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CMPSC 311 - Introduction to Systems Programming

Shell Programming

Professor

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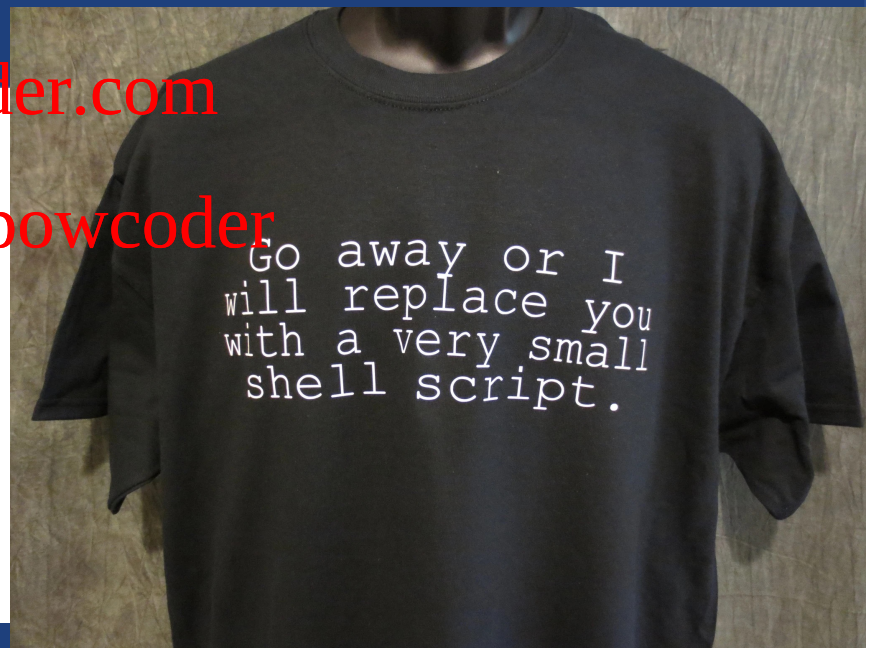
(Slides are mostly by *Professor Patrick McDaniel* and *Professor Abutalib Aghayev*)



Shell programming

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- aka "shell scripting," "Bash scripting"
- What is it?
  - Series of commands
  - Programming with programs
- What for
  - Automating
  - System administration
  - Prototyping

A sample script: `shello`

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- First line: interpreter
  - The `#!` is important!
- Comment: `#` to end-of-line
- Give the file execute permission

  ```
  chmod +x shello
  ```
  - Not determined by file extension
  - Typical: `.sh` or none
- Run it

  ```
  ./shello
  ```

```
#! /bin/bash

# Greetings!
echo Shello world

# Use a variable
echo Shello "$USER"

# Set a variable
greetz=Shellutations
echo "$greetz world"
```

Shell variables

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- Setting/unsetting
  - `export var=value`
  - No spaces!
  - `unset var`
- Using the value
  - `$var`
- Untyped by default
  - Behave like strings
  - (See `help declare` for more)

Special variables

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- Change shell behavior or give you information
  - `PWD`: current directory
  - `USER`: name of the current user
  - `HOME`: the current user's home directory
    - Can usually be abbreviated as a tilde (`~`)
  - `PATH`: where to search for executables
  - `PS1`: Bash prompt (will see later)

Exercise

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- Make a directory `~/bin`
- Move `shello` script there
- Prepend the directory to your `$PATH`
  - `PATH=~/bin:$PATH`
- Change to home dir
- Run by typing `shello`

Shell initialization

- Set custom variables
- At startup, bash runs shell commands from `~/.bashrc`
  - Just a shell script
- This script can do whatever you want

Fun with prompts

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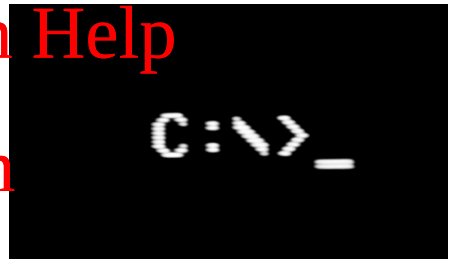
- Main prompt: `$PS1`
- Special values
  - \u: username
  - \h: hostname
  - \w: working dir
  - \e: escape (for colors)
  - many others
- This is something you can set in your `.bashrc`



