CS 351 Lab #0 Part 1 - Linux & Tools

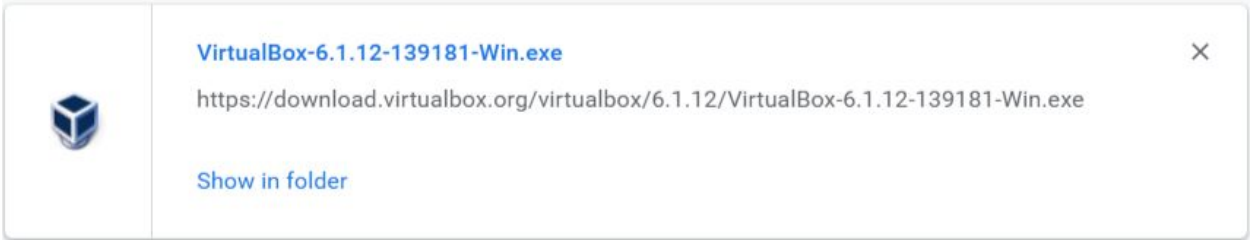
Ivan Prskalo
A20446839

1. (7 points) Setup VM, Linux, and basic testing – must take screen shots at each step to receive points

a. Read Oracle VirtualBox White Paper (http://www.oracle.com/us/technologies/virtualization/oracle-vm-virtualbox-overview2981353.pdf)

The white paper outlines what a VM is and how Oracle is an open-source cross-platform virtualization software. It allows multi platform environments on a single machine

b. Download Oracle VirtualBox 6.1.12 (https://www.virtualbox.org/wiki/Downloads)

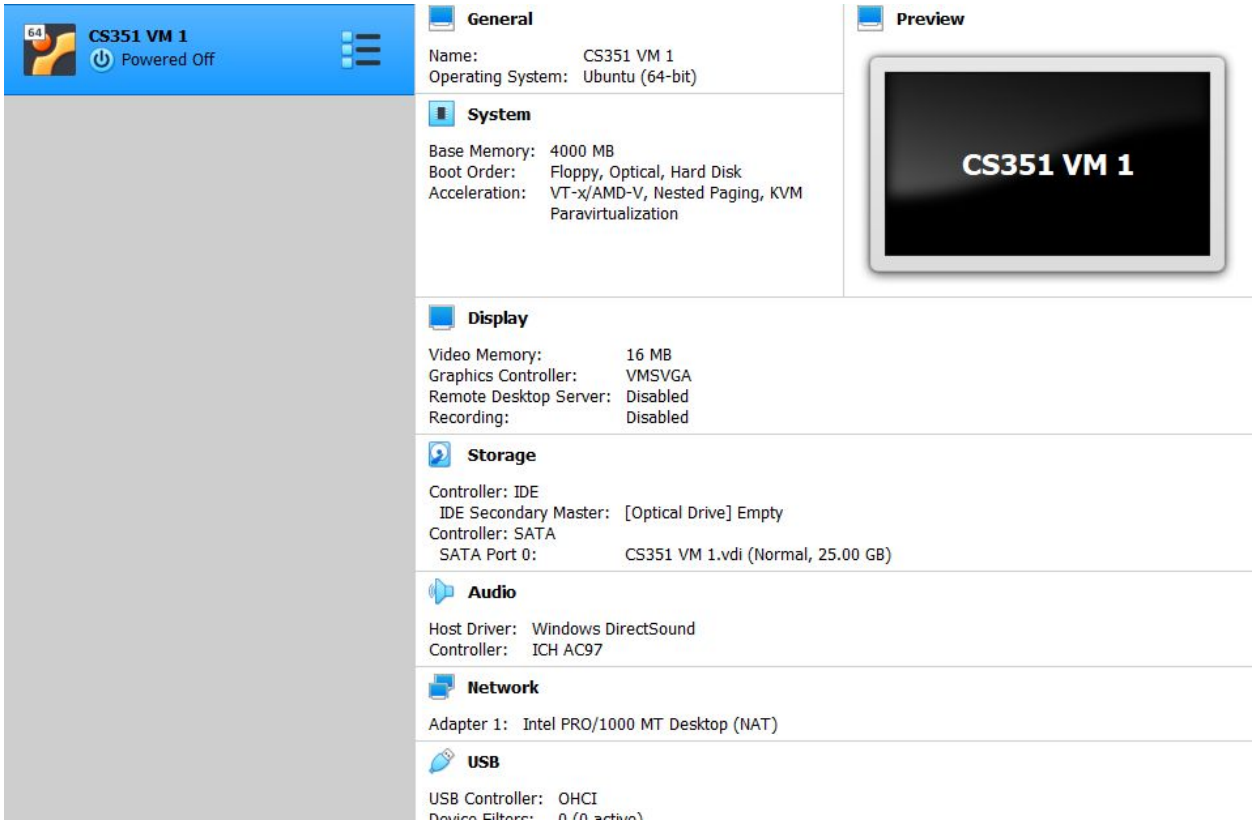


c. Install VirtualBox (if VirtualBox is not supported on your platform, document it carefully why it does not work, and download/install Cygwin, https://cygwin.com/install.html)

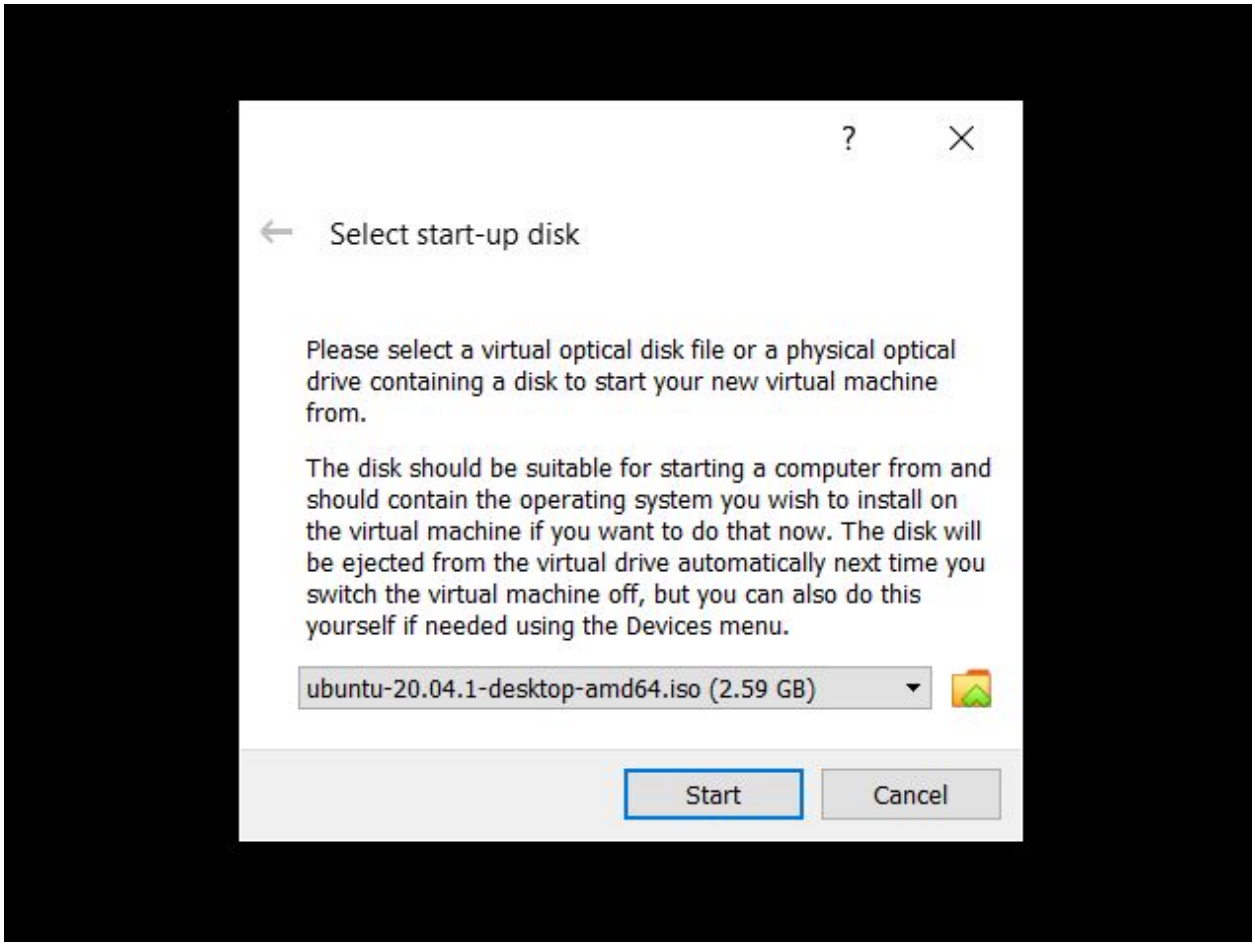
I have no idea what is expected of me to screenshot here. I already ran the installation which should be clear from other screenshots showing the VM manager like in part e.

d. Download Ubuntu Desktop 20.04.1 LTS Linux (https://ubuntu.com/download/desktop) ISO image

