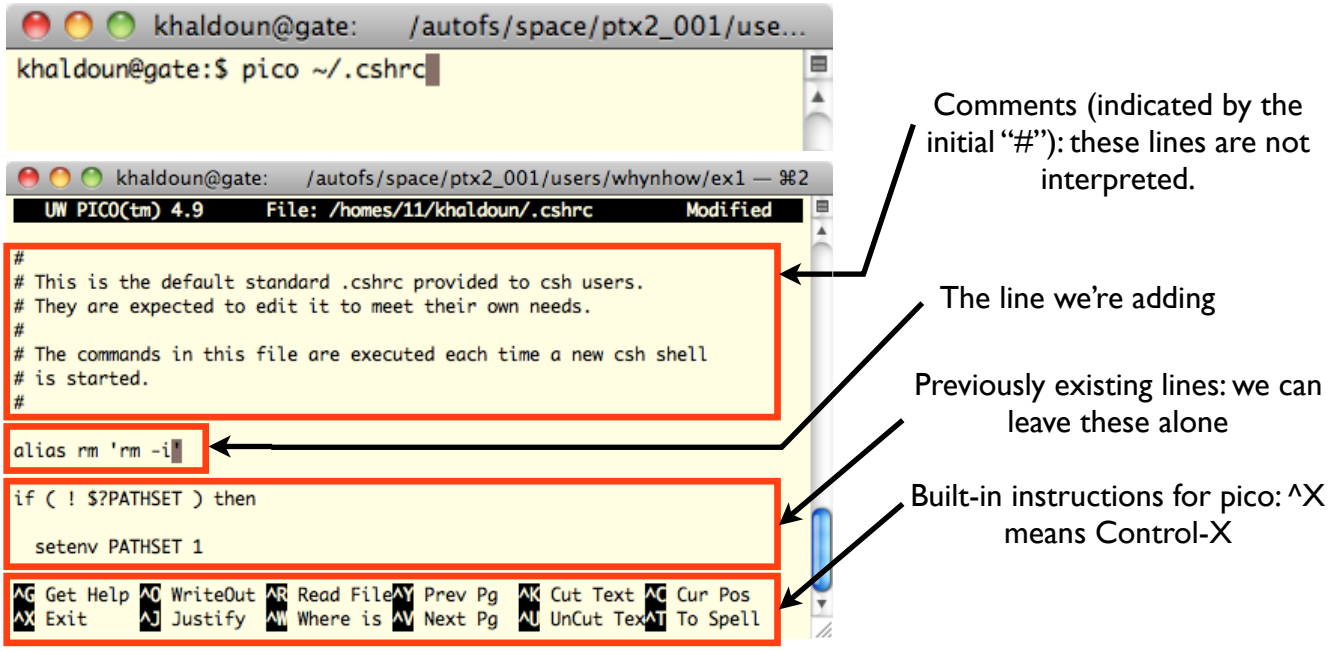
So this is where alias comes in. If you have a command that you execute often, you can give it an alias. For example, I use as alias for `ls -l`, which lists files with more details (permissions, time, size, etc)

We can make an alias for `rm -i` so it's easier to type. Better yet, let's just make it such that when you type `rm`, the system interprets it as `rm -i`

There are two things going on here. We could make an alias that allows you to type "`del`" of "`safe_rm`" or anything you like to mean "`rm -i`". But if safety is what you're after, you can simply make it so that you alias "`rm`" itself to mean "`rm -i`".

Example 1: making `rm` safer

Finally, you should note that any alias you use is only in use during your current log in session. As soon as you close that terminal, all the aliases you created will be gone. To make this change permanent, you can include it as a line in your `.cshrc` file, which is a configuration file that is read-in every time you open a new c shell. Here I use the text editor pico to perform this task.



We want to modify the file `.cshrc` (pronounced, "dot-C-S-H-R-C". The period at the beginning is the first character in the file name, and is not optional). This file is located in your home directory (a sort of "My Documents" for Linux). The character "~" is an alias for your home directory, whatever its actual location in the filesystem is. The slash, /, is the separator between folders in a hierarchy, or between the folder and the file at the end of the file path.

You will need to use a text editor at some point in your work, and you might as well get used to it asap. This is not the same as a word processor in that a text editor always manipulates plain text files (no fonts, no page layouts, etc... just text). pico is a good first choice because it comes with built-in instructions on how to use it as soon as you launch it (see the bottow of your terminal window). To save the file after you've modified it, type ^O (Control-O). To exit, type ^X (Control-X).

