Linux Basics III:
Text file manipulation

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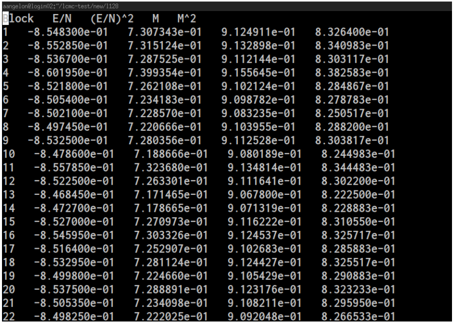
Text manipulation

We are scientists: we deal in **datafiles**



```
Block   E/N   (E/N)^2   M   M^2
1   -8.548300e-01   7.307343e-01   9.124911e-01   8.326400e-01
2   -8.552850e-01   7.315124e-01   9.132898e-01   8.340983e-01
3   -8.536700e-01   7.287525e-01   9.112144e-01   8.303117e-01
4   -8.601950e-01   7.399354e-01   9.155645e-01   8.382583e-01
5   -8.521800e-01   7.262108e-01   9.102124e-01   8.284867e-01
6   -8.505400e-01   7.234183e-01   9.098782e-01   8.278783e-01
7   -8.502100e-01   7.228570e-01   9.083235e-01   8.250517e-01
8   -8.497450e-01   7.220666e-01   9.103955e-01   8.288200e-01
9   -8.532500e-01   7.280356e-01   9.112528e-01   8.303817e-01
10   -8.478600e-01   7.188666e-01   9.080189e-01   8.244983e-01
11   -8.557850e-01   7.323680e-01   9.134814e-01   8.344483e-01
12   -8.522500e-01   7.263301e-01   9.111641e-01   8.302200e-01
13   -8.468450e-01   7.171465e-01   9.067800e-01   8.222500e-01
14   -8.472700e-01   7.178665e-01   9.071319e-01   8.228883e-01
15   -8.527000e-01   7.270973e-01   9.116222e-01   8.310550e-01
16   -8.545950e-01   7.303326e-01   9.124537e-01   8.325717e-01
17   -8.516400e-01   7.252907e-01   9.102683e-01   8.285883e-01
18   -8.532950e-01   7.281124e-01   9.124427e-01   8.325517e-01
19   -8.499800e-01   7.224660e-01   9.105429e-01   8.290883e-01
20   -8.537500e-01   7.288891e-01   9.123176e-01   8.323233e-01
21   -8.505350e-01   7.234098e-01   9.108211e-01   8.295950e-01
22   -8.498250e-01   7.222025e-01   9.092048e-01   8.266533e-01
```

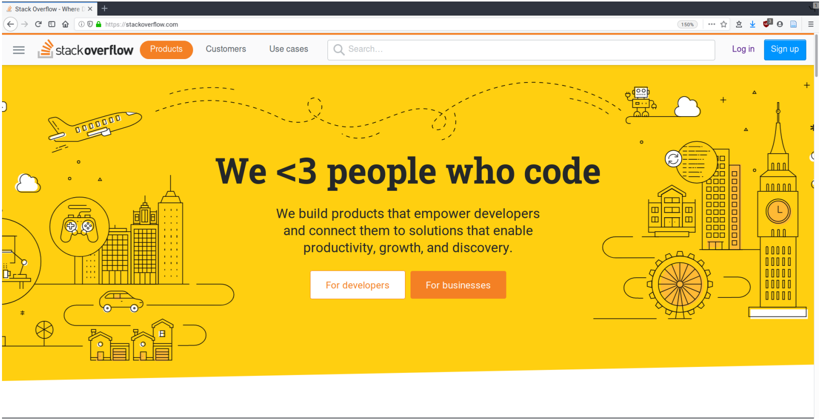
Shell commands allow us to manipulate them as **text files**:
great versatility and relatively simple, sometimes requires attention

You see files as a bunch of **rows** or **columns**:
different commands for different tasks

Before we go, remember:

nobody knows everything (except the internet)

Stackoverflow and **Google** will help you, use them



Stack Overflow - Where D

https://stackoverflow.com

We <3 people who code

We build products that empower developers and connect them to solutions that enable productivity, growth, and discovery.