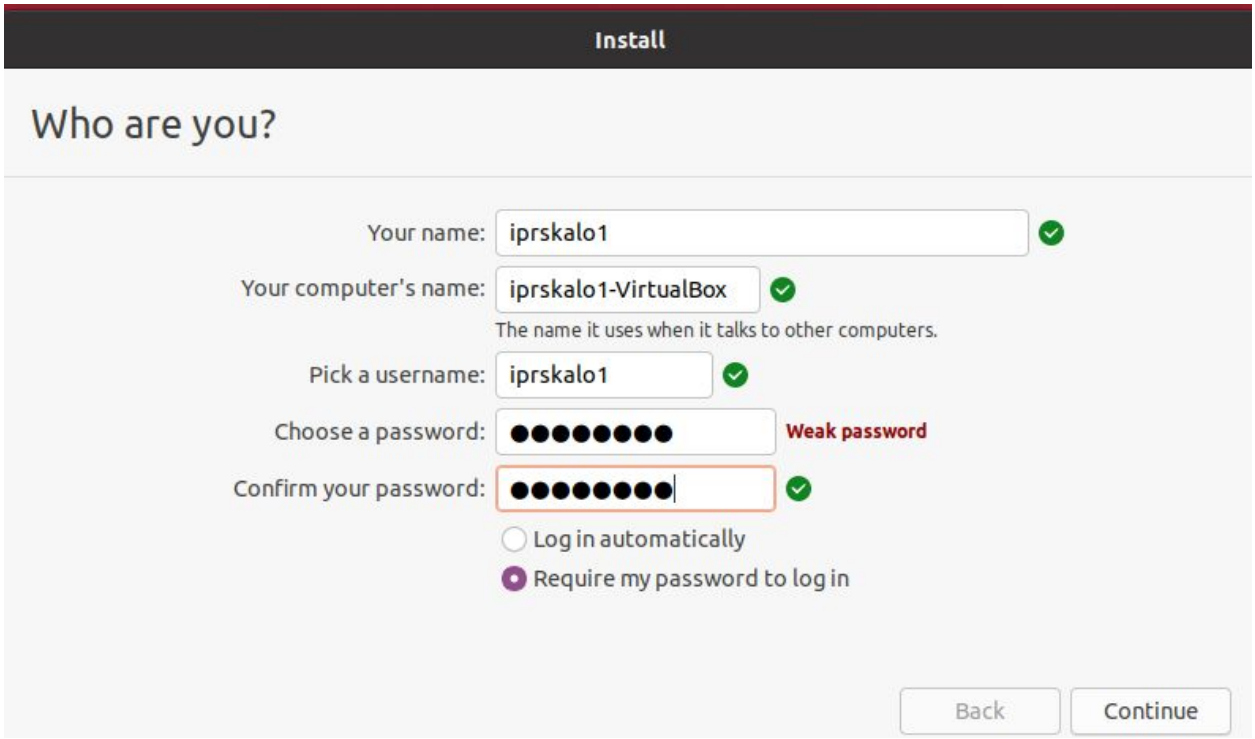
e. Create Virtual Machine (VM), to support Linux, Ubuntu, 64-bit, 4GB RAM, Virtual Disk 25GB, VDI image, dynamically allocated, 2-core, and a network interface (1GbE or WiFi) with NAT support



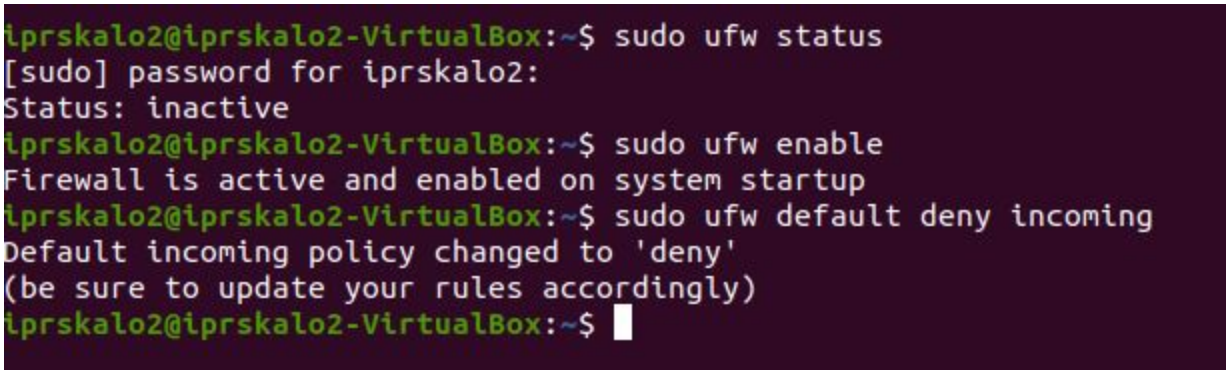
f. Install Linux from the ISO image



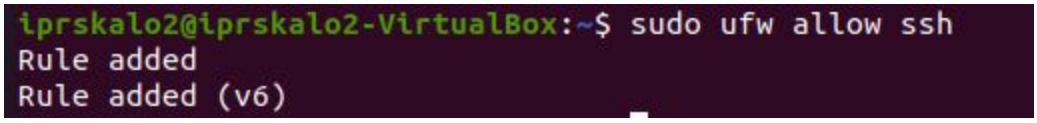
g. Create a user id and password



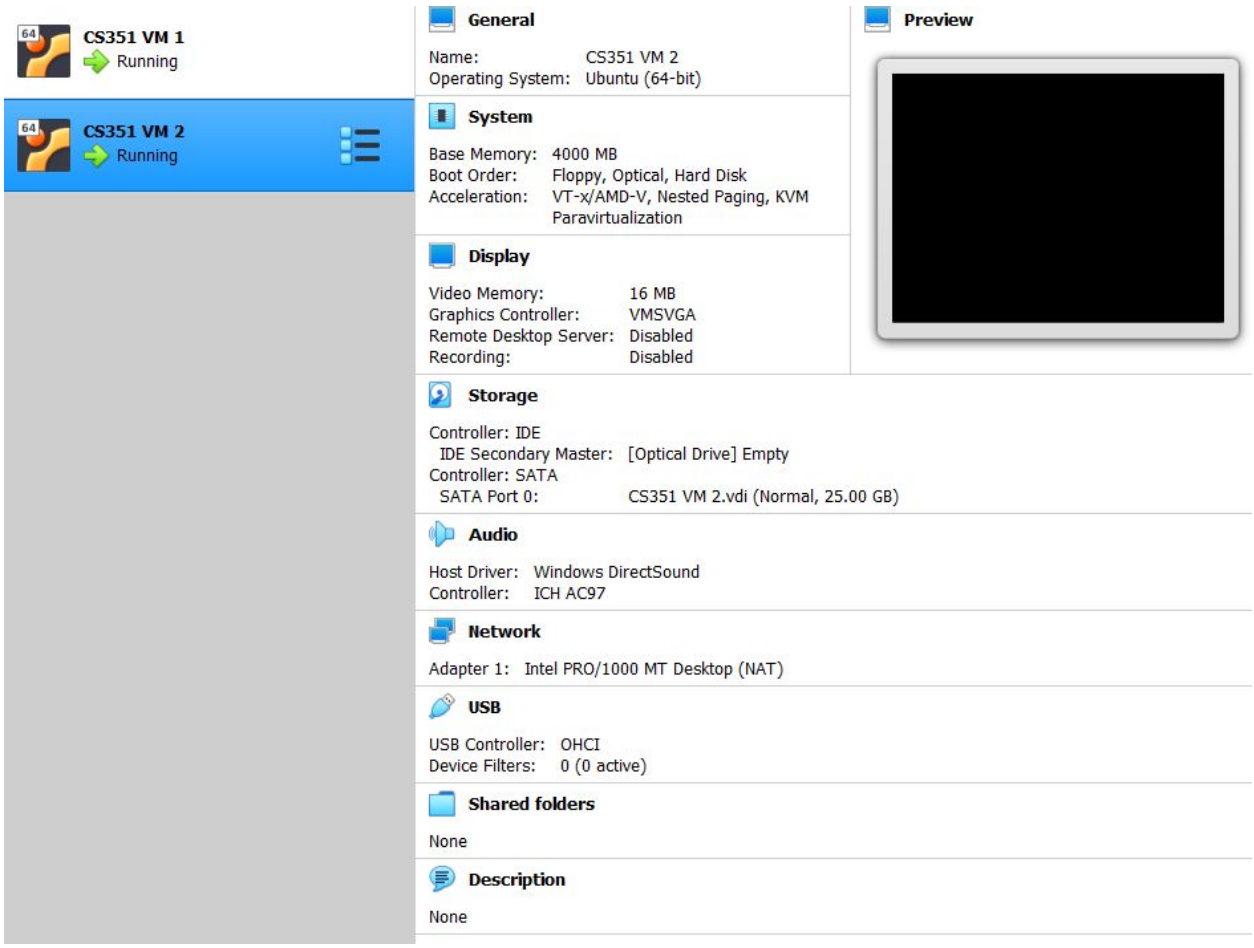
h. Turn on Firewall and block all ports



i. Enable SSH access to your new Linux installation; open SSH port in firewall



j. Repeat steps 5 through 9, and create another VM with the same specifications as the first one



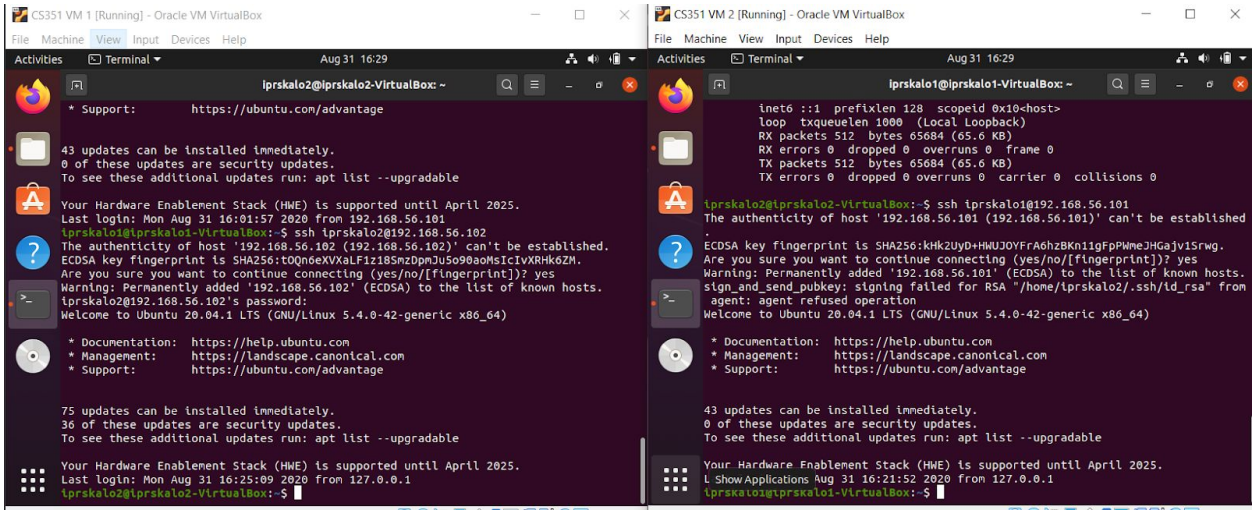
k. Create private/public keys and install them properly in both of your new VMs

```
iprskalo1@iprskalo1-VirtualBox:~$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/iprskalo1/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/iprskalo1/.ssh/id_rsa
Your public key has been saved in /home/iprskalo1/.ssh/id_rsa.pub
```

```
iprskalo1@iprskalo1-VirtualBox:~$ ssh-add ~/.ssh/id_rsa
Identity added: /home/iprskalo1/.ssh/id_rsa (iprskalo1@iprskalo1-VirtualBox)
```