Example 2: More basic commands

- **pwd** (print working directory)
- **mkdir** `dirname` (make directory, i.e. a folder)
- **cd** `dirname` (change directory, i.e. go to that folder)
- **cp** `source destination` (copy files/dirs)
- **mv** `source destination` (move or rename)
- **less**/**more** `textfilename` (display contents of file)
- **cat** `textfilename` (concatenate contents of text file)

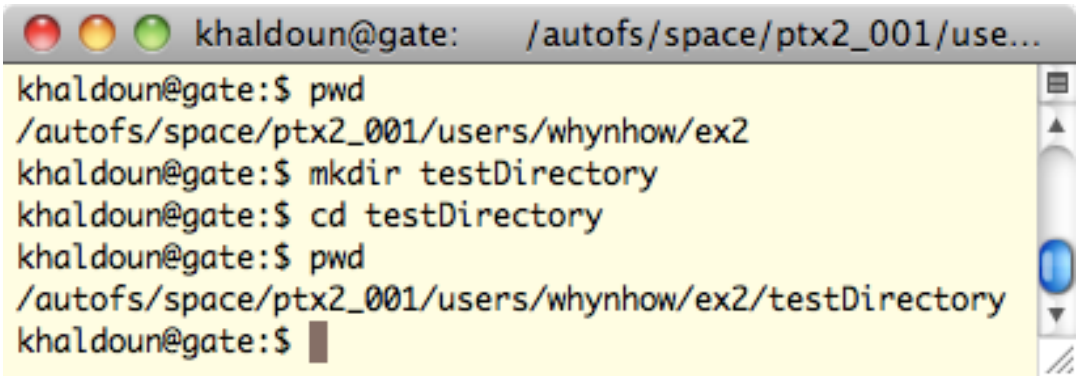
Syntax is almost always one of the following:

- **command**
- **command** *options*
- **command** arguments
- **command** *options* arguments

Unless you spend your time on the computer deleting files, you'll want to know a few more commands to get started. These are the basics of the basics. Your fingers will probably end up typing these out automatically within a few days of Linux use.

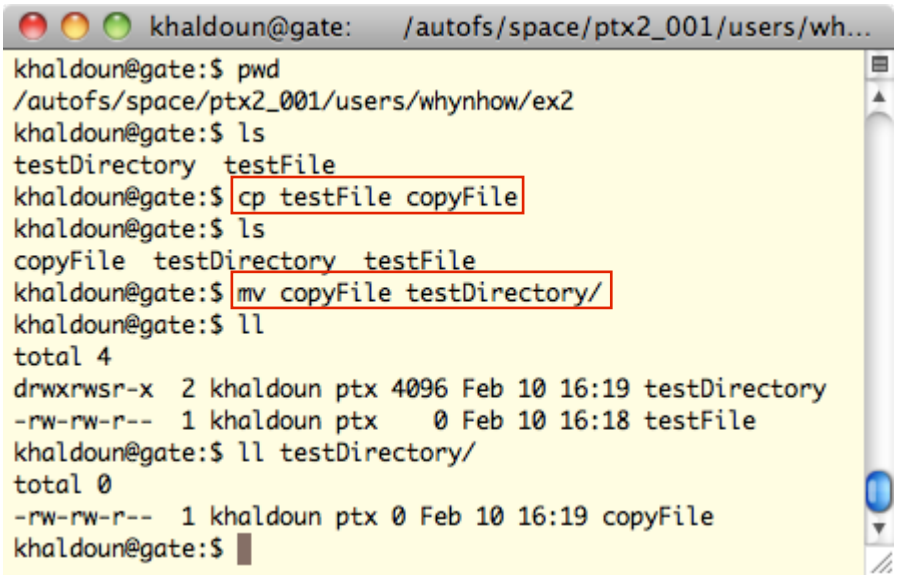
Example 2: More basic commands

- **`pwd`** (print working directory)
- **`mkdir`** `dirname` (make directory, i.e. a folder)
- **`cd`** `dirname` (change directory, i.e. go to that folder)