Manual Pages

All basic UNIX commands come with a manual page. The manual page can be accessed through the `man` program.

- `man` is the system manual pager program. You provide as argument the name of a program, utility or function.
- The program searches for the manual page in various section in a pre-defined order.
- The manual page is shown using a pager program after being formatted for the particular terminal output.

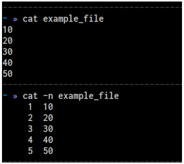
Example:

```
man cat
```

Row Operations I - Listing

`cat <files>`: displays entire files

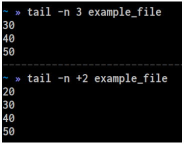
- `-n`: numbers lines



```
~ » cat example_file
10
20
30
40
50

~ » cat -n example_file
     1  10
     2  20
     3  30
     4  40
     5  50
```

`tail <file>`: **last** 10 lines of the file

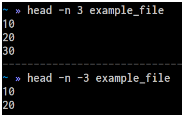
- `-n <num>`: last `<num>` lines
- `-n +<num>`: after line `<num>`



```
~ » tail -n 3 example_file
30
40
50

~ » tail -n +2 example_file
20
30
40
50
```

`head <file>`: **first** 10 lines of the file

- `-n <num>`: first `<num>` lines
- `-n -<num>`: before line `<num>`



```
~ » head -n 3 example_file
10
20
30

~ » head -n -3 example_file
10
20
```

Useful on their own, can be combined with **pipes**

Interlude I: Pipes and redirection

Piping:
output of command ⟶ input to another

```
command_1 <arguments> | command_2 | ...  | command_N
```

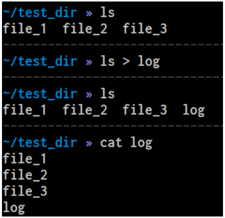
Example: extract 3rd line of file

```
head -n 3 <file> | tail -n 1
```

Redirection:
output of command ⟶ file

```
command <options> <arguments> > <file>
```

Use `>>` to append to existing file

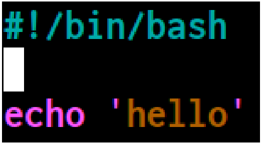


```
~/test_dir » ls
file_1  file_2  file_3

~/test_dir » ls > log

~/test_dir » ls
file_1  file_2  file_3  log

~/test_dir » cat log
file_1
file_2
file_3
log
```

Interlude II: basic shell scripting

As said before, you can **recycle** commands you use more than once:
write once, use more than once

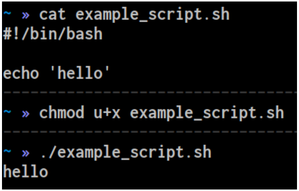
You can create **scripts**:
files containing instructions
which you launch to perform tasks



```
#!/bin/bash

echo 'hello'
```

- The first line tells the shell which **interpreter** to use (i.e. which scripting language, we use `bash`)
- The rest is **instructions** (this here prints 'hello')

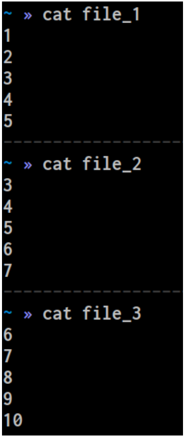
Scripts can be made **executable**
(remember `chmod`?)
and launched from the command line:
`./<script>`



```
~ » cat example_script.sh
#!/bin/bash

echo 'hello'
------------------------------------------------
~ » chmod u+x example_script.sh
------------------------------------------------
~ » ./example_script.sh
hello
```

Exercise I - cat, tail, head

Create the following 3 files:



```
~ » cat file_1
1
2
3
4
5
------------------
~ » cat file_2
3
4
5
6
7
------------------
~ » cat file_3
6
7
8
9
10
```

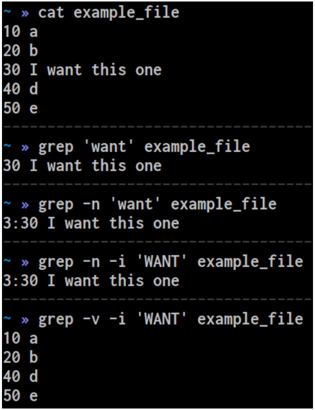
Write a scripts that creates a file containing the first 3 rows of `file_1`, the 2nd and 3rd lines of `file_2` and the last 3 lines of `file_3` and displays this file on the screen.

