Introduction to Unix

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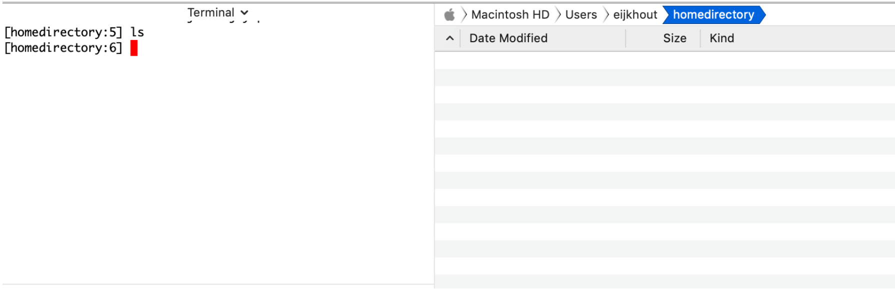
Justification

Unix, in particular Linux, is the *de facto* operating system in High-Performance Computing (HPC).

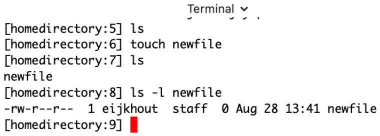
Files and such

`ls`, `touch`

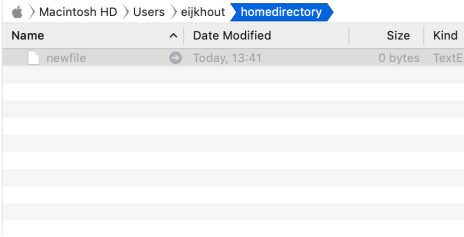
- List files: `ls`
- Maybe your account is still empty: do `touch newfile`, then `ls` again.
- Options: `ls -l` or for specific file `ls -l newfile`.



```
[homedirectory:5] ls
[homedirectory:6]
```



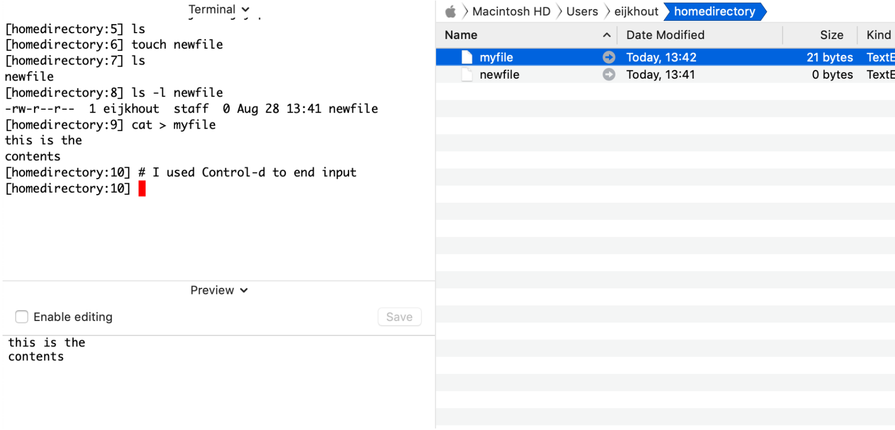
```
[homedirectory:5] ls
[homedirectory:6] touch newfile
[homedirectory:7] ls
newfile
[homedirectory:8] ls -l newfile
-rw-r--r--  1 eijkhout  staff  0 Aug 28 13:41 newfile
[homedirectory:9]
```