Example 2: More basic commands

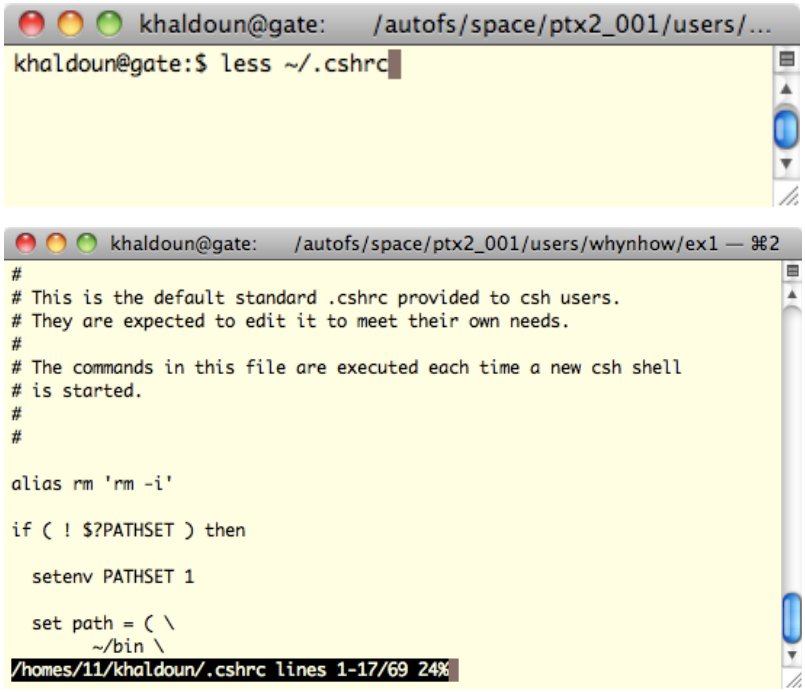
- **cp** `source destination` (copy files/dirs)
- **mv** `source destination` (move or rename)



We copy the file `testFile`, and name the copy `copyFile`. We then move the `copyFile` into the `testDirectory`. We then verify that everything is as we intended using a couple `ls` statements (well, "`ls -l`" aliased to "`ll`")

Example 2: More basic commands

- **`less`**/**`more`** `textfilename` (display contents of file)



`more` allows you to view text files (no editing). It dumps out the contents of the file to the terminal window.

`less` performs the same function, but it more powerful and better suited for longer files (scrolling, searching, etc).

Getting around a file using `less` works like it does when using `man`:

To scroll, hit SPACE. To scroll backwards hit the letter `b`. To quit and return to the command line, type `q`. To search for a phrase, type `/`, then type the query, then type ENTER. While in search mode, hit `n` to go to the next match, and `p` to go to the previous match.

Example 2: Useful info

`.`	Current directory
`..`	Parent directory (up one level)
`~`	User's home directory

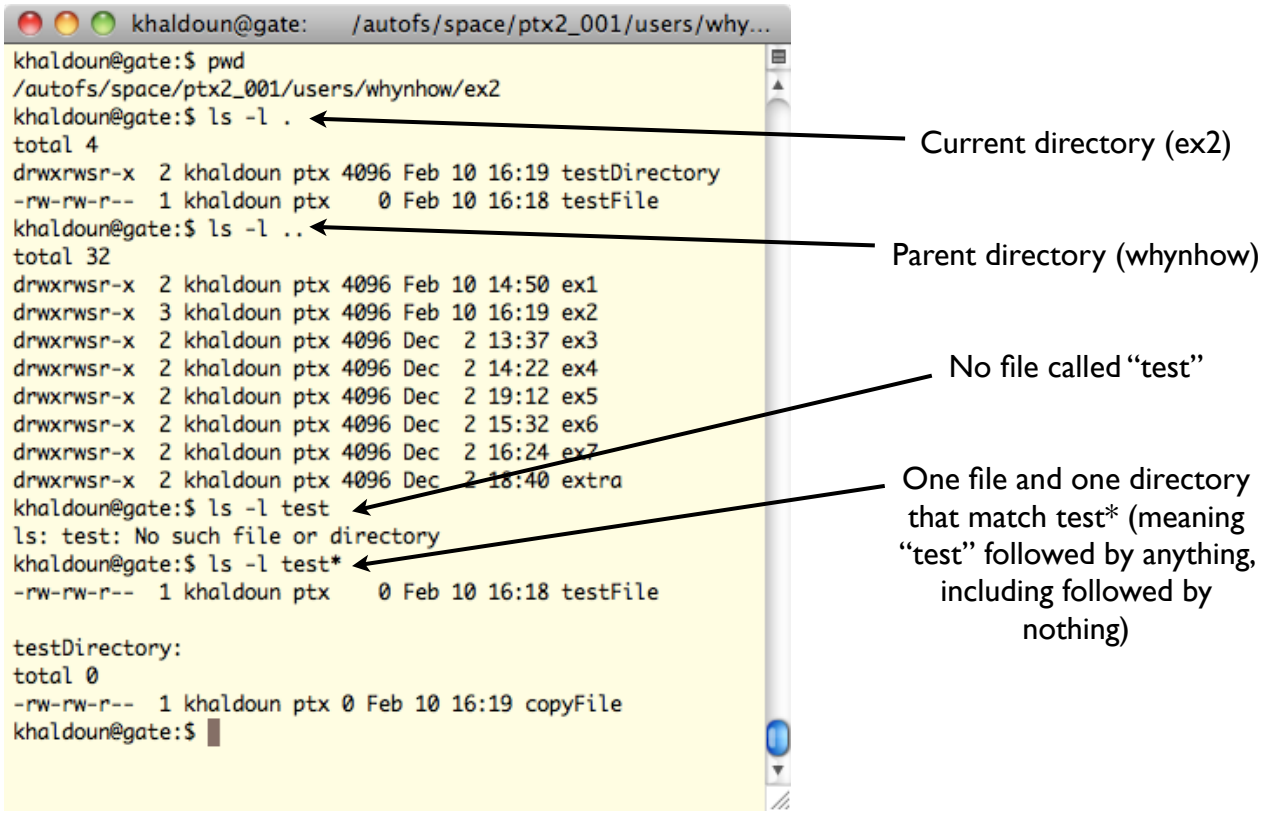
often used as `./` `../` and `~/` since the forward slash denotes separation between directories in Unix paths

