UNIVERSITY OF BIRMINGHAM

Worksheet 1 Report

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Issue: 1

Date: October 11, 2016

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Contents

1 Question 1

For the first excercise a number of commands were input to the linux bash prompt, in order to understand what the different commands do and how to use them. The commands are listed here in order, with the output following and finally a description of what the command has done.

a) mkdir compphys

   No output, but a new directory has been created called "compphys"

b) cd compphys

   No output again, but now the current working directory is " /compphys"

c) cat > file1.txt [rtn] this is my first file [rtn][ctrl-c]

   No output is printed to the screen, however a new file called "file1.txt" has been created, containing the text "this is my first file"

d) ls

   Ouput is:

   ```
   file1.txt
   ```

   The ls command lists the contents of the current working directory.

e) more file1.txt

   Output is:

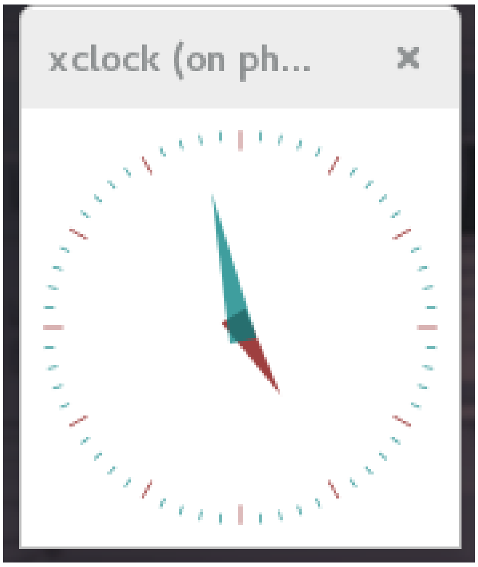


Figure 1: xclock open through the ssh session

```
this is my first file
```

The more command pages files to the standard output, seen as the file “file1.txt” only has one line, that line is simply printed to the terminal.

f) xclock&

Output is shown in figure 1.

The xclock& command starts an xclock process. This will be opened on the client side through ssh if X11 forwarding is enabled, and the client is able to display xwindow objects. The ampersand is to tell the process to start the process in the background, ie. to allow the shell session to continue while xclock is still running.

g) whoami

Output is:

```
mfk364
```

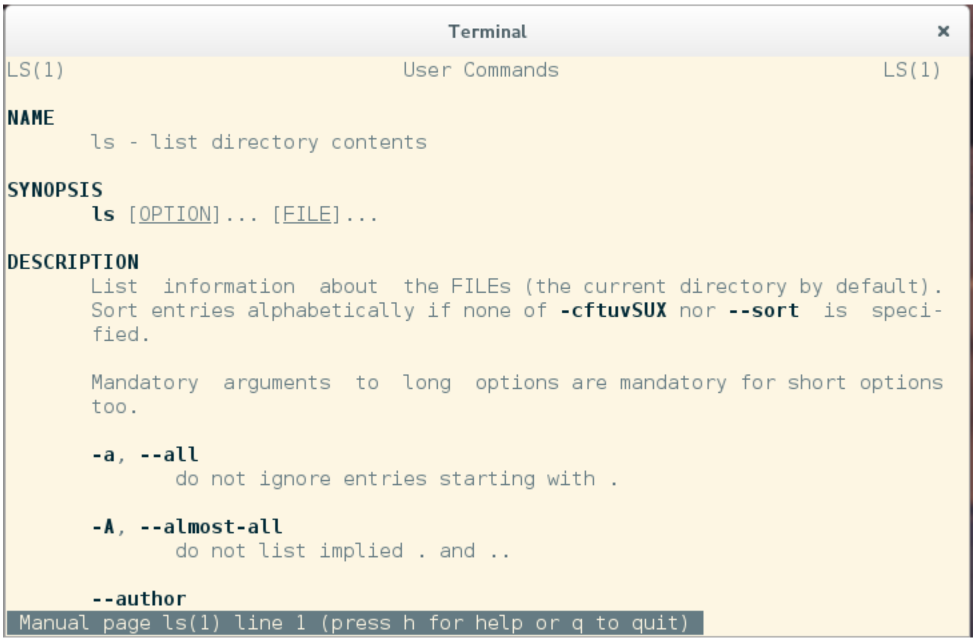
This command prints the username of the current user.

h) man ls

Output is a man page, a text document describing the usage of the “ls” command. Calling man <command> will display a man page on any command with proper documentation. Figure 2 shows the top of the ls man page.