Name	Date Modified	Size	Kind
newfile	Today, 13:41	0 bytes	TextE

Display / add to file: `cat`

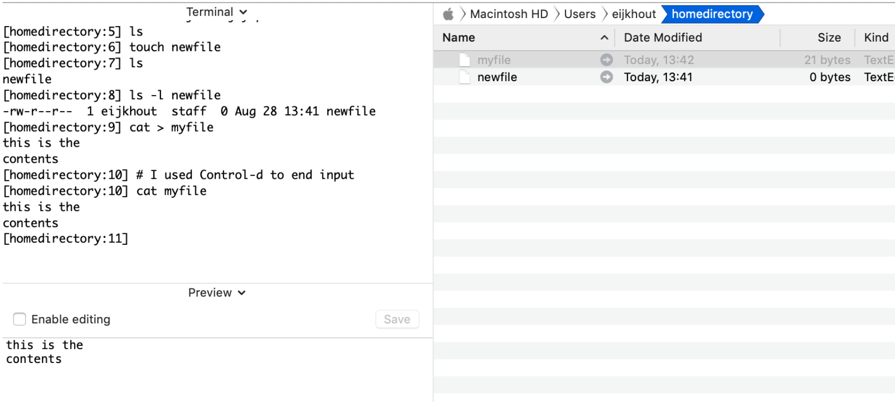
- Display a file: `cat myfile`
- Put something in a file: `cat > myfile`
  end with Control-D.
  Or use an editor, but this is sometimes still useful.
- Now `cat` it again.



```
[homedirectory:5] ls
[homedirectory:6] touch newfile
[homedirectory:7] ls
newfile
[homedirectory:8] ls -l newfile
-rw-r--r--  1 eijkhout  staff  0 Aug 28 13:41 newfile
[homedirectory:9] cat > myfile
this is the
contents
[homedirectory:10] # I used Control-d to end input
[homedirectory:10] 
```

```
this is the
contents
```

Name	Date Modified	Size	Kind
myfile	Today, 13:42	21 bytes	TextE
newfile	Today, 13:41	0 bytes	TextE



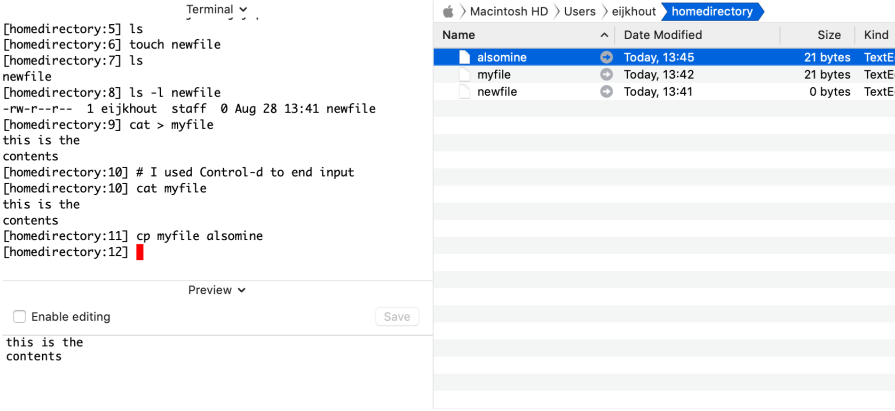
```
[homedirectory:5] ls
[homedirectory:6] touch newfile
[homedirectory:7] ls
newfile
[homedirectory:8] ls -l newfile
-rw-r--r--  1 eijkhout  staff  0 Aug 28 13:41 newfile
[homedirectory:9] cat > myfile
this is the
contents
[homedirectory:10] # I used Control-d to end input
[homedirectory:10] cat myfile
this is the
contents
[homedirectory:11]
```

```
this is the
contents
```

Name	Date Modified	Size	Kind
myfile	Today, 13:42	21 bytes	TextE
newfile	Today, 13:41	0 bytes	TextE

`cp`, `mv`, `rm`

- Copy: `cp file1 file2`
  Do this, check that it's indeed a copy.
- Rename or 'move': `mv file1 file2`
  check that the original file doesn't exist any more.
- Remove: `rm myfile`
  This is irrevocable!

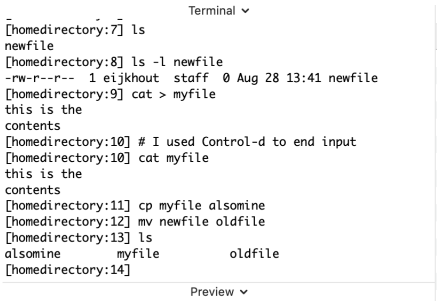


```
[homedirectory:5] ls
[homedirectory:6] touch newfile
[homedirectory:7] ls
newfile
[homedirectory:8] ls -l newfile
-rw-r--r--  1 eijkhout  staff  0 Aug 28 13:41 newfile
[homedirectory:9] cat > myfile
this is the
contents
[homedirectory:10] # I used Control-d to end input
[homedirectory:10] cat myfile
this is the
contents
[homedirectory:11] cp myfile alsomine
[homedirectory:12] 
```