`*`	matches any number of any characters
`?`	matches one of any character
`[abc]`	matches `a` or `b` or `c`

Also useful: the TAB key autocompletes

These are just a few of the useful things to know about typing commands in the command line.

Example 2: Useful info



On TAB autocompletion: it is not necessary to type "`ls testFile`" to list this file. It's enough to type "`ls testF`" and then press the TAB key. The command line autocompletes to the only completion available. If you type "`ls t`" then TAB, it will autocomplete to "`test`" and then wait for user input to differentiate between testFile and testDirectory.

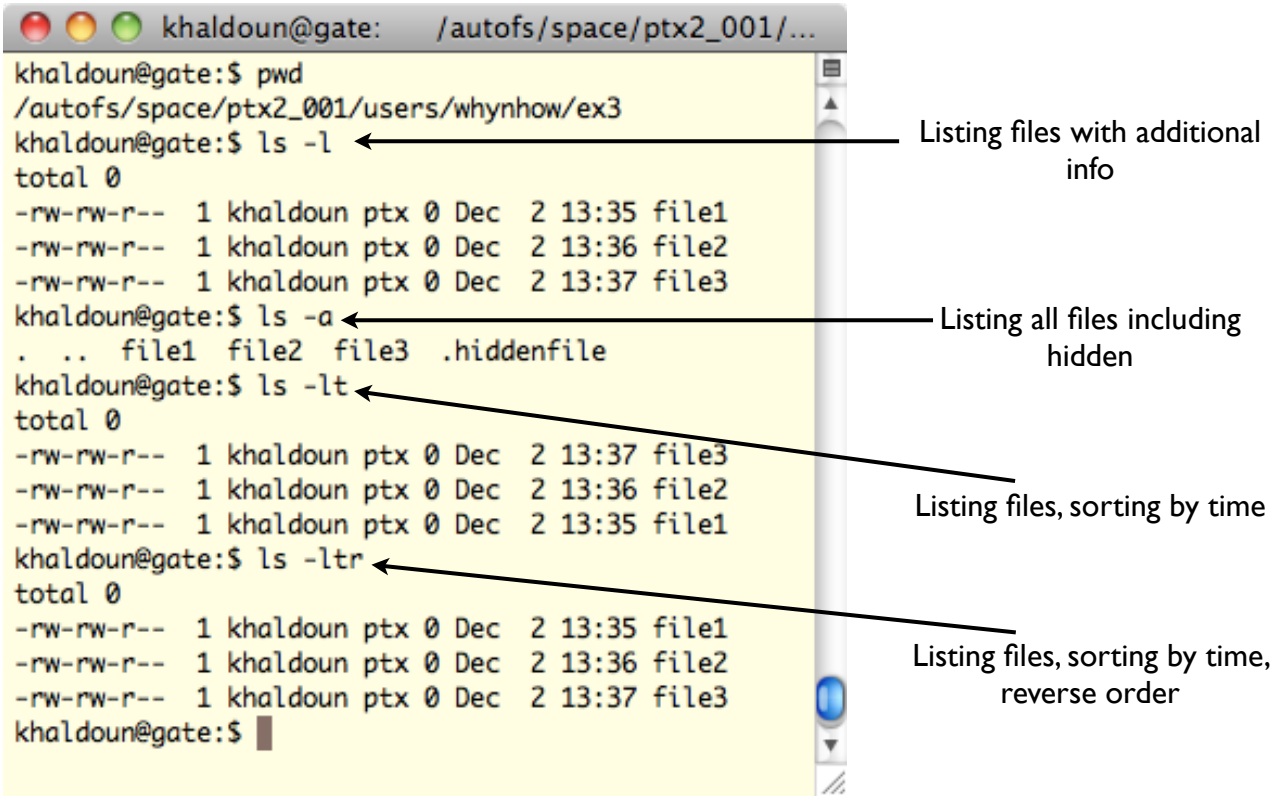
The parent directory is the one that contains the current directory. So if you create a directory called whynhow (as I did) and then create inside it directories called ex1, ex2, etc, then whynhow is the parent directory or ex1, ex2, etc.