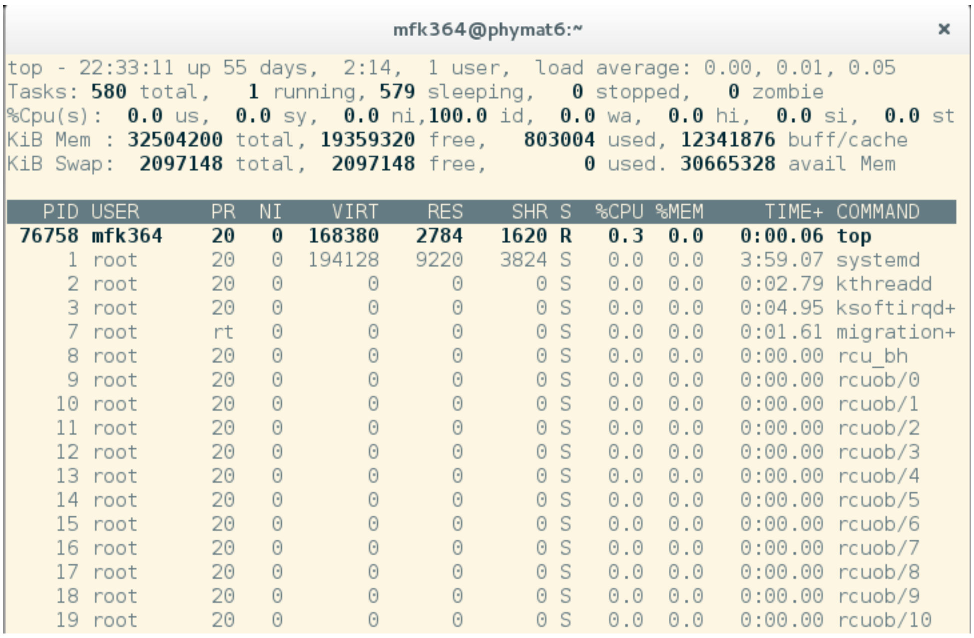
i) top

Output is a display of running processes, ordered by CPU usage. The column processes are sorted by, and other options can be changed using commands while top is running. Figure 3 shows top while running, with the columns sorted by CPU usage.



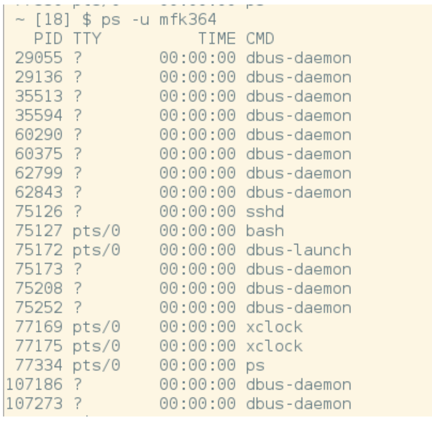
```
Terminal
LS(1)                        User Commands                        LS(1)

NAME
       ls - list directory contents

SYNOPSIS
       ls [OPTION]... [FILE]...

DESCRIPTION
       List  information  about  the FILEs (the current directory by default).
       Sort entries alphabetically if none of -cftuvSUX nor --sort  is  speci-
       fied.

       Mandatory  arguments  to  long  options are mandatory for short options
       too.

       -a, --all
              do not ignore entries starting with .

       -A, --almost-all
              do not list implied . and ..

       --author
 Manual page ls(1) line 1 (press h for help or q to quit)
```