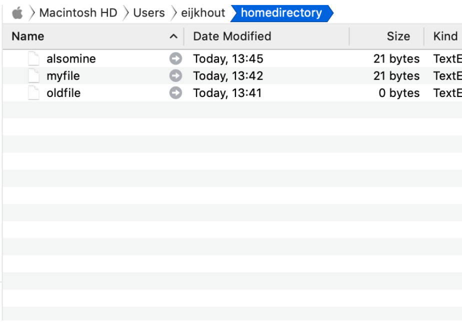
```
this is the
contents
```

Macintosh HD 〉 Users 〉 eijkhout 〉 homedirectory

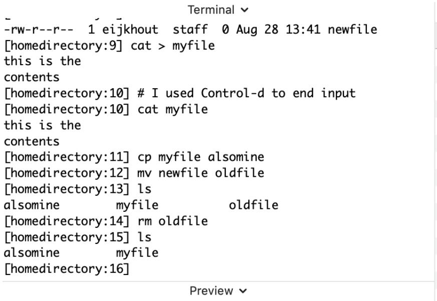
Name	Date Modified	Size	Kind
alsomine	Today, 13:45	21 bytes	TextE
myfile	Today, 13:42	21 bytes	TextE
newfile	Today, 13:41	0 bytes	TextE



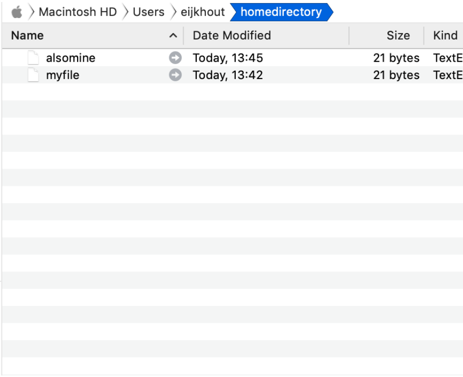
```
[homedirectory:7] ls
newfile
[homedirectory:8] ls -l newfile
-rw-r--r--  1 eijkhout  staff  0 Aug 28 13:41 newfile
[homedirectory:9] cat > myfile
this is the
contents
[homedirectory:10] # I used Control-d to end input
[homedirectory:10] cat myfile
this is the
contents
[homedirectory:11] cp myfile alsomine
[homedirectory:12] mv newfile oldfile
[homedirectory:13] ls
alsomine        myfile          oldfile
[homedirectory:14]
```



Name	Date Modified	Size	Kind
alsomine	Today, 13:45	21 bytes	TextE
myfile	Today, 13:42	21 bytes	TextE
oldfile	Today, 13:41	0 bytes	TextE



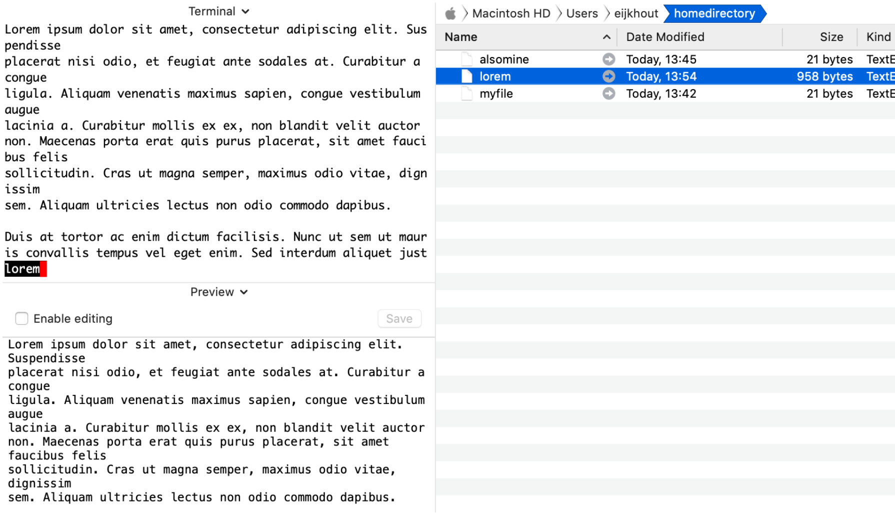
```
-rw-r--r--  1 eijkhout  staff  0 Aug 28 13:41 newfile
[homedirectory:9] cat > myfile
this is the
contents
[homedirectory:10] # I used Control-d to end input
[homedirectory:10] cat myfile
this is the
contents
[homedirectory:11] cp myfile alsomine
[homedirectory:12] mv newfile oldfile
[homedirectory:13] ls
alsomine        myfile          oldfile
[homedirectory:14] rm oldfile
[homedirectory:15] ls
alsomine        myfile
[homedirectory:16]
```