Example 3: command options

Almost all commands include options you can invoke if need be. The syntax is usually `command -option`. We first take `ls` as an example.

- **`ls`** `-l` (list in long format)
- **`ls`** `-a` (list all files including hidden)
- **`ls`** `-t` (list and sort by time)
- **`ls`** `-r` (list and reverse sort order)
- Combinations possible: **`ls`** `-latr` (list all files in long format in reverse order of recently modified)

Example 3: command options



Any file which begins with a dot (e.g. "`.filename`") is by default a hidden file, which will not be shown by `ls` unless specified. Here I've created a file named `.hiddenfile` to demonstrate how to show it with `ls -a`.

Listing by time defaults to showing you the oldest files at the bottom. If you're interested in seeing the newest files, it's best to use `-r` to reverse the order and have the newest files at the bottom. This is because a long scrolling list will chop off (in your terminal window) the top of the list.

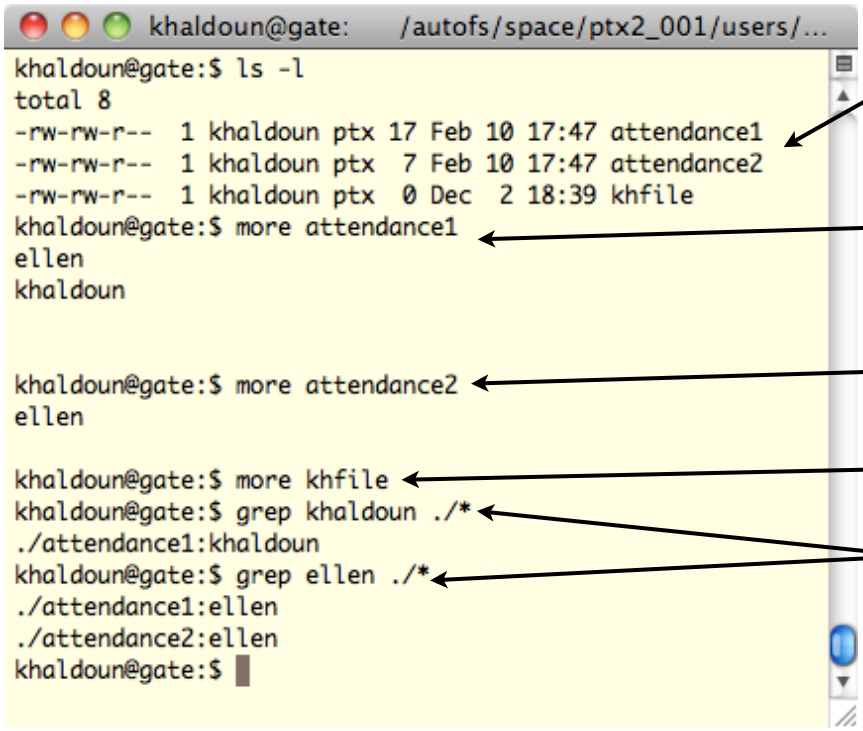
`grep` and `find`

`grep` and `find` are good examples of the power of the tools you'll typically use on Linux. They both become very powerful as you learn to use their options, but start out as relatively straightforward pattern-matching tools.