Very detailed treatment: http://www.tldp.org/HOWTO/Bash-Prompt-HOWTO/

Special characters

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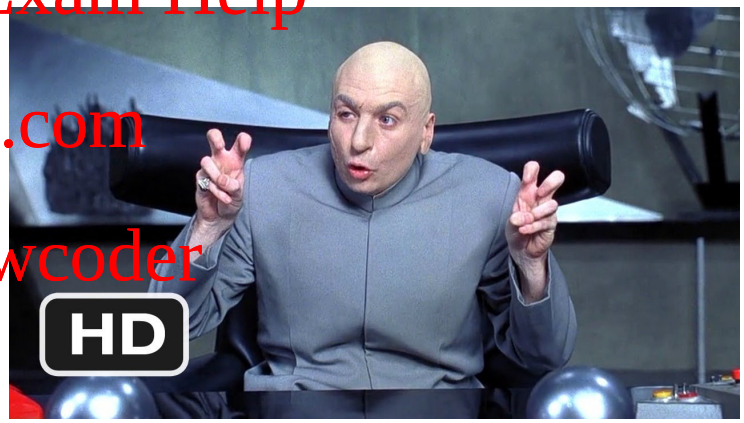
```
echo Penn State is #1
echo Micro$oft Windows
echo Steins;Gate
```


- What happened?
- Many special characters
  - Whitespace
  - #$*&^?!~'`"\{}[]<>()|;
- What if we want these characters?

Quoting

- Removes specialness
- Hard quotes: '...'
  - Quote everything except closing '
- Soft quotes: "..."
  - Allow variables (and some other things)
  - Good practice: "$var"
- Backslash (escaping)
  - Quotes next character



Arguments

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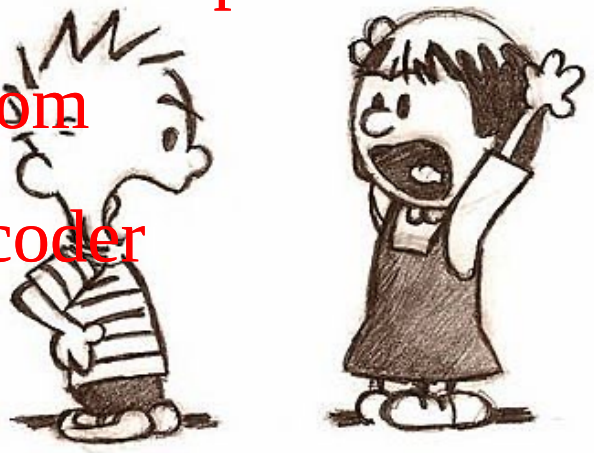
- In C: `argc` and `argv[]`
- Split at whitespace
  - How can we override this?
- Arguments to a script:
  - `./script foo bar`
  - `$#` is the same as argc
  - `"$@"`: all args
  - `"$1"` to `"$9"`: individual



Debug mode

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- Shows each command
  - Variables expanded
  - Arguments quoted
- Run with `bash -x`
  - Temporary – just for that run
  - `bash -x shello`
  - Use `-xv` for even more info

Exercises

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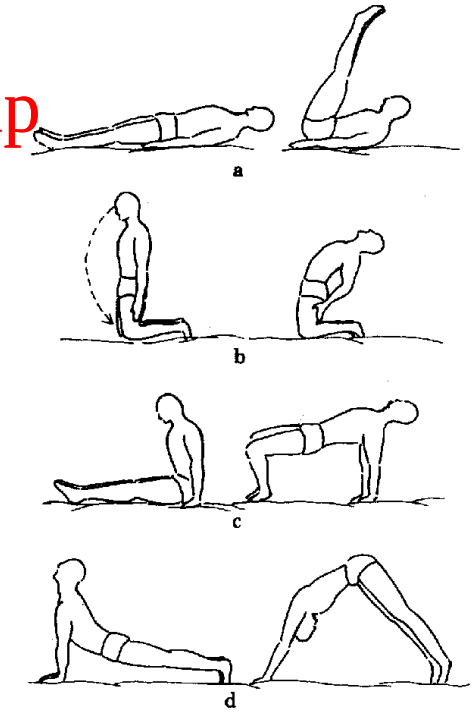
- Make a script that:
  - Prints its first argument doubled

```
./script1 foo
foofoo
```

  - Prints its first four args in brackets, one per line

```
./script2 "foo bar" baz
[foo bar]
[baz]
[]
[]
```