Use pipes and redirection where needed.

Row Operations II - Matching and Filtering

`grep <content> <files>` filters lines based on their content

- `<content>` can be a part of the line
- Quoting (`'<content>'`) is advised
- `-n`: adds numbers to matching lines
- `-i`: case-insensitive matching
- `-v`: prints non-matching lines



```
~ » cat example_file
10 a
20 b
30 I want this one
40 d
50 e
------------------------------------
~ » grep 'want' example_file
30 I want this one
------------------------------------
~ » grep -n 'want' example_file
3:30 I want this one
------------------------------------
~ » grep -n -i 'WANT' example_file
3:30 I want this one
------------------------------------
~ » grep -v -i 'WANT' example_file
10 a
20 b
40 d
50 e
```

More flexibility using **regular expressions**

Interlude III - Regular Expressions Basics

Regular expressions (regexps) are **templates** that lines can match
They can use special characters and **wildcards**:

- `.`: any single character
- `.*`: any number of characters
- `^`: beginning of the line
- `$`: end of the line
- `[adf]`, `[a-z]`, `[A-Za-z]`: group of characters

Example: `The quick brown fox jumped`

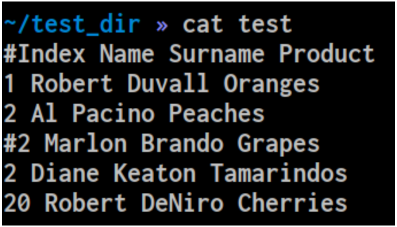
- `.*quick.*` **matches**
- `The quick brown.*jumped.*` **matches**
- `The quick brown [foxape]* jumped .*` **matches**
- `^quick.*` **doesn’t match**

Now you can do `grep <regexp> <files>`:

```
grep ’.*quick.*’ <files>
```

Exercise II - grep

Create the following file:



```
~/test_dir » cat test
#Index Name Surname Product
1 Robert Duvall Oranges
2 Al Pacino Peaches
#2 Marlon Brando Grapes
2 Diane Keaton Tamarindos
20 Robert DeNiro Cherries
```

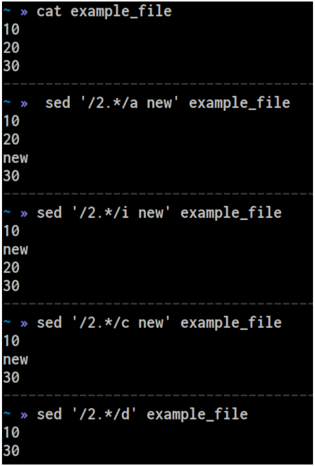
Create a script which filters out commented lines (starting with `#`), selects all lines where the index is 2, then selects only who sells tamarindos. Use redirection and/or piping.

Hint: the line begins with the index. Watch case.

Row Operations III - sed

`sed` (stream editor) operates on files as groups of lines:
finds lines matching regexps and acts on (or around) them

- `sed ’/<regexp>/a <text>’`
  adds `<text>` after matching lines
- `sed ’/<regexp>/i <text>’`
  adds `<text>` before matching lines
- `sed ’/<regexp>/c <text>’`
  replaces matching lines with `<text>`
- `sed ’/<regexp>/d’`
  deletes all matching lines



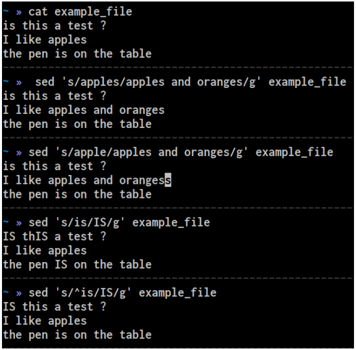
```
~ » cat example_file
10
20
30
------------------------------------------------
~ »  sed '/2.*/a new' example_file
10
20
new
30
------------------------------------------------
~ » sed '/2.*/i new' example_file
10
new
20
30
------------------------------------------------
~ » sed '/2.*/c new' example_file
10
new
30
------------------------------------------------
~ » sed '/2.*/d' example_file
10
30
```