Name	Date Modified	Size	Kind
alsomine	Today, 13:45	21 bytes	TextE
myfile	Today, 13:42	21 bytes	TextE

Dealing with large (text) files

- If a file is larger than your screen:
  `less yourfile`
- If the start or end is interesting enough:
  `head yourfile`, `tail yourfile`
- Explore options: `head -n 5 yourfile`



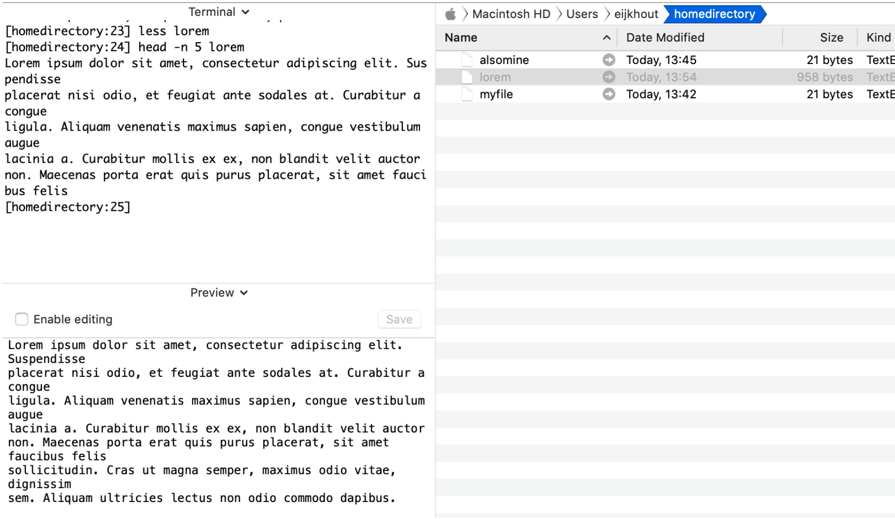
```
Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sus
pendisse
placerat nisi odio, et feugiat ante sodales at. Curabitur a
congue
ligula. Aliquam venenatis maximus sapien, congue vestibulum
augue
lacinia a. Curabitur mollis ex ex, non blandit velit auctor
non. Maecenas porta erat quis purus placerat, sit amet fauci
bus felis
sollicitudin. Cras ut magna semper, maximus odio vitae, dign
issim
sem. Aliquam ultricies lectus non odio commodo dapibus.

Duis at tortor ac enim dictum facilisis. Nunc ut sem ut maur
is convallis tempus vel eget enim. Sed interdum aliquet just
lorem
```

```
Lorem ipsum dolor sit amet, consectetur adipiscing elit.
Suspendisse
placerat nisi odio, et feugiat ante sodales at. Curabitur a
congue
ligula. Aliquam venenatis maximus sapien, congue vestibulum
augue
lacinia a. Curabitur mollis ex ex, non blandit velit auctor
non. Maecenas porta erat quis purus placerat, sit amet
faucibus felis
sollicitudin. Cras ut magna semper, maximus odio vitae,
dignissim
sem. Aliquam ultricies lectus non odio commodo dapibus.
```

Macintosh HD 〉 Users 〉 eijkhout 〉 homedirectory

Name	Date Modified	Size	Kind
alsomine	Today, 13:45	21 bytes	TextE
lorem	Today, 13:54	958 bytes	TextE
myfile	Today, 13:42	21 bytes	TextE



```
[homedirectory:23] less lorem
[homedirectory:24] head -n 5 lorem
Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sus
pendisse
placerat nisi odio, et feugiat ante sodales at. Curabitur a
congue
ligula. Aliquam venenatis maximus sapien, congue vestibulum
augue
lacinia a. Curabitur mollis ex ex, non blandit velit auctor
non. Maecenas porta erat quis purus placerat, sit amet fauci
bus felis
[homedirectory:25]
```