Redirecting input/output

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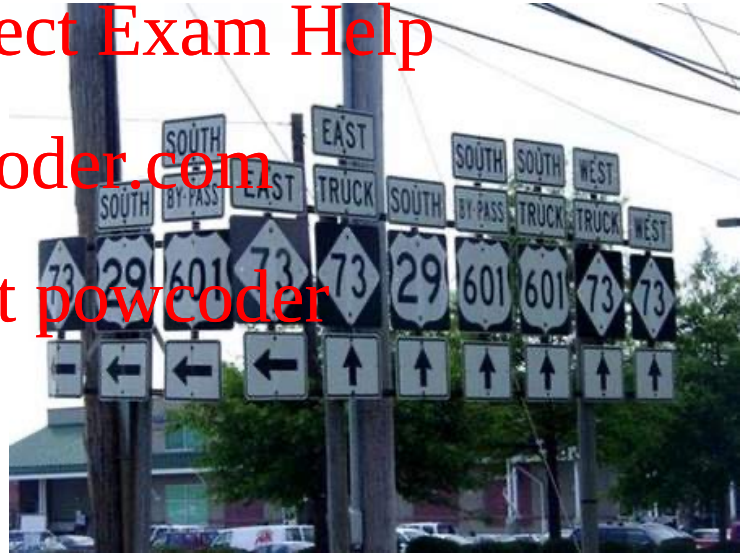
- Assigns stdin and/or stdout to a file
- `echo hello > world`
- `echo hello >> world`
- `tr h j < world`



Pipelines

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- Connect stdout of one command to stdin of the next

```
echo hello | tr h j
... | rev
... | hexdump -C
... | grep 06
```

- UNIX philosophy at work!

Some references

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- Advanced Bash-Scripting Guide
  - http://tldp.org/LDP/abs/html/
  - A great reference from beginner to advanced
- commandlinefu.com
  - Lots of gems, somewhat more advanced
  - Fun to figure out how they work
- Bash man page
  - `man bash`

How to kill a process

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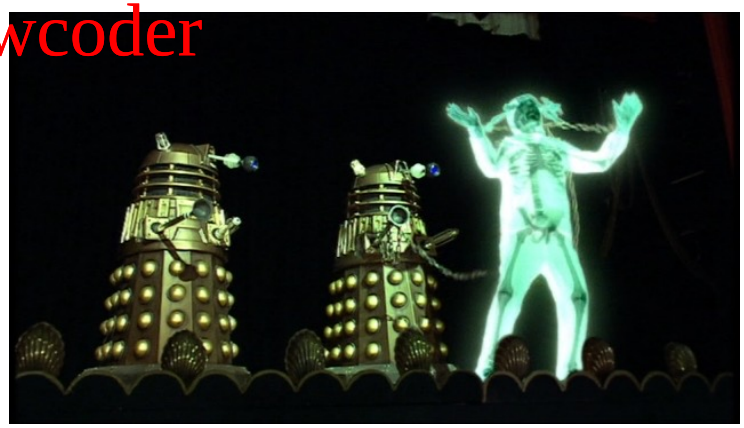
- Today we're learning some loops
- If it starts to run away, Ctrl-C is your friend
  - Sends a signal that ends the process
    - More on signals later...
  - Works on many different programs, as long as they were started from the command line
  - Displayed as ^C



Return from `main`

- In C, the main function always returns an `int`
  - Used as an error code for the entire process
  - Same convention as any other C function
    - Zero: success
    - Nonzero: failure, error, killed by a signal, etc.
- Also known as the *exit status* of the process

Status sample program

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```
$ ./status 0
$ echo $?

$ ./status 2
$ echo $?

$ ! ./status 2
$ echo $?

$ ./status -1
$ echo $?
```



```c
#include <stdlib.h>

int main(int argc, char **argv)
{
    // Quick-and-dirty int conversion
    return atoi(argv[1]);
}
```

Custom prompt for today

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- You can include `$?` in your prompt
- Now try:


```
./status 42
```

Exit status in scripts

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- `$?`: get exit status of the previous command
- The exit status of a script comes from the last command it runs
  - Or use the `exit` builtin to exit early, e.g. `exit 1`
- `! cmd` reverses the value: 0 for failure and 1 for success
  - Exactly like the ! ("logical not") operator in C

Conditionals

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- Exit status is used as the test for `if` statements:

```
if list; then
  cmds
fi
```


- Runs *list*, and if the *exit status* is 0, then *cmds* is executed
- There are also `elif` and `else` commands that work the same way.

Test commands

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- Builtin commands that test handy conditions
- `true`: always succeeds
- `false`: always fails
- Many other conditions: `test` builtin
  - Returns 0 if test is true, 1 otherwise
  - Full list: `help test`

What do these do?

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```
$ test -e status.c
$ test -e asdf

$ test -d status.c
$ test -d /etc

$ test 10 -gt 5
$ test 10 -lt 10
$ test 10 -le 10
$ test 12 -ge 15
```