- grep searches for string (i.e. text) matches inside files
  `grep pattern filelist`
- find searches for files matching certain conditions:
  `find directory -name 'filename'`

Note the difference between `grep` and `find` in syntax. `grep` places the files to be searched after the pattern, whereas `find` first specifies the directory. Besides the order, note that `grep` asks for a file list (so all the files in the present directory would be `./*`), whereas `find` asks for just a directory (`./`).

grep and find



3 files in this directory

First file contains 2 names and 2 empty lines (shown by more)

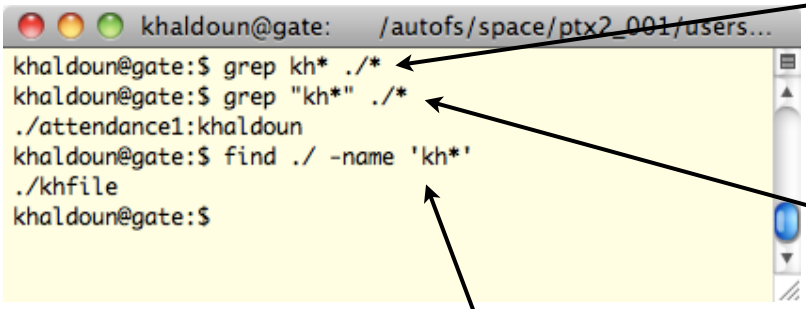
Second file contains 1 name and 1 empty lines

Third file is empty

`grep` commands to search for these patterns in all the files that are in the current directory

Being able to match patterns from inside a file is extremely useful, especially once you include matching conditions using *, ?, and other matching syntax. You'll be going through log files and code considerably faster than you would otherwise.

grep and find



Quotation marks are required for pattern matching or the search will fail

Note that grep searches the **contents** of files, and will not match a file that has the searched pattern only its filename (here khfile)

Use `find` to search for patterns in file names, or files times, or many many other file attributes (check the `man` page!)

In addition to these simple examples, you can tailor these tools to your liking. Use `grep` with the `-v` option to invoke anti-matching: it will find the lines that do not match the specified pattern. Use `find` with time specifiers to find files older than n minutes or newer than m days. And much much more. Check the `man` pages!

Part II

Intro to shell scripting

Scripting basics

- A script is a sequence of commands stored in a text file that can be run like any other command
- The use of programming constructs such as variables, loops and conditional statements make this more powerful than just a saved list of commands

At first, a script is useful because it saves you the trouble of typing in the commands you need repeatedly. If you find yourself performing the same series of steps over and over (say on several data sets), it's not only more convenient, but also better for the reproducibility of your experiment & analysis to write this series of steps into a script, and then simply run the script.

But the true power of scripting lies in the fact that it enables the use of important algorithmic & programming contructs (with little user overhead such as compilation of code, etc). If your work requires loops and conditional statements using command line commands, scripting isn't simply a convenience; it's the only way to get your work done.

Example 4: a backup script

Type this into a file called backup.csh

```
#!/bin/csh

# comment here: very basic backup

cd parentdirectory

rsync -avr originDir backupDir/
```

Then make it executable & run it!

```
chmod u+x ./backup.csh

./backup.csh
```


This will demonstrate the simple command list version of a script.

One of the most important computing habits to develop is the use of regular backups. So we'll demonstrate putting together a very simple backup script. This script will copy some data from a directory called originDir (modify for your own needs) to a destination called backupDir. This very simple backup overwrites any previous backup in the destination directory. In other words, any files which have changed in the origin will replace the older files in the destination. However, it will not delete files from the destination if they have been deleted from the source. The options used for `rsync` are: `-a` for archive mode (preserve time stamps, file attribures, etc), `-v` for verbose so that we see output on the terminal screen of what `rsync` is doing at all times, and `-r` to recursively enter directories and sync everything inside them as well.