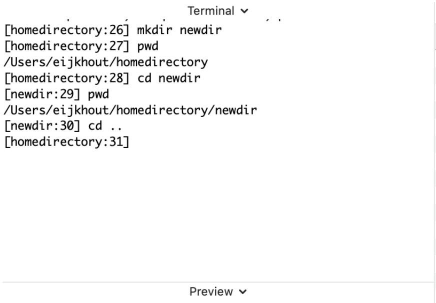
```
Lorem ipsum dolor sit amet, consectetur adipiscing elit.
Suspendisse
placerat nisi odio, et feugiat ante sodales at. Curabitur a
congue
ligula. Aliquam venenatis maximus sapien, congue vestibulum
augue
lacinia a. Curabitur mollis ex ex, non blandit velit auctor
non. Maecenas porta erat quis purus placerat, sit amet
faucibus felis
sollicitudin. Cras ut magna semper, maximus odio vitae,
dignissim
sem. Aliquam ultricies lectus non odio commodo dapibus.
```

Name	Date Modified	Size	Kind
alsomine	Today, 13:45	21 bytes	TextE
lorem	Today, 13:54	958 bytes	TextE
myfile	Today, 13:42	21 bytes	TextE

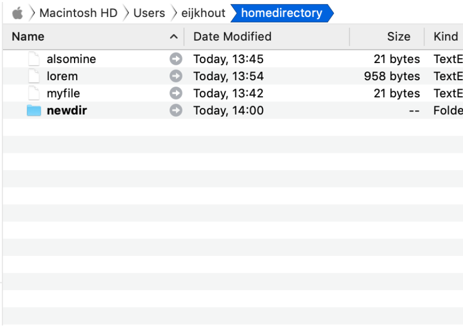
Directories

Directories

- Make a subdirectory 'folder': `mkdir newdir`
- Check where you are: `pwd`
- Now go to the new directory: `cd newdir` and `pwd`
  'change directory' and 'present working directory'
- Back to your home directory: `cd` without further arguments.



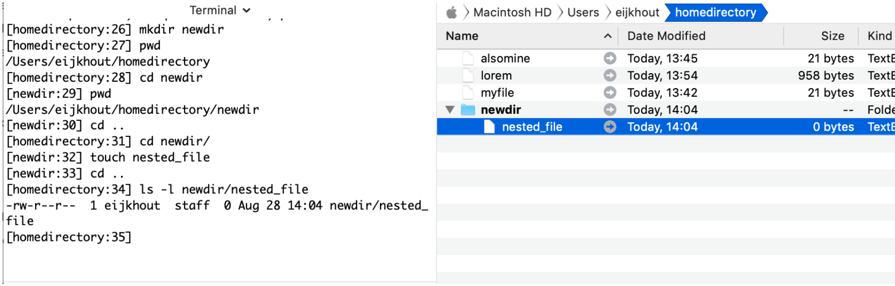
```
[homedirectory:26] mkdir newdir
[homedirectory:27] pwd
/Users/eijkhout/homedirectory
[homedirectory:28] cd newdir
[newdir:29] pwd
/Users/eijkhout/homedirectory/newdir
[newdir:30] cd ..
[homedirectory:31]
```



Name	Date Modified	Size	Kind
alsomine	Today, 13:45	21 bytes	TextE
lorem	Today, 13:54	958 bytes	TextE
myfile	Today, 13:42	21 bytes	TextE
newdir	Today, 14:00	--	Folde

Paths

- Do:
  1. `cd newdir`
  2. `touch nested_file`
  3. `cd`
- Now: `ls newdir/nested_file`
- That is called a path
  - Relative path: does not start with slash
  - Absolute path (such as `pwd` output): starts at root



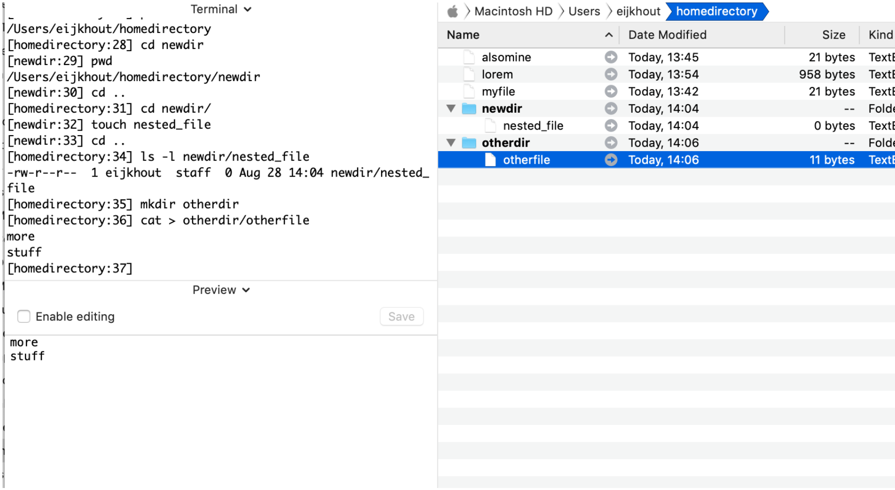
```
[homedirectory:26] mkdir newdir
[homedirectory:27] pwd
/Users/eijkhout/homedirectory
[homedirectory:28] cd newdir
[newdir:29] pwd
/Users/eijkhout/homedirectory/newdir
[newdir:30] cd ..
[homedirectory:31] cd newdir/
[newdir:32] touch nested_file
[newdir:33] cd ..
[homedirectory:34] ls -l newdir/nested_file
-rw-r--r--  1 eijkhout  staff  0 Aug 28 14:04 newdir/nested_
file
[homedirectory:35]
```