Useful tests

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- `test -e file`
  - True if file exists
- `test -d dir`
  - True if dir exists and is a directory
- `test -z "$var"`
  - True if var is empty (zero-length)
- `test -n "$var"`
  - True if var is nonempty
- `test str1 = str2`
- `test num1 -gt num2`
  - or `-lt`, `-ge`, `-le`, `-eq`, `-ne`

Shorthand tests

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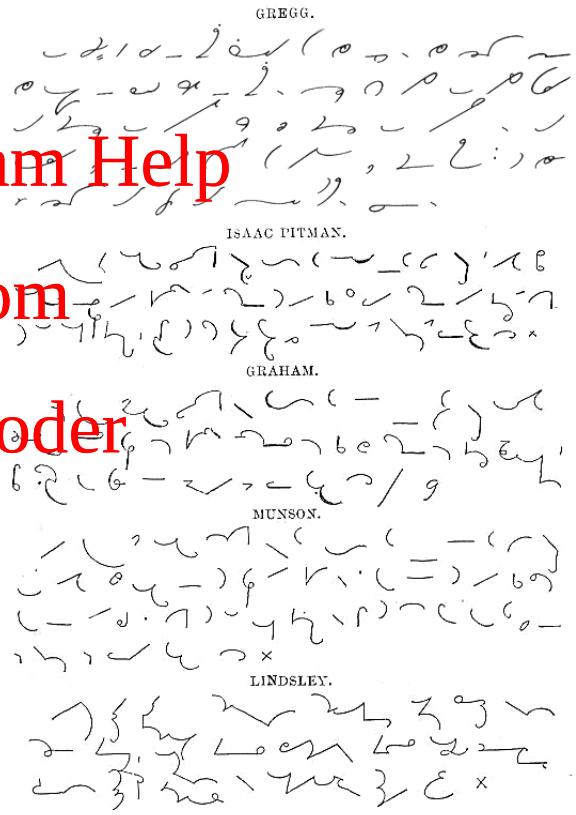
- Shorthand test: `[[ … ]]`
  - Workalike for `test`
- For example:

```
age=20
test $age -ge 16 &&
  echo can drive
[[ $age -ge 16 ]] &&
  echo can drive
```

- Now say age=3 and try again



Command lists

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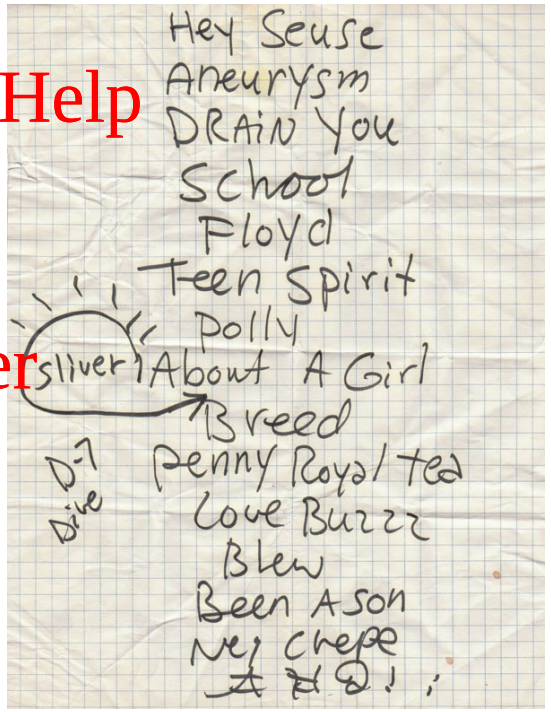
- Simple command list: `;`
  - Runs each command regardless of exit status
  - Example:

```
do_this; do_that
```

- Shortcutting command lists
  - `&&` stops after failure
  - `||` stops after success
  - Examples:

```
foo && echo success
bar || echo failed
```