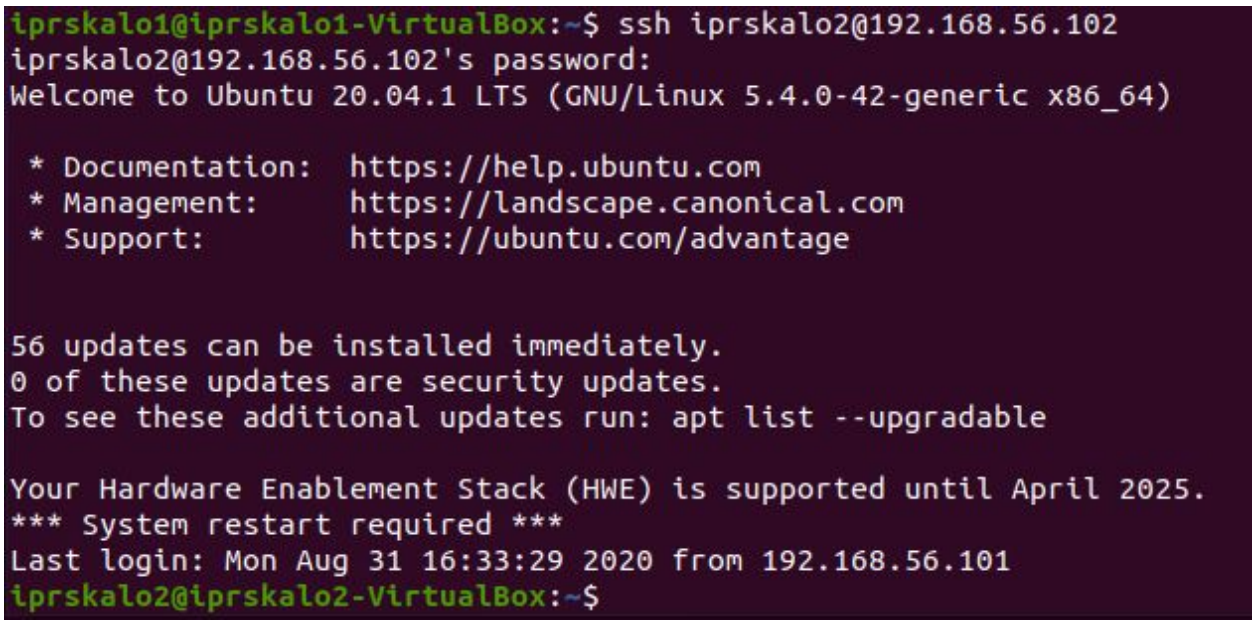
```
iprskalo1@iprskalo1-VirtualBox:~$ ssh-copy-id -i ~/.ssh/id_rsa.pub iprskalo1@iprskalo1-VirtualBox
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/home/iprskalo1/.ssh/id_rsa.pub"
The authenticity of host 'iprskalo1-virtualbox (127.0.1.1)' can't be established.
ECDSA key fingerprint is SHA256:kHk2UyD+HWUJOYFrA6hzBKn11gFpPWmeJHGajv1Srwg.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already in
s
/ Ubuntu Software py-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the
 new keys
iprskalo1@iprskalo1-virtualbox's password:

Number of key(s) added: 1

Now try logging into the machine, with:   "ssh 'iprskalo1@iprskalo1-VirtualBox'"
and check to make sure that only the key(s) you wanted were added.
```

I. Test that you can connect remotely to your VMs with your keys, from one VM to the other VM



2. (3 points) Show an example of using the following commands (hint: you can use man to find more information about each one); take screen shots of your commands; make sure to clear the screen between each command; explain in your own words what these commands do:

a. ssh: used to connect to a remote host



b. ssh-keygen: generates a secure ssh key (your identity on ssh)

```
iprskalo1@iprskalo1-VirtualBox:~$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/iprskalo1/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/iprskalo1/.ssh/id_rsa
Your public key has been saved in /home/iprskalo1/.ssh/id_rsa.pub
```

c. scp: used to copy files from one host to another

```
iprskalo1@iprskalo1-VirtualBox:~$ scp numbers.txt iprskalo2@192.168.56.102:/home/iprskalo2
iprskalo2@192.168.56.102's password:
numbers.txt                                   100%   21    24.8KB/s   00:00
```

d. history: shows a list of previously inputted commands

```
iprskalo1@iprskalo1-VirtualBox:~$ history
    1  ssh iprskalo2@192.168.56.102
    2  ssh iprskalo1@192.168.56.102
    3  man ssh-copy-id
    4  ssh-copy-id -i ~/.ssh/id_rsa.pub iprskalo1@iprskalo1-VirtualBox
    5  ssh iprskalo1@iprskalo1-VirtualBox
    6  ssh-copy-id -i ~/.ssh/id_rsa.pub iprskalo1@iprskalo1-VirtualBox
    7  ip address show
    8  sudo apt install net-tools
    9  ifconfig
   10  ssh iprskalo@192.168.56.101
   11  ssh iprskalo1@192.168.56.101
   12  man SSH
   13  man ssh-keygen
   14  man scp
   15  man history
   16  history
```

e. sudo: used to execute commands as a superuser (like running as administrator on windows)

```
iprskalo1@iprskalo1-VirtualBox:~$ sudo apt install pwgen
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  pwgen
0 upgraded, 1 newly installed, 0 to remove and 66 not upgraded.
Need to get 18.1 kB of archives.
After this operation, 52.2 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu focal/universe amd64 pwgen amd64 2.08-2 [18.1 kB]
Fetched 18.1 kB in 0s (107 kB/s)
Selecting previously unselected package pwgen.
(Reading database ... 128621 files and directories currently installed.)
Preparing to unpack .../pwgen_2.08-2_amd64.deb ...
Unpacking pwgen (2.08-2) ...
Setting up pwgen (2.08-2) ...
Processing triggers for man-db (2.9.1-1) ...
```

f. ip: used to configure or show network interfaces

```
iprskalo1@iprskalo1-VirtualBox:~$ ip address show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen
1000
    link/ether 08:00:27:4b:b5:49 brd ff:ff:ff:ff:ff:ff
    inet 10.0.2.15/24 brd 10.0.2.255 scope global dynamic noprefixroute enp0s3
       valid_lft 76947sec preferred_lft 76947sec
    inet6 fe80::5796:8713:a444:edc8/64 scope link noprefixroute
       valid_lft forever preferred_lft forever
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen
1000
    link/ether 08:00:27:5c:35:ff brd ff:ff:ff:ff:ff:ff
    inet 192.168.56.101/24 brd 192.168.56.255 scope global dynamic noprefixroute enp0s8
       valid_lft 447sec preferred_lft 447sec
    inet6 fe80::65:d9b7:b7b2:889f/64 scope link noprefixroute
       valid_lft forever preferred_lft forever
```

g. dd: used to convert and copy files

```
iprskalo1@iprskalo1-VirtualBox:~$ dd if=/home/iprskalo1 | hexdump -C |grep [^00]
dd: error reading '/home/iprskalo1': Is a directory
0+0 records in
0+0 records out
0 bytes copied, 0.000560092 s, 0.0 kB/s
```

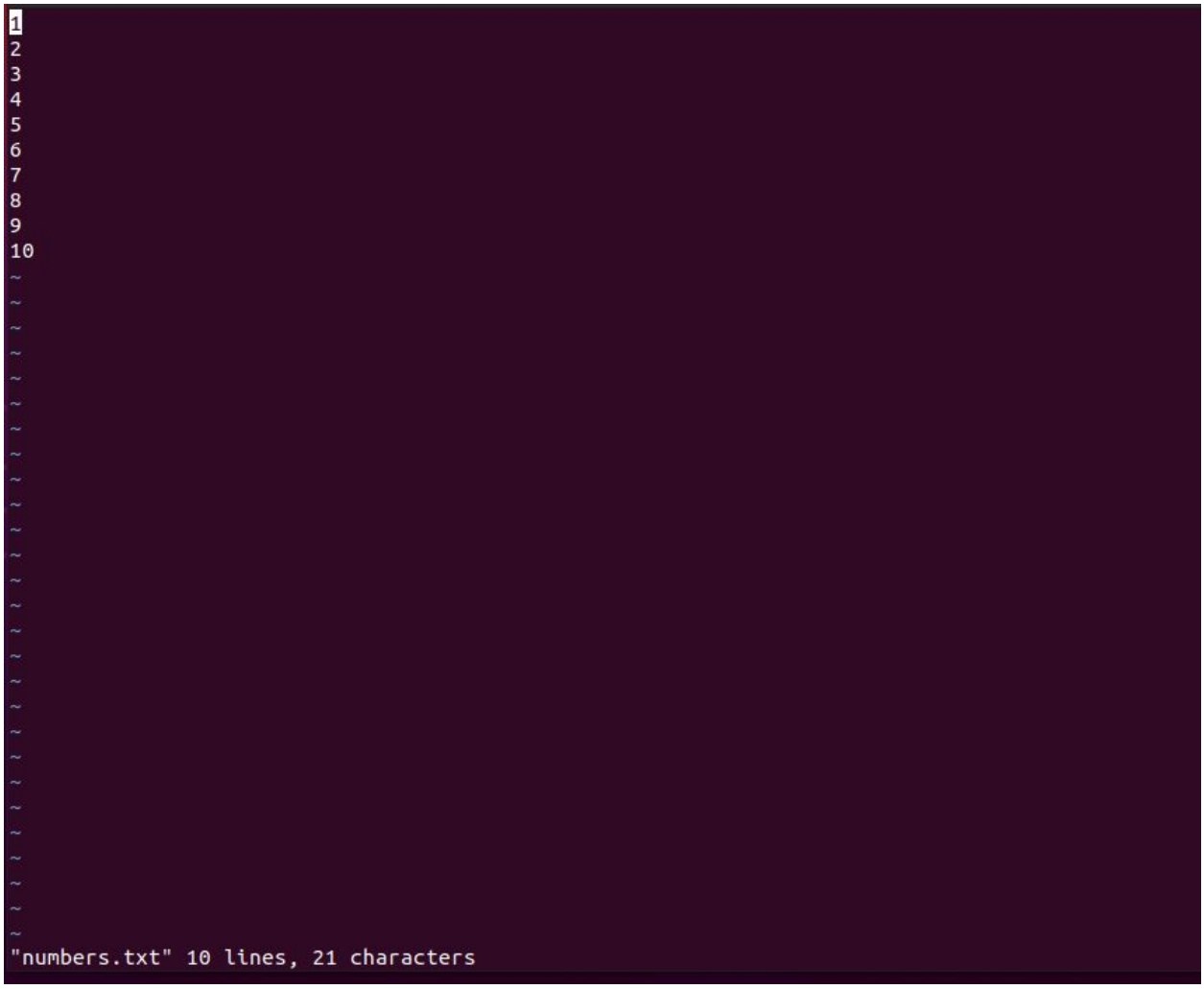
h. fdisk: used to manipulate partitions on a hard drive

```
iprskalo1@iprskalo1-VirtualBox:~$ fdisk -l
fdisk: cannot open /dev/loop0: Permission denied
fdisk: cannot open /dev/loop1: Permission denied
fdisk: cannot open /dev/loop2: Permission denied
fdisk: cannot open /dev/loop3: Permission denied
fdisk: cannot open /dev/loop4: Permission denied
fdisk: cannot open /dev/loop5: Permission denied
fdisk: cannot open /dev/loop6: Permission denied
fdisk: cannot open /dev/sda: Permission denied
```