Figure 2: Top of the man page for the "ls" command



```
mfk364@phymat6:~
top - 22:33:11 up 55 days,  2:14,  1 user,  load average: 0.00, 0.01, 0.05
Tasks: 580 total,   1 running, 579 sleeping,   0 stopped,   0 zombie
%Cpu(s):  0.0 us,  0.0 sy,  0.0 ni,100.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
KiB Mem : 32504200 total, 19359320 free,   803004 used, 12341876 buff/cache
KiB Swap:  2097148 total,  2097148 free,        0 used. 30665328 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU %MEM     TIME+ COMMAND
76758 mfk364    20   0  168380   2784   1620 R   0.3  0.0   0:00.06 top
    1 root      20   0  194128   9220   3824 S   0.0  0.0   3:59.07 systemd
    2 root      20   0       0      0      0 S   0.0  0.0   0:02.79 kthreadd
    3 root      20   0       0      0      0 S   0.0  0.0   0:04.95 ksoftirqd+
    7 root      rt   0       0      0      0 S   0.0  0.0   0:01.61 migration+
    8 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcu_bh
    9 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/0
   10 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/1
   11 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/2
   12 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/3
   13 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/4
   14 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/5
   15 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/6
   16 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/7
   17 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/8
   18 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/9
   19 root      20   0       0      0      0 S   0.0  0.0   0:00.00 rcuob/10
```

Figure 3: The "top" command in action



```
~ [18] $ ps -u mfk364
  PID TTY          TIME CMD
 29055 ?        00:00:00 dbus-daemon
 29136 ?        00:00:00 dbus-daemon
 35513 ?        00:00:00 dbus-daemon
 35594 ?        00:00:00 dbus-daemon
 60290 ?        00:00:00 dbus-daemon
 60375 ?        00:00:00 dbus-daemon
 62799 ?        00:00:00 dbus-daemon
 62843 ?        00:00:00 dbus-daemon
 75126 ?        00:00:00 sshd
 75127 pts/0    00:00:00 bash
 75172 pts/0    00:00:00 dbus-launch
 75173 ?        00:00:00 dbus-daemon
 75208 ?        00:00:00 dbus-daemon
 75252 ?        00:00:00 dbus-daemon
 77169 pts/0    00:00:00 xclock
 77175 pts/0    00:00:00 xclock
 77334 pts/0    00:00:00 ps
107186 ?        00:00:00 dbus-daemon
107273 ?        00:00:00 dbus-daemon
```

Figure 4: An example of "ps -u [username]" output

j) kill

The "kill" command is used to stop running processes. In order to use kill one needs the PID of the process to be stopped. For this the "ps" command is used, which lists all the processes running under the current user's UID. Once a PID is known "kill [PID]" will send a terminate signal to the process.

The output of the kill command is:

```
[running processes] Terminated\tab [process name]
```

k) ps -u [username]

As described above the "ps" command displays currently running processes. The -u option denotes that all the processes belonging to a user specified by [username] should be displayed. The default behaviour of "ps" is to display the processes belonging to the current user running in the current TTY.

An example output of the "ps -u [username]" is shown in figure 4.

2 Question 4

For this question a C++ program was required to calculate different powers of ϕ (the silver ratio), given by $\phi = \frac{-1+\sqrt{5}}{2}$, and output the data to a file. The source code for this program is called "w1q4.cpp", and when run will output data to a file called "output". The code calculates and writes the power of phi by basic multiplication in lines 53-56.

The recursion relation

$$\phi^{n+1} = \phi^{n-1} - \phi^{n}$$

can be shown by noting that if we multiply both sides by ϕ we get

$$\phi^{n+2} = \phi^{n} - \phi^{n+1}$$

we can then substitute $m = n + 1$ to give us

$$\phi^{m+1} = \phi^{m-1} - \phi^{m}$$

This means the recursion relation is always valid for any value of $n \in \mathbb{Z}, n \geq n_0$ as long as the base case n_0 is defined for n (as we can see m must also be an integer greater than n_0).

The base case is relatively easy to show using the properties of the golden ratio, and by extension its conjugate which we are interested in. It is easiest to show by taking the case that $n_0 = 0$, especially when we note that a property of the golden ratio (see reference [2]) (Φ) is

$$\frac{1}{\Phi} = \Phi - 1$$

and therefore, because the silver ratio $\phi = \frac{1}{\Phi}$, that the silver ratio has a similar property

$$\frac{1}{\phi} = \phi + 1$$

If we now take our recursion relation with $n = 0$

$$\phi^{1} = \phi^{-1} - \phi^{0}$$

$$\phi = \frac{1}{\phi} - 1$$

we can see that the recursion relation is satisfied by considering the properties of the silver ratio as the conjugate of the golden ratio.