Name	Date Modified	Size	Kind
alsomine	Today, 13:45	21 bytes	TextE
lorem	Today, 13:54	958 bytes	TextE
myfile	Today, 13:42	21 bytes	TextE
newdir	Today, 14:04	--	Folde
nested_file	Today, 14:04	0 bytes	TextE

More paths

- Path to your home directory: tilde `cd ~`
- Current directory: `.`
- Going out of a directory: `cd ..`
  (confusing: do you call this a level up or down?)
- You can use this in paths: `ls newdir/subdir1/../subdir2`

Exercise: copy the lorem ipsum file from the repo to a new directory.

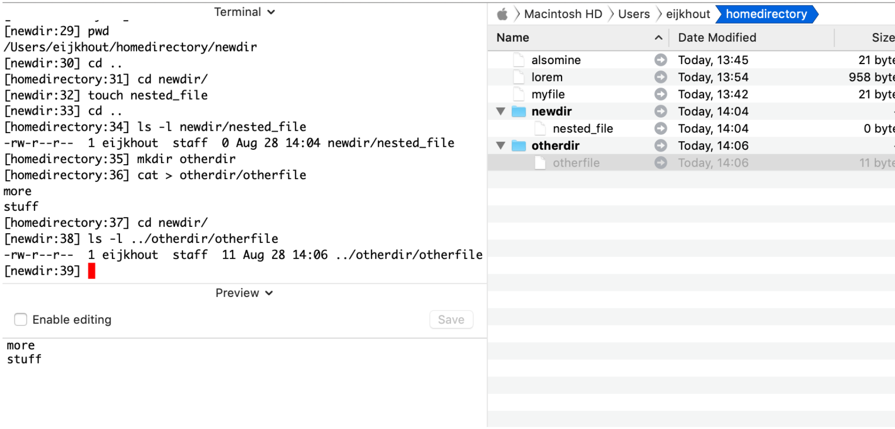


```
/Users/eijkhout/homedirectory
[homedirectory:28] cd newdir
[newdir:29] pwd
/Users/eijkhout/homedirectory/newdir
[newdir:30] cd ..
[homedirectory:31] cd newdir/
[newdir:32] touch nested_file
[newdir:33] cd ..
[homedirectory:34] ls -l newdir/nested_file
-rw-r--r--  1 eijkhout  staff  0 Aug 28 14:04 newdir/nested_
file
[homedirectory:35] mkdir otherdir
[homedirectory:36] cat > otherdir/otherfile
more
stuff
[homedirectory:37]
```

```
more
stuff
```

Macintosh HD 〉 Users 〉 eijkhout 〉 homedirectory

Name	Date Modified	Size	Kind
alsomine	Today, 13:45	21 bytes	TextE
lorem	Today, 13:54	958 bytes	TextE
myfile	Today, 13:42	21 bytes	TextE
▼ newdir	Today, 14:04	--	Folde
nested_file	Today, 14:04	0 bytes	TextE
▼ otherdir	Today, 14:06	--	Folde
otherfile	Today, 14:06	11 bytes	TextE



```
[newdir:29] pwd
/Users/eijkhout/homedirectory/newdir
[newdir:30] cd ..
[homedirectory:31] cd newdir/
[newdir:32] touch nested_file
[newdir:33] cd ..
[homedirectory:34] ls -l newdir/nested_file
-rw-r--r--  1 eijkhout  staff  0 Aug 28 14:04 newdir/nested_file
[homedirectory:35] mkdir otherdir
[homedirectory:36] cat > otherdir/otherfile
more
stuff
[homedirectory:37] cd newdir/
[newdir:38] ls -l ../otherdir/otherfile
-rw-r--r--  1 eijkhout  staff  11 Aug 28 14:06 ../otherdir/otherfile
[newdir:39] 
```

```
more
stuff
```