Try it out

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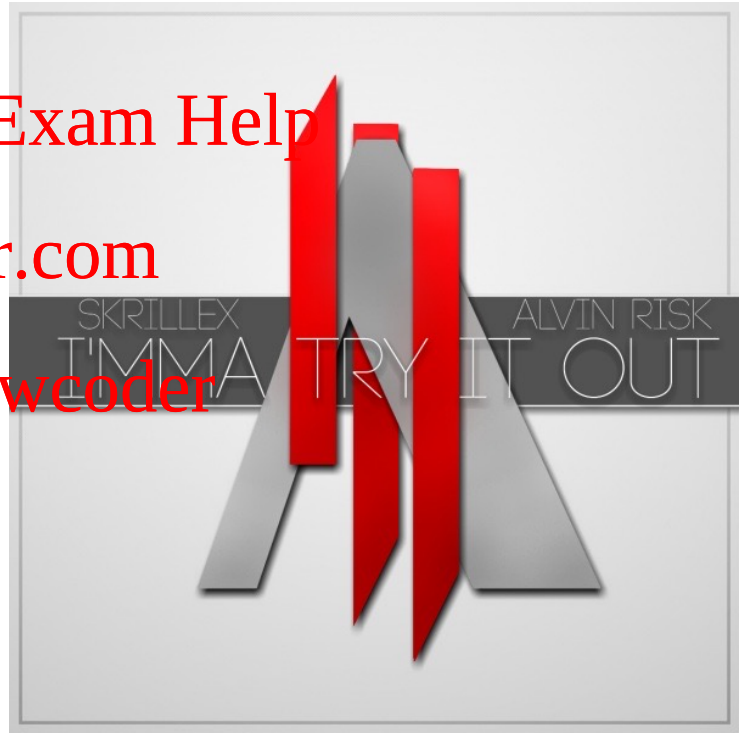
```
true && echo one
true || echo two
false && echo three
false || echo four
test -e Makefile && make
cat dog || echo bird
./status 4 && echo 4
./status 0 && echo 0
cat dog; cat status.c
touch status.c; make
make clean && make
```

Conditional loops

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- You can write a `while` loop using the same idea:

```
while list; do
   cmds
done
```

- Runs *list*, *cmds*, *list*, *cmds*, *list*... for as long as *list* succeeds (exit status 0)
- Similarly, an `until` loop will execute as long as *list* fails

Conditional practice

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```
if ! [[ -e foo ]]; then
  echo hello > foo
fi

while [[ "$x" -lt 99999 ]]; do
  echo "$x"
  x="1$x"
done

if cat foo; then
  echo Same to you
fi

if cat dog; then
  echo Woof
fi
```

Command substitution

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- Command substitution allows the output of a command to replace the command itself
  - In recent versions of bash: $(command)
  - More commonly: `command`
- file $(which ls)
- file `which ls`

For statement

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- The `for` loop is "for-each" style:

```
for var in words; do
   cmds
done
```


- The *cmds* are executed once for each argument in *words*, with *var* set to that argument
- for i in $(seq 1 5); do

  echo $i;

  done
- for i in {1..5}; do echo $i; done

For example...

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```
for a in A B C hello 4; do
  echo "$a$a$a"
done

for ext in h c; do
  cat "hello.$ext"
done
```

Globbing

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- Old name for *filename wildcards*
  - (Comes from "global command")
- * means any number of characters:

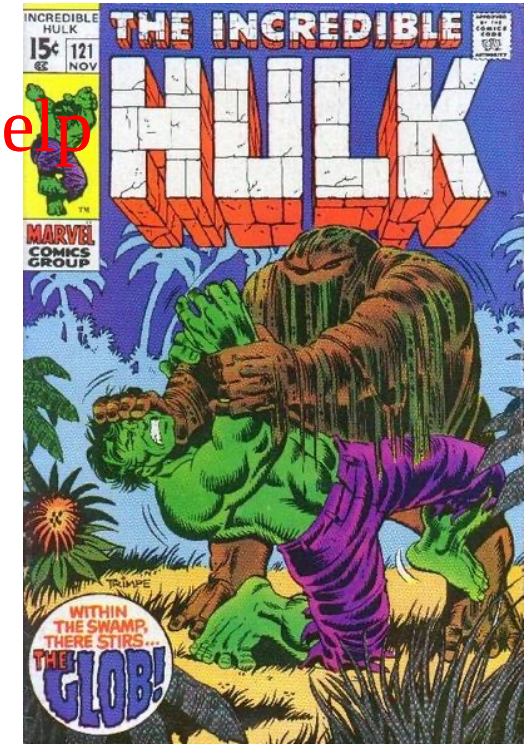
```
echo *
echo *.c
```

- ? means any one character:

```
echo hello.?
```

- Bulk rename:

```
for f in hello.*; do
  mv "$f" "$f.bak"
done
```

Some more useful tools

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- `touch` *foo*: "modify" the file *foo* without really changing it
- `sleep` *t*: wait for *t* seconds
- `grep -F` *string*: filter stdin to just lines containing *string*
- `find . -name '*.c'`: list all the .c files under the current directory
  - Many other things you can search for; see `man find`
- `file` *foo*: determine what kind of file *foo* is
- `wc`: counts words/characters/lines from stdin
- `bc`: command line calculator

Exercise time

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- Print out "foo" once per second until ^C'd
- Find all the .png files in dir/
- Find all the files in dir/ which are *actually* PNG graphics
- Use a pipe and bc to calculate the product of 199 and 42