The function `recursion_relation` (starting at line 20 in the code) is the reursive function that uses the recursion relation defined as $\phi^{n+1} = \phi^{n-1} - \phi^{n}$. When the programme is run with values of N greater than around 40 the programme runs extremely slowly. This is because this recursive function runs in $O(n^2)$ time, and is therefore very slow.

We can see by looking at the results that the two recursive functions both fail with varying degrees of severity. The function using floats begins to fluctuate relatively quickly, and produces very poor results. The double precision recursive function performs better, however it still produces fluctuations and innacuracies compared to our reference value calculated using direct multiplication.

3 Question 6

In this problem we consider a mass suspended by two springs from a bench, as shown in figure 5. We need to find the angle θ that the two spings make with the bench in terms of the known quantities: the length of the bench L, the mass m, and the spring constant k. The springs both have natural length $L/2$.

The equation for *theta* can be found by balancing forces. If we start with the equation

$$mg = 2T \sin\theta$$

where T is the tension in one spring, we can use the equation

$$T = k\Delta x$$

We then find Δx in terms of the L and θ

$$\Delta x = \frac{L}{2\cos\theta} - \frac{L}{2}$$

$$T = k\frac{L}{2}(\frac{1}{\cos\theta} - 1)$$

If we now substitute back into our first equation then we get

$$mg = kL(\tan\theta - \sin\theta)$$

We will use values $m = 5.5$kg, $L = 0.6$m and $k = 850$N. The code uses a recursive function to calculate and output the result using the bisection method of root finding (see chapter 03.03 in reference [1]). A precision of 6 significant figures is used, with our initial "bracket" around the root being 0 and $\pi/2$. By considering the physical properties of the system it is clear that these are sensible choices for out initial lower and upper bounds as θ must lie between these two points. The error at each iteration is given by half the difference between the upper and lower bounds, as we know the root must lie somewhere between this boundary and therefore cannot be more than half the difference from the centre of the boundary. Once the difference between the upper and lower bounds is less than our required precision we take the average of the upper and lower bound, and this gives us our answer to our chosen significant figures.

4 Question 7

Here we are considering the error propogation when using the bisection and Newton-Raphson methods for root finding. We can analyse the error when using the bisection method by considering that if at step n we have upper and lower bound u_n and l_n, middle value $m_n = \frac{u_n+l_n}{2}$ and error $\epsilon_n = \frac{u_n-l_n}{2}$. We can then say that our new boundaries will be one of u_n or l_n along with m_n, which has error $epsilon_n$ associated with it. If we assume that the error in the value of u_n/l_n is negligible compared to $epsilon_n$ then we can see that the middle on the $n+1$ iteration is

$$m_{n+1} = \frac{|m_n + \epsilon_n - (u_n\, or\, l_n)|}{2}$$

This shows us simply that the error is halved on each iteration, giving us:

$$\epsilon_{n+1} = \frac{\epsilon_n}{2}$$

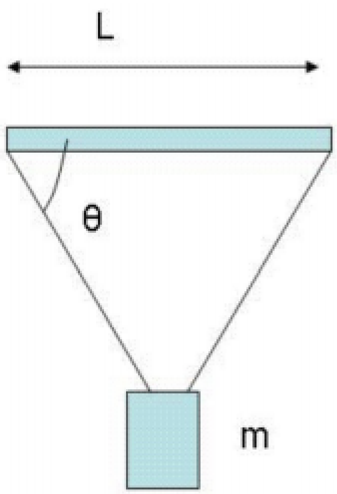


Figure 5: Mass suspended from a bench by two springs.

References

[1] Autar K. Kaw. *Holistic Numerical Methods*. URL: http://nm.mathforcollege.com/topics/textbook_index.html.

[2] Eric W. Weisstein. *Golden Ratio*. URL: http://mathworld.wolfram.com/GoldenRatio.html.