i. apt: used to manage deb packages

```
iprskalo1@iprskalo1-VirtualBox:~$ sudo apt install pwgen
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  pwgen
0 upgraded, 1 newly installed, 0 to remove and 66 not upgraded.
Need to get 18.1 kB of archives.
After this operation, 52.2 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu focal/universe amd64 pwgen amd64 2.08-2 [18.1 kB]
Fetched 18.1 kB in 0s (107 kB/s)
Selecting previously unselected package pwgen.
(Reading database ... 128621 files and directories currently installed.)
Preparing to unpack .../pwgen_2.08-2_amd64.deb ...
Unpacking pwgen (2.08-2) ...
Setting up pwgen (2.08-2) ...
Processing triggers for man-db (2.9.1-1) ...
```

j. vi: a text editor



k. time: used to execute commands and returns time values for executing that command

```
iprskalo1@iprskalo1-VirtualBox:~$ time traceroute google.com
traceroute to google.com (172.217.6.110), 30 hops max, 60 byte packets
 1  _gateway (10.0.2.2)  0.764 ms  0.733 ms  0.721 ms
 2  * * *
 3  * * *
 4  * * *
 5  * * *
 6  * * *
 7  * * *
 8  * * *
 9  * * *
10  * * *
11  * * *
12  * * *
13  * * *
14  * * *
15  * * *
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *

real    0m30.036s
user    0m0.006s
sys     0m0.000s
```

l. tar: used to archive files (storing multiple files/directories into a single file)

```
iprskalo1@iprskalo1-VirtualBox:~$ tar -cf number.tar numbers.txt
iprskalo1@iprskalo1-VirtualBox:~$ ls
Desktop    Downloads           Music        number.tar  Public     Videos
Documents  linux-4.17.2.tar.xz  numbers.txt  Pictures    Templates
```

m. cat: prints out the contents of a file

```
iprskalo1@iprskalo1-VirtualBox:~$ cat numbers.txt
1
2
3
4
5
6
7
8
9
10
```

n. watch: used to repeatedly run a command and display its output

```
Every 2.0s: date                                  iprskalo1-VirtualBox: Tue Sep  1 20:20:50 2020

Tue 01 Sep 2020 08:20:50 PM CDT
```

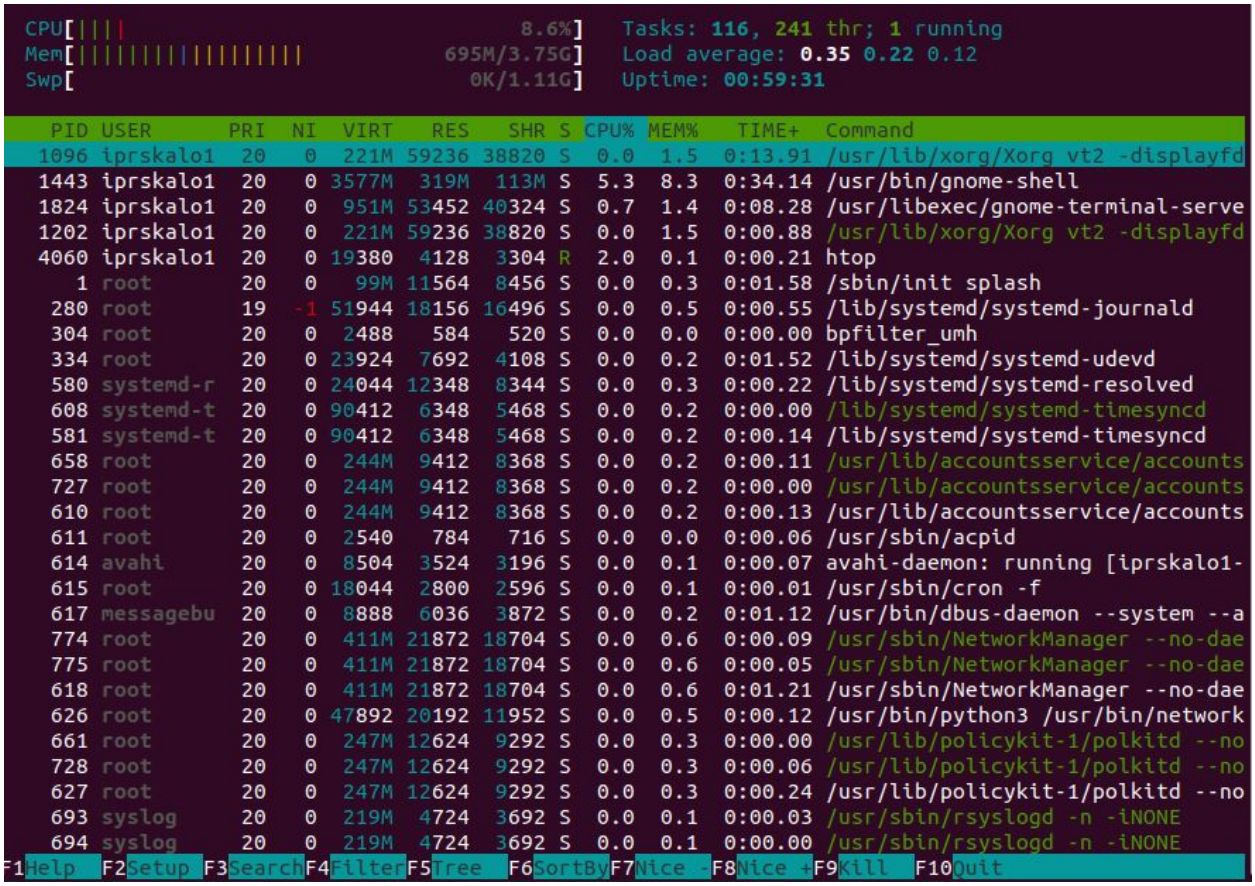
o. ps: used to show the currently running processes

```
iprskalo1@iprskalo1-VirtualBox:~$ ps
    PID TTY          TIME CMD
   1835 pts/0    00:00:00 bash
   3206 pts/0    00:00:00 ps
```

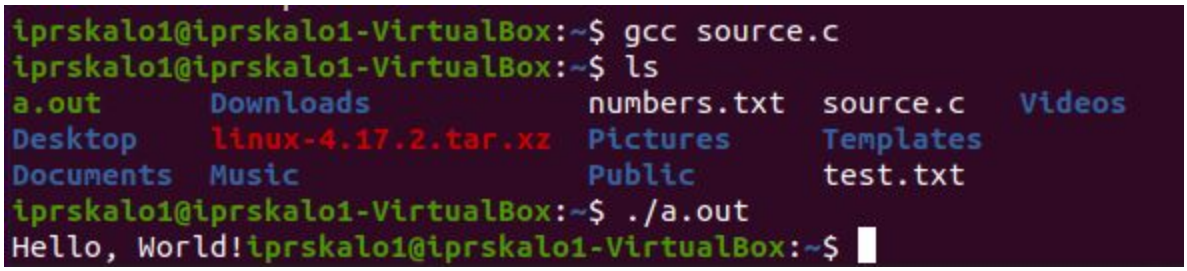
p. top: used to display information about the CPU and memory usage (like task manager)

```
top - 14:50:47 up 56 min,  1 user,  load average: 0.33, 0.16, 0.10
Tasks: 179 total,   1 running, 178 sleeping,   0 stopped,   0 zombie
%Cpu(s):  6.4 us,  4.4 sy,  0.0 ni, 89.2 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :   3840.4 total,   2312.4 free,    683.7 used,    844.4 buff/cache
MiB Swap:   1138.5 total,   1138.5 free,      0.0 used.   2920.6 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
   1096 iprskal+  20   0  226908  59236  38820 S   3.3   1.5   0:12.66 Xorg
   1443 iprskal+  20   0 3663388 327252 116540 S   3.3   8.3   0:31.23 gnome-shell
   1824 iprskal+  20   0  974132  53452  40324 S   3.0   1.4   0:07.27 gnome-terminal-
   3259 iprskal+  20   0   20468   4064   3304 R   0.7   0.1   0:00.51 top
   1306 iprskal+  20   0  163952   2756   2384 S   0.3   0.1   0:09.93 VBoxClient
   1339 iprskal+  20   0  323328   9120   7636 S   0.3   0.2   0:01.46 ibus-daemon
      1 root      20   0  102012  11564   8456 S   0.0   0.3   0:01.55 systemd
      2 root      20   0       0      0      0 S   0.0   0.0   0:00.00 kthreadd
      3 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 rcu_gp
      4 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 rcu_par_gp
      6 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/0:0H-kblockd
      9 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 mm_percpu_wq
     10 root      20   0       0      0      0 S   0.0   0.0   0:00.14 ksoftirqd/0
     11 root      20   0       0      0      0 I   0.0   0.0   0:00.49 rcu_sched
     12 root      rt   0       0      0      0 S   0.0   0.0   0:00.03 migration/0
     13 root     -51   0       0      0      0 S   0.0   0.0   0:00.00 idle_inject/0
     14 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/0
     15 root      20   0       0      0      0 S   0.0   0.0   0:00.00 kdevtmpfs
     16 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 netns
     17 root      20   0       0      0      0 S   0.0   0.0   0:00.00 rcu_tasks_kthre
```