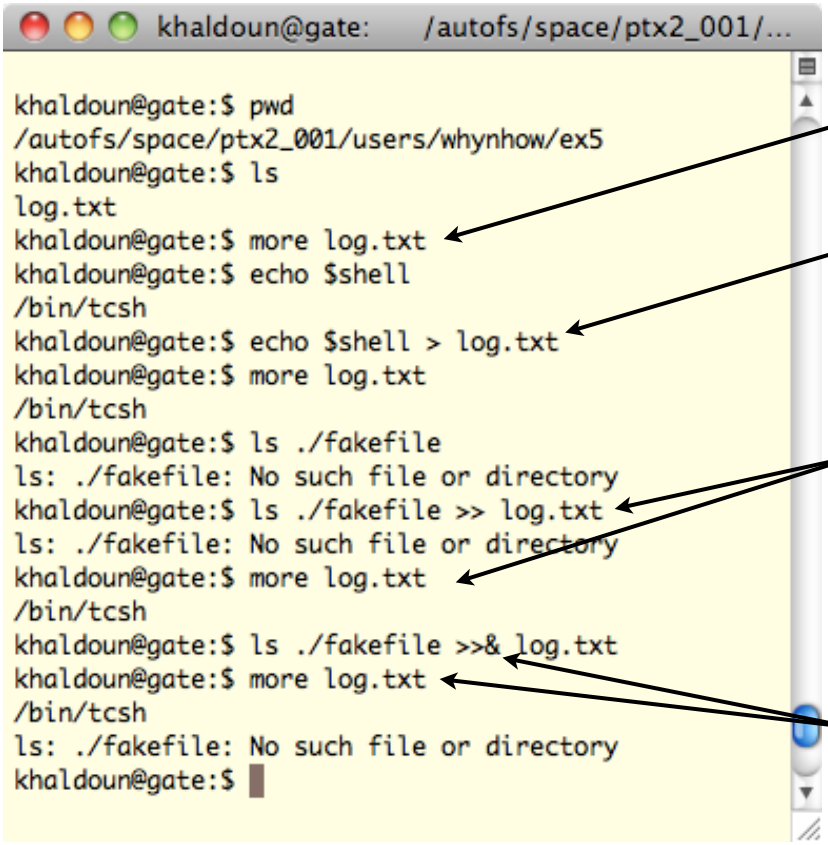
After we have written a file called `backup.csh`, we have to specify that this file is now executable (i.e. not just readable – for viewing, and writeable – for modifying, but also executable like any other command). We do so with the `chmod` command. The syntax is: `u` for user permission (as opposed to group or other), `x` for executable, and `+` for add this permission (as opposed to remove it).

We then run the script using `./backup.csh`. We specify the location of the executable as "this directory" (using ./) or the system may not know where to find this now-brand-new command called "backup.csh".

Example 5: output redirection & pipes

- The output from command and any errors normally get dumped to the terminal screen
- It's useful to save them when running scripts so that you can examine if anything went wrong
- **`command`** `> somelogfile` will save the output of **`command`** into the file `somelogfile`
- **`command`** `>& somelogfile` will save the output of AND any errors resulting from **`command`** into the file `somelogfile`
- `>>` and `>>&` append to the file `somelogfile` instead of replacing it
- You can also pipe the output of one command to be the input of another command using `|` (SHIFT-backslash on most keyboards). See example using `tee` and `wc`

Example 5: output redirection & pipes



`log.txt` is empty to start

We redirect the output of the `echo` command into `log.txt`, and check the content

We try a command we know will give an error, but `>>` does not seem to redirect to the log file

The use of `>>&` allows us to redirect for the normal output and the error output

Example 5: output redirection & pipes

This time, we use the `tee` command to split the output: it will be shown on the screen and at the same time go into the log file.

We say that we have "piped" the output of the `echo` command to `tee` as an input. `tee` then takes that input, a second input (a file name), and splits the stream from the first input to copy it into a file whose file name is given by the user

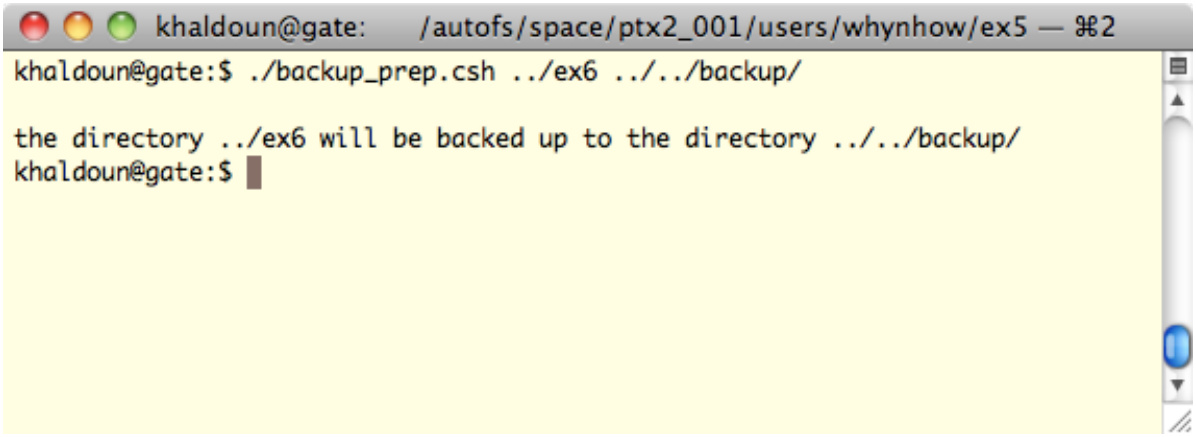
Example 6: input parameters

- You can pass input parameters to your script just like you would to other commands:
  `myscript` `param1 param2`
- Inside the script, these parameters are referenced with `$1 $2` etc
- Although it's needless complication for the simple backup script, we'll use this for origin & destination to demonstrate