Row Operations IV - More sed

```
sed ’s/<regexp>/<text>/g’ <files>
```

replaces **all** occurrence of `<regexp>` with `<text>` in all lines

- Replacement and matching will break words
- Matching is case-sensitive
- All regexp tools available
- `sed -i` applies modifications to the files: **be careful!**

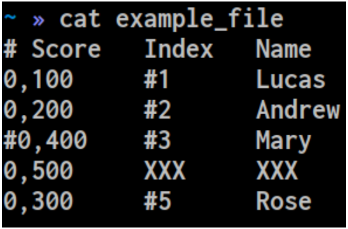


```
~ » cat example_file
is this a test ?
I like apples
the pen is on the table
--------------------------------------------------------
~ »  sed 's/apples/apples and oranges/g' example_file
is this a test ?
I like apples and oranges
the pen is on the table
--------------------------------------------------------
~ » sed 's/apple/apples and oranges/g' example_file
is this a test ?
I like apples and orangess
the pen is on the table
--------------------------------------------------------
~ » sed 's/is/IS/g' example_file
IS thIS a test ?
I like apples
the pen IS on the table
--------------------------------------------------------
~ » sed 's/^is/IS/g' example_file
IS this a test ?
I like apples
the pen is on the table
--------------------------------------------------------
```

Remember: `sed` can be used in pipes

Exercise III - sed

Create the following file:



```
~ » cat example_file
# Score   Index   Name
0,100     #1      Lucas
0,200     #2      Andrew
#0,400    #3      Mary
0,500     XXX     XXX
0,300     #5      Rose
```

Create a script which:

- Replaces corrupted lines (lines containing `XXX`) with `#CORRUPTED`
- Removes commented lines (beginning with `#`) from the file
- Shows on screen the last two lines of the file replacing `,` with `.` (**do not apply this last modification to the file**)

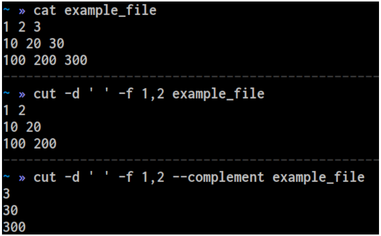
Hint: the use of `sed -i` and pipes is suggested. A copy of the original file is also handy to have at all times.

Column Operations I - cut and paste

Datafiles can also be seen as an ensemble of **columns** (fields)

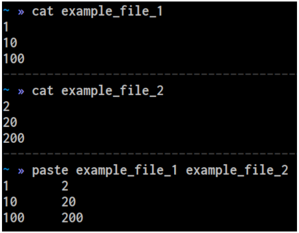
`cut <options> <file>`:
extract selected fields from file

- `-d`: specify field delimiter (often `' '` or `','`)
- `-f`: specify the desired fields (separate with `,`)
- `--complement`: print unselected fields



```
~ » cat example_file
1 2 3
10 20 30
100 200 300
------------------------------------------------
~ » cut -d ' ' -f 1,2 example_file
1 2
10 20
100 200
------------------------------------------------
~ » cut -d ' ' -f 1,2 --complement example_file
3
30
300
```

`paste <files>`:
join lines in multiple files



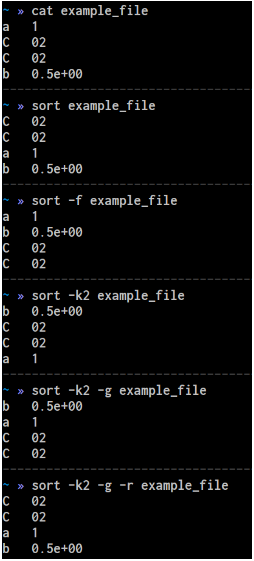
```
~ » cat example_file_1
1
10
100
---------------------------------------
~ » cat example_file_2
2
20
200
---------------------------------------
~ » paste example_file_1 example_file_2
1       2
10      20
100     200
```