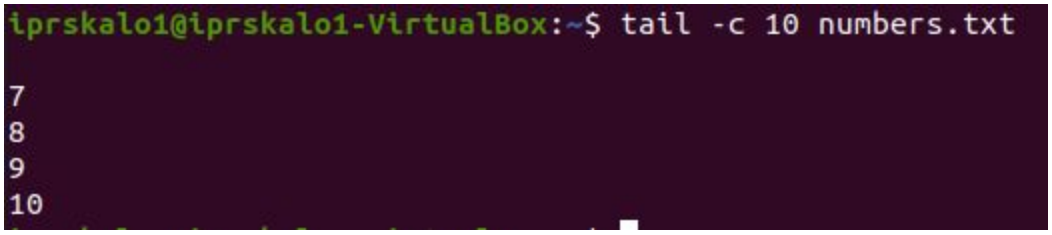
q. htop: a more interactive version of the top command



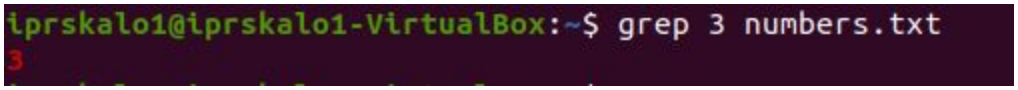
r. gcc: a C and C++ compiler



s. tail: prints the last lines of a file



t. grep: a search tool used to find patterns



u. kill: sends a signal to a process to terminate it

```
iprskalo1@iprskalo1-VirtualBox:~$ ps
    PID TTY          TIME CMD
   1835 pts/0    00:00:00 bash
  12191 pts/0    00:00:00 bash
  15721 pts/0    00:00:00 vi
  16011 pts/0    00:00:00 ps
iprskalo1@iprskalo1-VirtualBox:~$ kill 15721
```

v. killall: sends a signal to terminate all processes specified by name

```
iprskalo1@iprskalo1-VirtualBox:~$ ps
    PID TTY          TIME CMD
   1835 pts/0    00:00:00 bash
  12191 pts/0    00:00:00 bash
  15721 pts/0    00:00:00 vi
  17122 pts/0    00:00:00 ps
iprskalo1@iprskalo1-VirtualBox:~$ killall vi
```

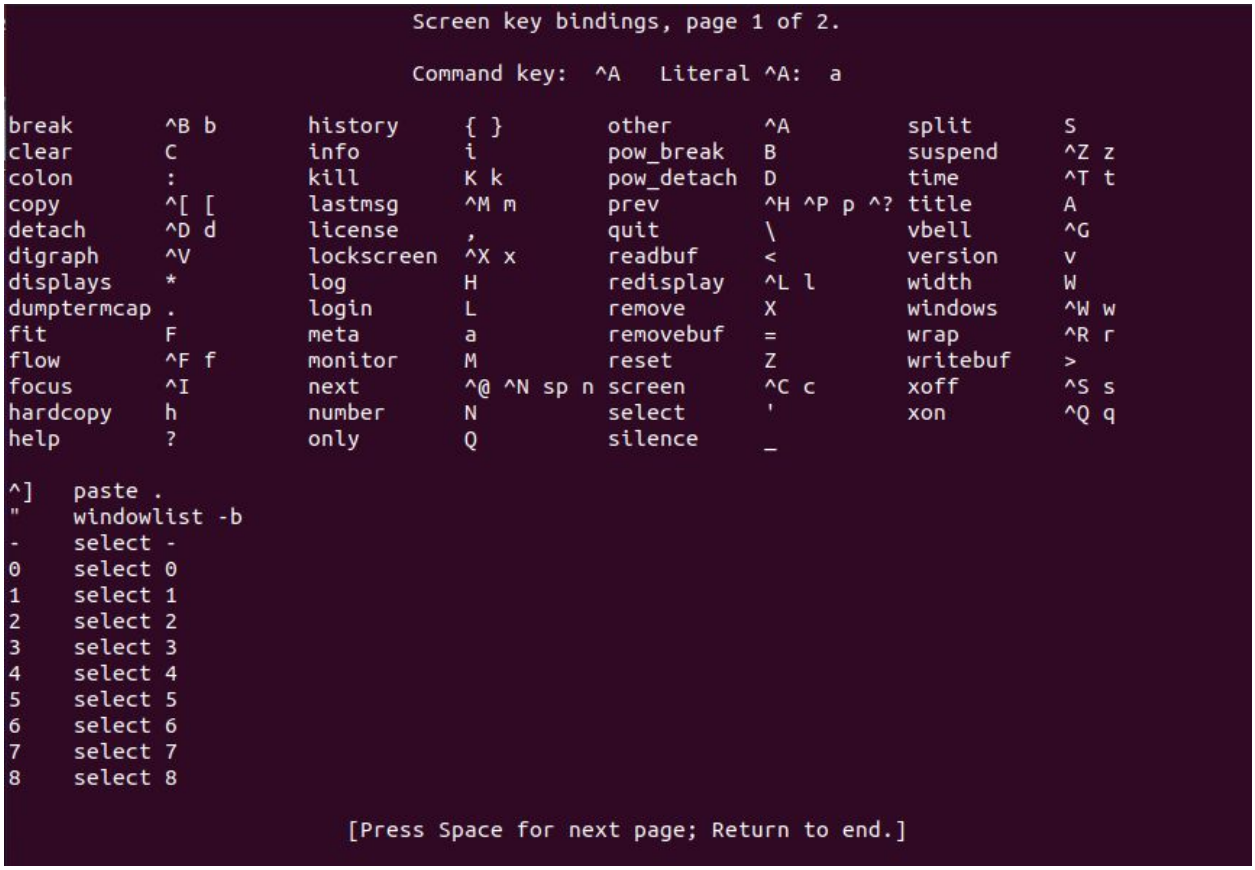
w. du: shows file space usage

```
iprskalo1@iprskalo1-VirtualBox:~$ du
4       ./Templates
4       ./.local/share/nautilus/scripts
8       ./.local/share/nautilus
4       ./.local/share/flatpak/db
8       ./.local/share/flatpak
4       ./.local/share/sounds
144     ./.local/share/gvfs-metadata
4       ./.local/share/ibus-table
60      ./.local/share/xorg
8       ./.local/share/gnome-shell
4       ./.local/share/evolution/mail/trash
8       ./.local/share/evolution/mail
4       ./.local/share/evolution/addressbook/trash
4       ./.local/share/evolution/addressbook/system/photos
92      ./.local/share/evolution/addressbook/system
100     ./.local/share/evolution/addressbook
4       ./.local/share/evolution/tasks/trash
8       ./.local/share/evolution/tasks/system
16      ./.local/share/evolution/tasks
4       ./.local/share/evolution/memos/trash
8       ./.local/share/evolution/memos
4       ./.local/share/evolution/calendar/trash
4       ./.local/share/evolution/calendar/system
12      ./.local/share/evolution/calendar
148     ./.local/share/evolution
4       ./.local/share/icc
4       ./.local/share/applications
848     ./.local/share/tracker/data
852     ./.local/share/tracker
4       ./.local/share/gnome-settings-daemon
```