Example 6: input parameters

Type this into a file called backup_prep.csh

```
#!/bin/csh
set origin = $1
set destination = $2
echo ""
echo "the directory $origin will be backed up to $destination"
```



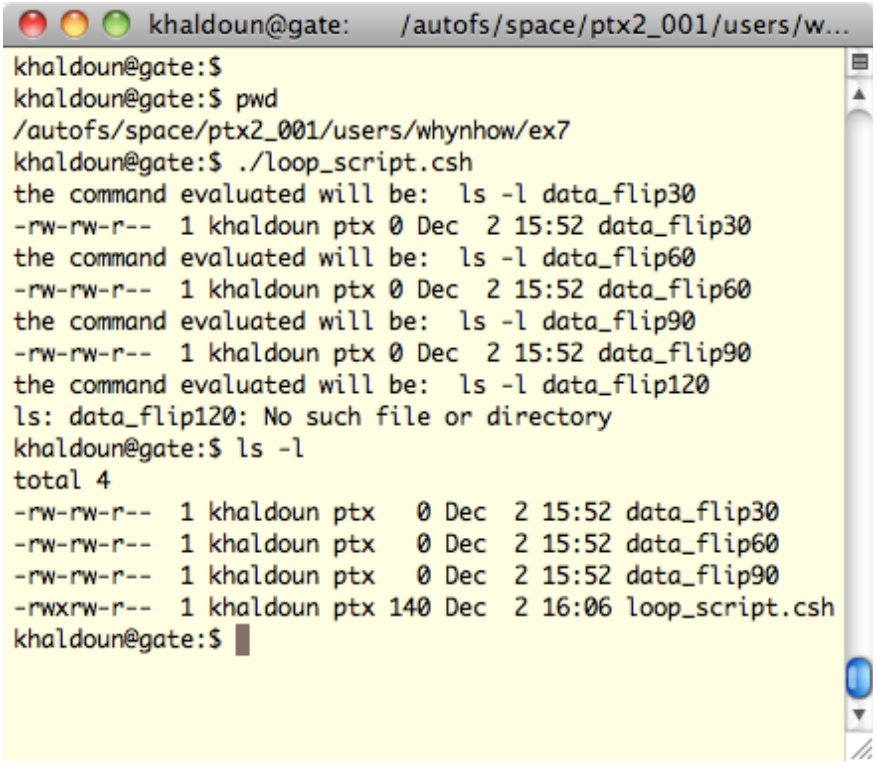
Example 7: Looping

- Two ways to loop: `foreach` and `while`
- `foreach` is demonstrated here

```
#!/bin/csh
foreach flipangle (30 60 90 120)
   set cmd = (ls -l data_flip${flipangle})
   echo $cmd
   eval $cmd
end
```

Credit to A. Stevens for exposure to the very useful "eval"

Example 7: Looping



The script loops through all the values listed in `foreach`, and executes a command each time.

The last value produces an error, since there is no file with the name data_flip120: an excellent time to have a log so that you can track how your script ran.

Conditional statements

- Structure of if statements is simple:

```
if (expression) then
    commands
    ...
else if (expression) then
    commands
    ...
    ...
else
    commands
    ...
endif
```

- The fun is in what you can put in `(expression)`

Conditional statements

- General logic and comparisons in expressions:
  - `!` logical negation
  - `&&` logical AND
  - `||` logical OR
  - `==` equals
  - `!=` not equals
  - `> < <= >=` their usual math meanings

Conditional statements

- File operators
  - `-e file` true if file exists
  - `-d dir` true if dir exists and is a directory
  - `-z file` true if file exists and is zero size

- More at www.csem.duke.edu/Cluster/csh_basics.htm or at `man csh` ("File inquiry operators")

General Hints

- Always look at the manual page for any command you're not familiar with, or at the very least Google the command for some basic info.
- Searching man pages (and `less` output) is done with `/` followed by the search phrase followed by RETURN/ENTER. Cycling through results is done with `n` (next) and `p` (previous). Quitting is done with `q`.
- Keep track of learned commands and hints in a text file as you go along. Learning Linux/C shell/scripting really means learning, then forgetting, then relearning, etc.
- Don't hesitate to email if there are any questions arising from this discussion later on: `khaldoun@nmr.mgh.harvard.edu`