Column Operations II - sort

`sort <options> <file>`:

sorts a file according to the given criteria

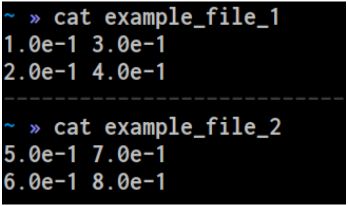
- `-k`: specify an index column (order following this column, default: 1)
- `-n`: numbers sorted according to value
- `-g`: like `-n`, more general formats (e.g., scientific notation)
- `-h`: like `-n`, human-readable formats (e.g., `4K, 8M`)
- `-r`: reverses sort order (descending)
- `-u`: eliminates repeated lines



```
~ » cat example_file
a   1
C   02
C   02
b   0.5e+00
------------------------------------
~ » sort example_file
C   02
C   02
a   1
b   0.5e+00
------------------------------------
~ » sort -f example_file
a   1
b   0.5e+00
C   02
C   02
------------------------------------
~ » sort -k2 example_file
b   0.5e+00
C   02
C   02
a   1
------------------------------------
~ » sort -k2 -g example_file
b   0.5e+00
a   1
C   02
C   02
------------------------------------
~ » sort -k2 -g -r example_file
C   02
C   02
a   1
b   0.5e+00
```

Exercise IV - cut, paste, sort

Create the following files:



```
~ » cat example_file_1
1.0e-1 3.0e-1
2.0e-1 4.0e-1
---------------------------
~ » cat example_file_2
5.0e-1 7.0e-1
6.0e-1 8.0e-1
```

Write a script which:

- Pastes the two files together
- Sorts the output according to the 3rd column
- Prints out the 2nd column of the line
  with the highest value of the 3rd column

Hint: Remember the options of `sort` (`-g` in particular).

Remember `head/tail`.

Column Operations III - awk

awk is a (simple) programming language for text operations
mostly used to work on files as sets of columns

An awk program can be structured in 3 blocks:

```
BEGIN { 1 } { 2 } END { 3 }
```

- **Initial instructions** (1) are executed only once, before starting to read the file.
- **Line instructions** (2) are executed on each line.
- **Final instructions** (3) are executed once the file has been read.

Usually when launched in shell only block (2) is used:

```
awk '{ <commands> }' <file>
```

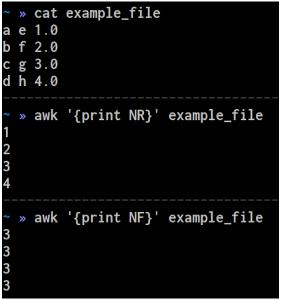
Powerful tools available, like **if...then...else**
We will not see them here (**stackoverflow** is always there though)

Column Operations IV - awk basics

`print` writes to standard output:
use `""` for strings

Special variables:

- `NR` is the current line
- `NF` is the number of fields of the current line

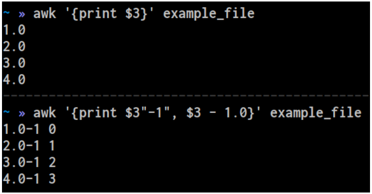


```
~ » cat example_file
a e 1.0
b f 2.0
c g 3.0
d h 4.0
------------------------------------
~ » awk '{print NR}' example_file
1
2
3
4
------------------------------------
~ » awk '{print NF}' example_file
3
3
3
3
```

Access fields via `$<field_number>`

- `$0` is the entire line
- `$NF` is the last field

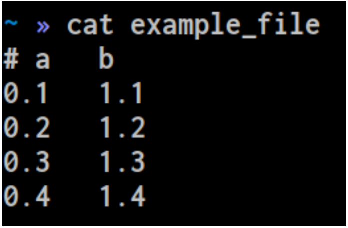
Fields can be manipulated as strings or floating-point numbers (file remains untouched)



```
~ » awk '{print $3}' example_file
1.0
2.0
3.0
4.0
------------------------------------------------
~ » awk '{print $3"-1", $3 - 1.0}' example_file
1.0-1 0
2.0-1 1
3.0-1 2
4.0-1 3
```

Exercise V - awk

Create the following file:



```
~ » cat example_file
# a   b
0.1   1.1
0.2   1.2
0.3   1.3
0.4   1.4
```

Write a script which writes to a new file the row number, the difference and the squared difference of columns 1 and 2 of the starting file (neglecting the label row).

In awk you can perform operations between columns, with the usual operators (`+, -, *, /, ()`).