Name	Date Modified	Size
alsomine	Today, 13:45	21 byte
lorem	Today, 13:54	958 byte
myfile	Today, 13:42	21 byte
newdir	Today, 14:04	-
nested_file	Today, 14:04	0 byte
otherdir	Today, 14:06	-
otherfile	Today, 14:06	11 byte

Exercise 1: Paths

After the following commands:

```
mkdir somedir
touch somedir/somefile
```

Give at least two ways of specifying the path to `somefile`, for instance for the `ls` command

Redirection, pipes

In/Output redirection

- There are three standard files: `stdin`, `stdout`, `stderr`
- Normally connected to keyboard and screen.
- Redirection: standard out to file:
  `ls > directorycontents`
  (actually, screen is a file, so it is really a **re**direct)
- Standard in from file: `mail < myfile`
  (actually, the keyboard is also a file, so again **re**direction)

Exercise: make a copy of a file, using redirection (so no `cp` command).

Splitting out and err

- Sometimes you want to split standard out and error:
- Use `stdout`= 1 and `stderr`= 2:

```
myprogram 1>results.out 2>results.err
```

- Very useful: get rid of errors:

```
myprogram 2>/dev/null
```

Pipes

- Redirection is command-to-file.
- Pipe: command-to-command
  ```
  ls | wc -l
  ```
- Unix philosophy: small building blocks, put together.

More command sequencing

More complicated case of one command providing input for another:

```
echo The line count is wc -l foo
```

where `foo` is the name of an existing file.

Use backquotes or command macro:

```
echo The line count is `wc -l foo`
echo "There are $( wc -l foo ) lines"
```

Exercise: this way `wc` prints the file name. Can you figure out a way to prevent that from happening?

Permissions

Basic permissions

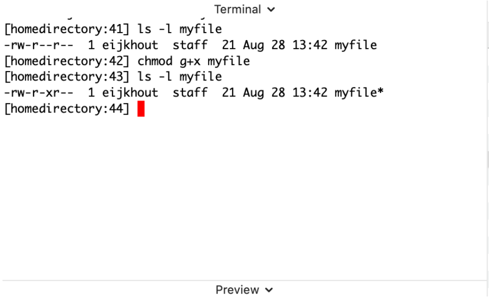
- Three degrees of access: user/group/other
- three types of access: read/write/execute

user	*group*	*other*
rwx	*rwx*	*rwx*

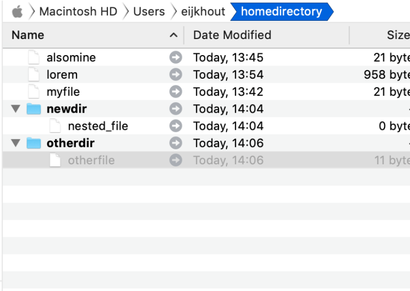
Example: `rw-r-----`:
owner read-write, group read, world: nothing

Permission setting

- Add permissions `chmod g+w myfile`
- recursively: `chmod -R o-r mydirectory`
- Permissions are a binary number: `chmod 644 myfile`



```
[homedirectory:41] ls -l myfile
-rw-r--r--  1 eijkhout  staff  21 Aug 28 13:42 myfile
[homedirectory:42] chmod g+x myfile
[homedirectory:43] ls -l myfile
-rw-r-xr--  1 eijkhout  staff  21 Aug 28 13:42 myfile*
[homedirectory:44] 
```



Name	Date Modified	Size
alsomine	Today, 13:45	21 byte
lorem	Today, 13:54	958 byte
myfile	Today, 13:42	21 byte
▼ **newdir**	Today, 14:04	-
nested_file	Today, 14:04	0 byte
▼ **otherdir**	Today, 14:06	-
otherfile	Today, 14:06	11 byte

Share files

- Make a file in your `$WORK` file system, and make it visible to the world.
- Ask a fellow student to view it.
- $\Rightarrow$ also necessary to make `$WORK` readable.
  (Not a good idea to make `$HOME` readable.)