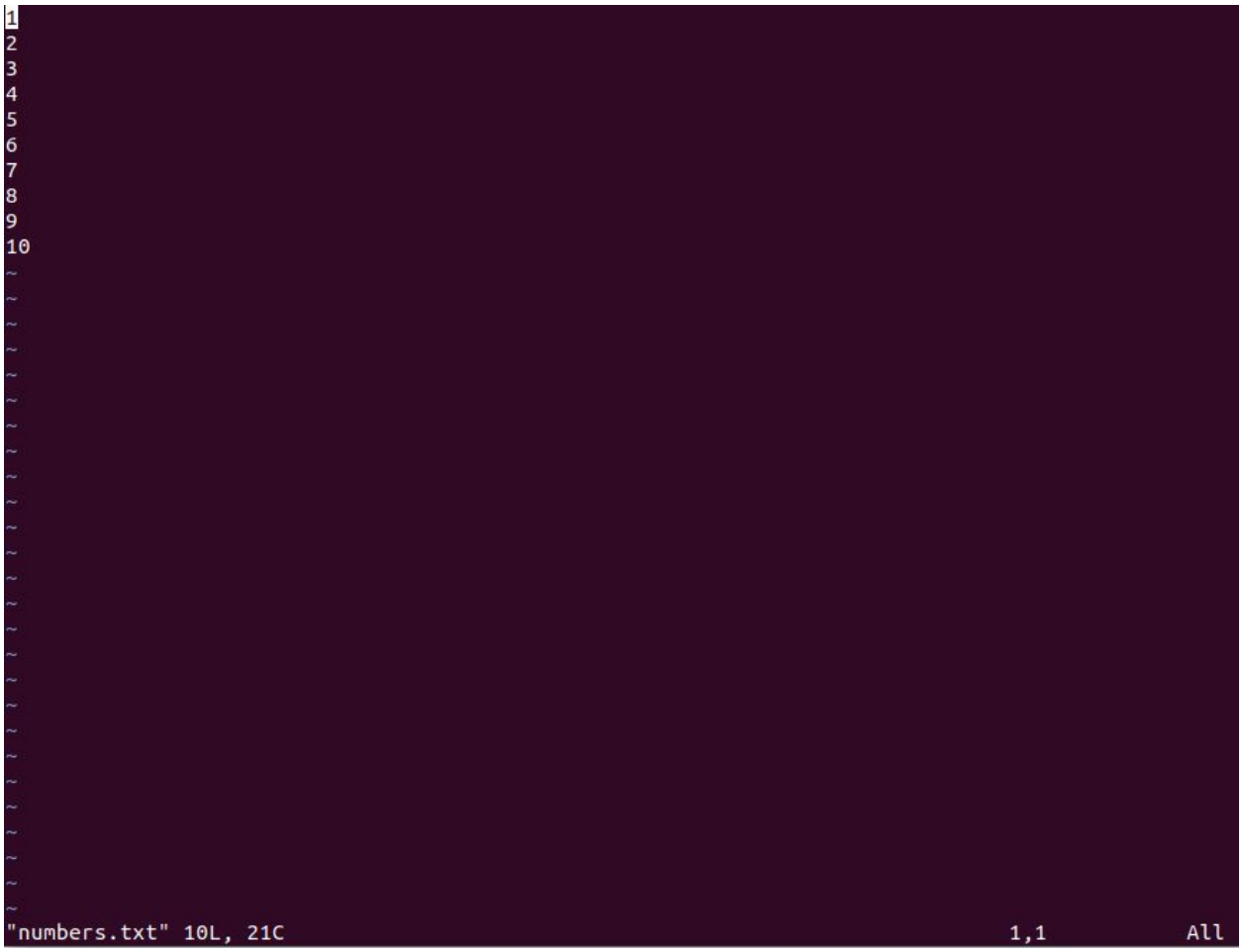
x. df: shows file systems total and available space

```
iprskalo1@iprskalo1-VirtualBox:~$ df
Filesystem     1K-blocks      Used Available Use% Mounted on
udev             1938132         0   1938132   0% /dev
tmpfs             393260      1352    391908   1% /run
/dev/sda5       24635728   5968272  17392988  26% /
tmpfs            1966292         0   1966292   0% /dev/shm
tmpfs               5120         4      5116   1% /run/lock
tmpfs            1966292         0   1966292   0% /sys/fs/cgroup
/dev/loop1        261760    261760         0 100% /snap/gnome-3-34-1804/36
/dev/loop2         63616     63616         0 100% /snap/gtk-common-themes/1506
/dev/loop0         56320     56320         0 100% /snap/core18/1880
/dev/loop4         30720     30720         0 100% /snap/snapd/8542
/dev/loop5         30720     30720         0 100% /snap/snapd/8790
/dev/loop6         56704     56704         0 100% /snap/core18/1885
/dev/loop3         51072     51072         0 100% /snap/snap-store/467
/dev/sda2         524272         4    524268   1% /boot/efi
VM_Shared      484048892 170082872 313966020  36% /media/sf_VM_Shared
tmpfs             393256        20    393236   1% /run/user/1000
/dev/sr0           59206     59206         0 100% /media/iprskalo1/VBox_GAs_6.1.12
```

y. screen: allows for multiple screens to be open



z. vim: an improved vi but still a text editor



aa. chmod: modifies file permissions

```
iprskalo1@iprskalo1-VirtualBox:~$ chmod u=rw,og=r numbers.txt
iprskalo1@iprskalo1-VirtualBox:~$
```

bb. chown: modifies user ownership of files

```
iprskalo1@iprskalo1-VirtualBox:~$ chown iprskalo1 numbers.txt
iprskalo1@iprskalo1-VirtualBox:~$
```

cc. useradd: creates a new user

```
iprskalo1@iprskalo1-VirtualBox:~$ sudo useradd test
iprskalo1@iprskalo1-VirtualBox:~$
```

dd. man: shows an interface of reference manuals for commands

```
MAN(1)                          Manual pager utils                          MAN(1)

NAME
       man - an interface to the system reference manuals

SYNOPSIS
       man [man options] [[section] page ...] ...
       man -k [apropos options] regexp ...
       man -K [man options] [section] term ...
       man -f [whatis options] page ...
       man -l [man options] file ...
       man -w|-W [man options] page ...
```

ee. locate: used to find files

```
iprskalo1@iprskalo1-VirtualBox:~$ locate numbers
/snap/core18/1880/usr/lib/python3.6/numbers.py
/snap/core18/1880/usr/lib/python3.6/__pycache__/numbers.cpython-36.pyc
/snap/core18/1885/usr/lib/python3.6/numbers.py
/snap/core18/1885/usr/lib/python3.6/__pycache__/numbers.cpython-36.pyc
/snap/gnome-3-34-1804/36/usr/include/c++/6/bits/parse_numbers.h
/snap/gnome-3-34-1804/36/usr/lib/python2.7/numbers.py
/snap/gnome-3-34-1804/36/usr/lib/python3.6/numbers.py
/snap/gnome-3-34-1804/36/usr/share/perl/5.26.1/overload/numbers.pm
/usr/lib/python3.8/numbers.py
/usr/lib/python3.8/__pycache__/numbers.cpython-38.pyc
/usr/share/perl/5.30.0/overload/numbers.pm
/usr/share/yelp-xsl/xslt/common/l10n-numbers.xsl
/usr/src/linux-headers-5.4.0-42/include/linux/prime_numbers.h
/usr/src/linux-headers-5.4.0-42/tools/testing/selftests/lib/prime_numbers.sh
```

ff. find: search for files

```
iprskalo1@iprskalo1-VirtualBox:~$ find . -name numbers.txt
./numbers.txt
```

gg. sed: text editor that parses and transforms text

```
iprskalo1@iprskalo1-VirtualBox:~$ sed 's/2/hello/' numbers.txt
1
hello
3
4
5
6
7
8
9
10
```

hh. awk: used for pattern scanning and processing

```
iprskalo1@iprskalo1-VirtualBox:~$ awk '{print}' numbers.txt
1
2
3
4
5
6
7
8
9
10
```

ii. diff: compares files line by line and points out differences

```
iprskalo1@iprskalo1-VirtualBox:~$ cat test.txt
1
2
3
3
4
5
6
7
8
9
10
iprskalo1@iprskalo1-VirtualBox:~$ diff test.txt numbers.txt
4d3
< 3
```

jj. sort: used to sort text files

```
iprskalo1@iprskalo1-VirtualBox:~$ sort test.txt
1
10
2
3
3
4
5
6
7
8
9
```

kk. export: used to mark variables and functions to pass down

```
iprskalo1@iprskalo1-VirtualBox:~$ a=test
iprskalo1@iprskalo1-VirtualBox:~$ echo $a
test
iprskalo1@iprskalo1-VirtualBox:~$ bash
iprskalo1@iprskalo1-VirtualBox:~$ echo $a

iprskalo1@iprskalo1-VirtualBox:~$ a=test
iprskalo1@iprskalo1-VirtualBox:~$ export a
iprskalo1@iprskalo1-VirtualBox:~$ bash
iprskalo1@iprskalo1-VirtualBox:~$ echo $a
test
```

ll. pwd: prints name of the directory you're in

```
iprskalo1@iprskalo1-VirtualBox:~$ pwd
/home/iprskalo1
```

mm. crontab: manages commands that will be run on a schedule

```
iprskalo1@iprskalo1-VirtualBox:~$ crontab -l
0 0 1 1 0 echo "hello world!"
```

nn. mount: used to attach file systems and removable devices at a particular point

```
iprskalo1@iprskalo1-VirtualBox:~$ mount
sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime)
proc on /proc type proc (rw,nosuid,nodev,noexec,relatime)
udev on /dev type devtmpfs (rw,nosuid,noexec,relatime,size=1938132k,nr_inodes=484533,mode=755)
devpts on /dev/pts type devpts (rw,nosuid,noexec,relatime,gid=5,mode=620,ptmxmode=000)
tmpfs on /run type tmpfs (rw,nosuid,nodev,noexec,relatime,size=393260k,mode=755)
/dev/sda5 on / type ext4 (rw,relatime,errors=remount-ro)
securityfs on /sys/kernel/security type securityfs (rw,nosuid,nodev,noexec,relatime)
tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev)
tmpfs on /run/lock type tmpfs (rw,nosuid,nodev,noexec,relatime,size=5120k)
tmpfs on /sys/fs/cgroup type tmpfs (ro,nosuid,nodev,noexec,mode=755)
cgroup2 on /sys/fs/cgroup/unified type cgroup2 (rw,nosuid,nodev,noexec,relatime,nsdelegate)
cgroup on /sys/fs/cgroup/systemd type cgroup (rw,nosuid,nodev,noexec,relatime,xattr,name=systemd)
pstore on /sys/fs/pstore type pstore (rw,nosuid,nodev,noexec,relatime)
none on /sys/fs/bpf type bpf (rw,nosuid,nodev,noexec,relatime,mode=700)
cgroup on /sys/fs/cgroup/devices type cgroup (rw,nosuid,nodev,noexec,relatime,devices)
cgroup on /sys/fs/cgroup/freezer type cgroup (rw,nosuid,nodev,noexec,relatime,freezer)
cgroup on /sys/fs/cgroup/cpu,cpuacct type cgroup (rw,nosuid,nodev,noexec,relatime,cpu,cpuacct)
cgroup on /sys/fs/cgroup/pids type cgroup (rw,nosuid,nodev,noexec,relatime,pids)
cgroup on /sys/fs/cgroup/hugetlb type cgroup (rw,nosuid,nodev,noexec,relatime,hugetlb)
cgroup on /sys/fs/cgroup/perf_event type cgroup (rw,nosuid,nodev,noexec,relatime,perf_event)
cgroup on /sys/fs/cgroup/rdma type cgroup (rw,nosuid,nodev,noexec,relatime,rdma)
cgroup on /sys/fs/cgroup/cpuset type cgroup (rw,nosuid,nodev,noexec,relatime,cpuset)
cgroup on /sys/fs/cgroup/memory type cgroup (rw,nosuid,nodev,noexec,relatime,memory)
cgroup on /sys/fs/cgroup/net_cls,net_prio type cgroup (rw,nosuid,nodev,noexec,relatime,net_cls,ne
t_prio)
cgroup on /sys/fs/cgroup/blkio type cgroup (rw,nosuid,nodev,noexec,relatime,blkio)
systemd-1 on /proc/sys/fs/binfmt_misc type autofs (rw,relatime,fd=28,pgrp=1,timeout=0,minproto=5,
maxproto=5,direct,pipe_ino=13357)
mqueue on /dev/mqueue type mqueue (rw,nosuid,nodev,noexec,relatime)
debugfs on /sys/kernel/debug type debugfs (rw,nosuid,nodev,noexec,relatime)
tracefs on /sys/kernel/tracing type tracefs (rw,nosuid,nodev,noexec,relatime)
hugetlbfs on /dev/hugepages type hugetlbfs (rw,relatime,pagesize=2M)
```