The `x` bit

The `x` bit has two meanings:

- For regular files: executable.
- For directories: you can go into them.
- Make all directories viewable:

  ```
  chmod -R g+X,o+X rootdir
  ```

Shell programming

Command execution

- Some shell commands are built-in, however most are programs.
- `which ls`
- Exercise: what can you find out about the `ls` program?
- Programs can be called directly: `/bin/ls` or found along the search path `$PATH`:
  ```
  echo $PATH
  ```

Things that look like commands

- Use `alias` to give a new name to a command:
  ```
  alias ls='ls -F'
  alias rm='rm -i'
  ```
- There is a shell level `function` mechanism, not explained here.

Processes

`ps`	list (all) processes
`kill`	kill a process
`CTRL-c`	kill the foreground job
`CTRL-z`	suspect the foreground job
`jobs`	give the status of all jobs
`fg`	bring the last suspended job to the foreground
`fg %3`	bring a specific job to the foreground
`bg`	run the last suspended job in the background

Exercise: how many programs do you have running?

Variables

- `PATH` is a variable, built-in to the shell
- you can make your own variables:

  ```
  a=5
  echo $a
  ```

  No spaces around the equals!

Exercise: what happens when you try to add two variables together?

```
a=3
b=5
```

Variable manipulation

- Often you want to strip prefixes or suffixes from a variable:
  `program.c` ⇒ `program`
  `/usr/bin/program` ⇒ `program`
- Parameter expansion:

```
a=program.c
echo ${a%%.c}
a=/foo/bar/program.c
eecho ${a##*/}
```

Conditionals

- Mostly text-based tests:

```
if [ $a = "foo" ] ; then
  echo "that was foo"
else
  echo "that was $a"
fi
```

- Single line:

```
if [ $a = "foo" ] ; then echo "foo" ; else echo "something" ; fi
```

  Note the semicolons!
  also spaces around square brackets.

Other conditionals

- Numerical tests:/

  ```
  if [ $a -gt 2 ] ....
  ```

- File and directory:

  ```
  if [ -f $HOME ] ; then echo "exists" ; else echo "no such" ; fi
  if [ -d $HOME ] ; then echo "directory!" ; else echo "file" ; fi
  ```

Looping

- Loop: for item in list
  the item is available as macro

  ```
  for letter in a b c ; do echo $letter ; done
  ```

- Loop over files:

  ```
  for file in * ; do echo $file ; done
  ```

Exercises:

1. for each file, print its name and how many lines there are in it.
2. loop through your files, print which ones are directories.
3. for each C program, remove the object file.

Numerical looping

- Type `seq 1 5`
- Exercise: can you figure out how to loop 1 . . . 5?

```
n=12
## input
for i in ....... ; do echo $i ; done
## output
1
....
12
```

Scripting

Scripp execution

- Create a script `script.sh`:

  ```
  #!/bin/bash
  echo foo
  ```

- Can you execute this? Does the error suggest a remedy?
- What is the remaining problem?

Arguments

- You want to call `./script.sh myfile`
- Parameters are `$1` et cetera:

  ```
  #!/bin/bash
  echo "$1 is a file"
  ```
- How many arguments: `$#`

Exercise

Write a script that takes as input a file name argument, and reports how many lines are in that file.

Edit your script to test whether the file has less than 10 lines (use the `foo -lt bar` test), and if it does, `cat` the file. Hint: you need to use backquotes inside the test.

Add a test to your script so that it will give a helpful message if you call it without any arguments.

Exercise

Write a 'plagiarism detector'.

- Write a script that accepts two argument: one text file and one directory

  ```
  ./yourscript.sh myfile targetdir
  ```

  (the `.sh` extension is required for this exercise)
- Your script should compare the text file to the contents of the directory:
  - If the file is different from anything in the directory, it should be copied into the directory; the script should not produce any output in this case.
  - If the file is the same as a file in the directory, the script should complain.
  - The test whether files are 'the same' should be made with the `diff` command. Explore options that allow `diff` to ignore differences that are only in whitespace.

Turn it in!

Here is how you submit your homework.

- There is a test/submit script:
  ```
  sds_plagiarism yourscript.sh
  ```
  This tests the correctness of your script.
- If your script passes the test, use the `-s` option to submit:
  ```
  sds_plagiarism -s yourscript.sh
  ```
  or use the `-i` option to submit incomplete:
  ```
  sds_plagiarism -i yourscript.sh
  ```
- Add the `-d` option for some debugging output:
  ```
  sds_plagiarism -d yourscript.sh
  ```
- (after you run the script once, you'll see in your directory the files that are used for testing)