oo. passwd: changes the password for the user

```
iprskalo1@iprskalo1-VirtualBox:~$ passwd
Changing password for iprskalo1.
Current password:
New password:
Retype new password:
passwd: password updated successfully
```

pp. uname: prints information about the system

```
iprskalo1@iprskalo1-VirtualBox:~$ uname -a
Linux iprskalo1-VirtualBox 5.4.0-42-generic #46-Ubuntu SMP Fri Jul 10 00:24:02 UTC 2020 x86_64 x8
6_64 x86_64 GNU/Linux
```

qq. whereis: shows location of the binary, source, and manual files for a certain command

```
iprskalo1@iprskalo1-VirtualBox:~$ whereis man
man: /usr/bin/man /usr/local/man /usr/share/man /usr/share/man/man1/man.1.gz /usr/share/man/man7/
man.7.gz
```

rr. whatis: displays a single line of the manual page

```
iprskalo1@iprskalo1-VirtualBox:~$ whatis whatis
whatis (1)           - display one-line manual page descriptions
```

ss. su: used to execute commands with the privledges of another user

```
iprskalo1@iprskalo1-VirtualBox:~$ su test
Password:
$ su iprskalo1
Password:
iprskalo1@iprskalo1-VirtualBox:~$
```

tt. ping: used to test reachability of a host on an ip network

```
iprskalo1@iprskalo1-VirtualBox:~$ ping google.com
PING google.com (172.217.9.78) 56(84) bytes of data.
64 bytes from ord38s09-in-f14.1e100.net (172.217.9.78): icmp_seq=1 ttl=115 time=15.3 ms
64 bytes from ord38s09-in-f14.1e100.net (172.217.9.78): icmp_seq=2 ttl=115 time=15.1 ms
64 bytes from ord38s09-in-f14.1e100.net (172.217.9.78): icmp_seq=3 ttl=115 time=11.5 ms
64 bytes from ord38s09-in-f14.1e100.net (172.217.9.78): icmp_seq=4 ttl=115 time=11.2 ms
64 bytes from ord38s09-in-f14.1e100.net (172.217.9.78): icmp_seq=5 ttl=115 time=11.3 ms
64 bytes from ord38s09-in-f14.1e100.net (172.217.9.78): icmp_seq=6 ttl=115 time=11.0 ms
64 bytes from ord38s09-in-f14.1e100.net (172.217.9.78): icmp_seq=7 ttl=115 time=11.2 ms
64 bytes from ord38s09-in-f14.1e100.net (172.217.9.78): icmp_seq=8 ttl=115 time=12.1 ms
^C
--- google.com ping statistics ---
8 packets transmitted, 8 received, 0% packet loss, time 7011ms
rtt min/avg/max/mdev = 11.037/12.348/15.284/1.677 ms
```

uu. traceroute: diagnostic command for displaying routes and measuring transit delays of packets

```
iprskalo1@iprskalo1-VirtualBox:~$ traceroute google.com
traceroute to google.com (172.217.9.78), 30 hops max, 60 byte packets
 1  _gateway (10.0.2.2)  0.522 ms  0.537 ms  0.526 ms
 2  * * *
 3  * * *
 4  * * *
 5  * * *
 6  * * *
 7  * * *
 8  * * *
 9  * * *
10  * * *
11  * * *
12  * * *
13  * * *
14  * * *
15  * * *
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

vv. date: shows the system date and time

```
iprskalo1@iprskalo1-VirtualBox:~$ date
Tue 01 Sep 2020 07:21:39 PM CDT
```

ww. time: look at k. (duplicate)

```
iprskalo1@iprskalo1-VirtualBox:~$ time traceroute google.com
traceroute to google.com (172.217.6.110), 30 hops max, 60 byte packets
 1  _gateway (10.0.2.2)  0.764 ms  0.733 ms  0.721 ms
 2  * * *
 3  * * *
 4  * * *
 5  * * *
 6  * * *
 7  * * *
 8  * * *
 9  * * *
10  * * *
11  * * *
12  * * *
13  * * *
14  * * *
15  * * *
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *

real    0m30.036s
user    0m0.006s
sys     0m0.000s
```

xx. wget: used to download files off the web

```
iprskalo1@iprskalo1-VirtualBox:~$ wget https://cdn.kernel.org/pub/linux/kernel/v4.x/linux-4.17.2.
tar.xz
--2020-09-01 19:29:17--  https://cdn.kernel.org/pub/linux/kernel/v4.x/linux-4.17.2.tar.xz
Resolving cdn.kernel.org (cdn.kernel.org)... 199.232.77.176, 2a04:4e42:53::432
Connecting to cdn.kernel.org (cdn.kernel.org)|199.232.77.176|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 102167060 (97M) [application/x-xz]
Saving to: ‘linux-4.17.2.tar.xz’

linux-4.17.2.tar.xz      100%[=============================>]  97.43M  40.0MB/s    in 2.4s

2020-09-01 19:29:28 (40.0 MB/s) - ‘linux-4.17.2.tar.xz’ saved [102167060/102167060]
```

yy. wc: displays the number of lines, word count, byte, and character count in the specified files

```
iprskalo1@iprskalo1-VirtualBox:~$ wc numbers.txt
10 10 21 numbers.txt
```

zz. pwgen: generates passwords

```
iprskalo1@iprskalo1-VirtualBox:~$ pwgen
ooSeich3 euneef9N Ueca8boo ePooyoo0 xooChai5 faYiu2re ouYogia7 neeng2Oo
ien9Zohh ohZa1eL7 aJei2yoo Hoos6ieN zahMu6uj ue8ohciN oa4Sooqu Vah4ue5p
lu9Ohv5j ea0OoF9a Ieloosh5 aChah5je Ume4sieT Ef2ieFao ooyah3uT fie5Eeh6
uf5Iingo Eo5Iewoh phoh1Ahp ua4Foo6u fai8aSae Aoc7eeth ohC6xae8 Tho5oDie
iK5ker5e Fiphil5s ee3gee3I hahNg0Ai yiedae5Z eeP1Oawa ohr6Nie9 ve4oyo8X
Paenah8x ohCh6Ohd Ier2anai huY0pah6 jai5aiXa KooGhoo7 Aithi6ec Oe8iShoe
ieroQu0a ooK6ohbu foop4Eic aal8Eut9 me3aijiY Ex7phoo1 VeisiL0E Egob9eej
EeSh4aBo paoQuoi0 Ahtae3pu Va6zai9u ilees2Ee aijo6oiG aifiek4A aiL1no4t
oKee4ahy hohgh2Ah meM0ieph aiveiy7Y jeeC0xig Oow6fesh pohNg1He ooCixii3
tei4meiJ ooTh5bu5 fo2Eit3x Tahpe6aD ieT1She4 io4Ieghi sheiWoh3 oath0Foh
yu8PooNg foZ8aeGh OoSh2tu5 Aeyaex4E pahnooC1 rah4Fa7u jieKie6h feGai8if
Juqu7qua MeeZ2ieT Oom1ooXi Bee0Tavo goh4Osie Qui4yain doosooB6 eiH2lo3y
Zee5ohX5 Fieyuv9l woor6Ait Utaphei5 ohph7Iem Ahh1aer8 Cieb0eey aeJie8oo
teeTeu0e yai0ESha Haegoh6e AruoGh4o bulee2Ch Aip6iyai EeSeek7m ieshaSa9
eegh9AHu eLoTo2Ee OoPhi1gu aiXo6Xae beb5oiXu Xu3guwai eiJoh7ie xu4Aejae
thuQu5oo dah0da4H Aevoom2l saiD1iBo oi5ekaiW peiYai4O Kiev7fai ahgaiNa2
Vohv3ueC eeh6io1V EisheR4i ouc0Lee5 kai5Toh0 Aen4Iquu ahhauW3f Que7hohf
Chu3eing JeiYohx6 oa4Izoo4 eiNgae3E Veav5ahp Ohya4aht fo4phohR Jeiph4xu
EeW4Mahf goFa9thi deexie1C iaw9Tohz Neeng4wi asuD9eij OiK7rauk OhkooQu1
Choh2ike oWoo4ej3 Aseew4Ee if3eiGh5 Ohjair4G EiZ4aepu Coogah5O nae3Iech
```

3. (3 points) Write bash scripts to do the following:

a. Write a script called “generate-dataset.sh <filename> <num_records>” with two command line arguments specifying the file name to output and the number of records, where each record is separated by new line character, and each has the following format: . The integer should be any random number up to a 32-bit integer. The ASCII_string should be any string using ASCII of exactly 100 bytes long. Use the “time” command to show how long the benchmark took to complete. The benchmark should run for at least 10 seconds, and it should complete even if the ssh (or bash) session is terminated. How many records does your file contain after running it? You must write this script entirely with existing Linux commands (which you can install if they don’t exist on your system), without using any other programming languages like C, C++, Java, or Python.

CODE:

```
#!/bin/bash

shuf -i 0-2147483647 -n $2 >> num.txt
base64 -w 100 /dev/urandom | tr -d '/+' | head -n $2 >> words.txt

paste num.txt num.txt words.txt >> $1

rm num.txt
rm words.txt
```

TIMES:
40.313 10000000
.348 100000
.013 1000

b. Write a script called “sort-data.sh” that takes input a file from part (a) above and sorts the file based on the first column data (make sure to only sort based on the first column data, and not on the entire line of data; also make sure you are treating the data in column 1 as numbers and not text). Use the “time” command to show how long the sort script took to complete.

CODE:

```
#!/bin/bash
sort -k 1 -n $1 -o $1
```

TIMES:
35.681 10000000
.199 100000
.004 1000

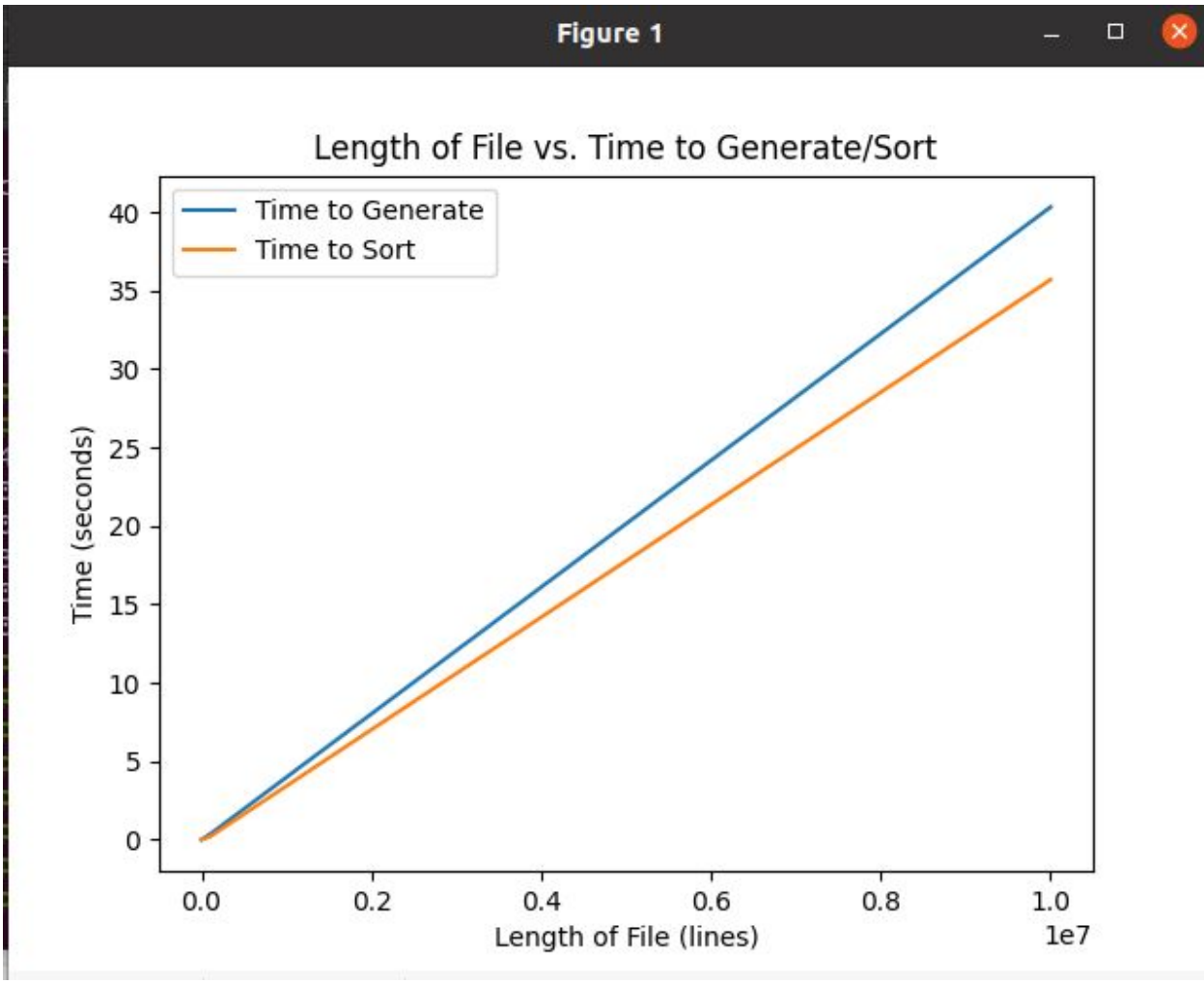
c. Use the script in part (a) and generate 3 data files with different number of records (1000, 100000, 10000000); measure time taken to generate these records. Sort the data with your script from part (b) and measure the time. Write a Python matplotlib script to generate a graph for the time taken to generate the data and the time taken to sort the data at the 3 different scales. The graph should automatically adjust to the number of entries, and the scale of the data.

CODE:

```
import matplotlib.pyplot as plt

times, length = [],[]
for lines in open('timesGen.txt', 'r'):
        data = [float(i) for i in lines.split(" ")]
        times.append(data[0])
        length.append(data[1])
plt.plot(length, times, label = "Time to Generate")

times, length = [],[]
for lines in open('timesSort.txt', 'r'):
        data = [float(i) for i in lines.split(" ")]
        times.append(data[0])
```

```
            length.append(data[1])

plt.plot(length, times, label = "Time to Sort")
plt.xlabel("Length of File (lines)")
plt.ylabel("Time (seconds)")
plt.title("Length of File vs. Time to Generate/Sort")
plt.legend()
plt.show()
```

GRAPH:



4. (2 point) Answer the following questions about VMs:

a. In the system configuration of the VM, explain how changing the number of processors changes the behavior of your VM. Explain a scenario where you want to set this to the minimum, and a scenario where you want to set it to the maximum. Why is setting it to the maximum potentially a bad idea?

A scenario where you want to set the number of processors to a minimum is when you need minimum processing power. A scenario where you want to set the number of processors to a maximum is when you need a lot of processing power. Setting it to the maximum is potentially a bad idea because it takes away processing power from the rest of the computer which could slow processes outside the VM down too much.

b. In the system configuration of the VM, under the Acceleration Tab, explain the difference between the paravirtualization options: None, Legacy, Minimal, Hyper-V, and KVM. Explain which one would be best to use with Ubuntu Linux, and why.

None: We are emulating the entire hardware environment there is no paravirtualization occurring

Legacy: The legacy option is chosen for VMs which were created with older VirtualBox versions and will pick a paravirtualization interface while starting the VM.

Minimal: Paravirtualization use by Mac OS guests. Announces the presence of a virtualized environment. Additionally, reports the TSC and APIC frequency to the guest operating system.

Hyper-V: Paravirtualization used by Windows guests. VirtualBox's implementation currently supports paravirtualized clocks, APIC frequency reporting, guest debugging, guest crash reporting and relaxed timer checks.

KVM hypervisor interface is recognized by Linux kernels version 2.6.25 or later. Whereas Minimal is recommended for Mac OS and Hyper-V for Windows guests.

Taken from the paravirtualization section in the virtualbox manual
https://www.virtualbox.org/manual/ch10.html

c. In storage devices when configuring the VM, there are multiple types of storage controllers: explain the difference between the IDE, SATA, and NVMe controller. Give an example for each type of storage controller of a scenario where you may want to use this type of controller.

IDE: this was the most widely used controller standard, but it has certain limitations and is now being replaced by the SATA standard. It's backwards compatible. It allows up to four storage devices. Allows speeds of up to 133 mb/s

SATA: The most widely used and latest drive controller standard. Compared to IDE, SATA provides both much higher speeds and more devices per controller. Allows you to connect up to 30 virtual hard disks to one machine instead of just three like IDE. Has data transfer rates of up to 6 Gb/s

NVMe: Designed for use with faster media. Has reduced latency in the host software stack, higher input/output operations per second, and potentially lower power consumption. Can support SSDs that use different types of non-volatile memory.

You would want to use IDE when an OS doesn't support SATA. You would want to use a SATA in most scenarios since its faster than IDE. You would want to use NVMe when you need to transfer data at extremely high speeds. It is the fastest of these three SSDs.

https://geek-university.com/oracle-virtualbox/hard-disk-controller/
https://searchstorage.techtarget.com/definition/NVMe-non-volatile-memory-express

d. In the network configuration of the VM, there are multiple types of network adapters: explain the difference between NAT, Bridged Adapter, Internal Network, and Host-only Network. Give an example for each type of network of a scenario where you may want to use this type of network.

NAT: NAT is the process where a network device assigns your computer a public IP address inside a private network.

Bridged Adapter: Using a bridged adapter lets your guest OS work on the same network as your host. You would want to use this for more advanced networking needs like network simulations and running servers in a guest.

Internal Network: Let's your VM communicate with other VMs but not the host and the outside world. You would want to use this to create a different kind of software-based network that is only visible to selected VMs

Host-only Network: Host-only lets you connect to the host and other VM's on the host not outside Net/LAN. You would want to do this for preconfigured virtual appliances, where multiple VMs are shipped together and designed to cooperate.

https://www.virtualbox.org/manual/ch06.html#:~:text=6.6.-,Internal%20Networking,to%20the%20same%20internal%20network.

e. For the USB configuration of the VM, explain the difference between USB 1.1, 2.0, and 3.0 controllers

USB 1.1: It was the first release to be widely adopted. Ideal for connecting devices with low bandwidth requirements.

USB 2.0: Made improvements to 1.1. Has an increase to bandwidth to a maximum of 480Mbps. Has backwards compatibility with USB 1.1. It is best suited for

supporting devices requiring higher bandwidth like mass storage devices, video adapters, and data transfer cables.

USB 3.0: Made further improvements to USB technology. Has an even greater increase to bandwidth with a maximum of 4.8Gbps. Has backward compatibility and is best suited for large mass storage devices and other devices requiring high bandwidth like the ones listed in USB 2.0

https://www.cablestogo.com/learning/library/standards-specs-certs/when-to-use-usb#:~:text=The%20USB%202.0%2C%20or%20Hi,to%20a%20maximum%20of%20480Mbps.&text=This%20specification%20retained%20a%20backwards%20compatibility%20that%20allows%20USB%203.0,2.0%20and%20USB%201.1%20devices.