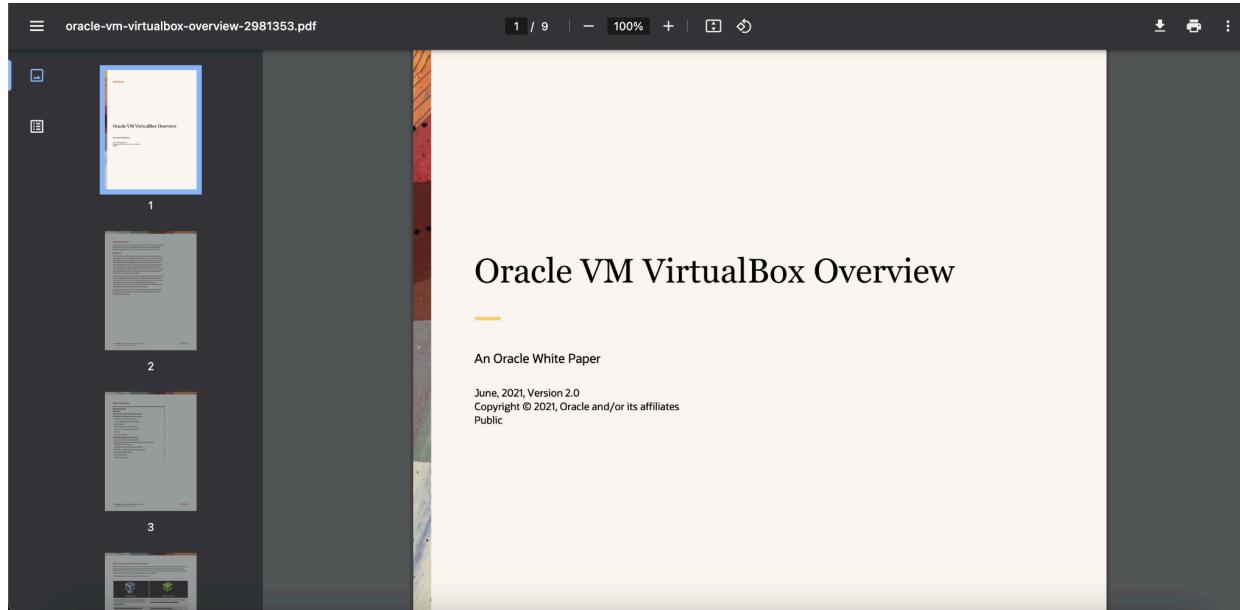


CS553 Cloud computing - Homework 1

Name: **Batkhisig Dulamsurankhor**
CWID: A20543498

1. (30 points) Setup VM, Linux, and basic testing – must take screen shots at each step to receive points

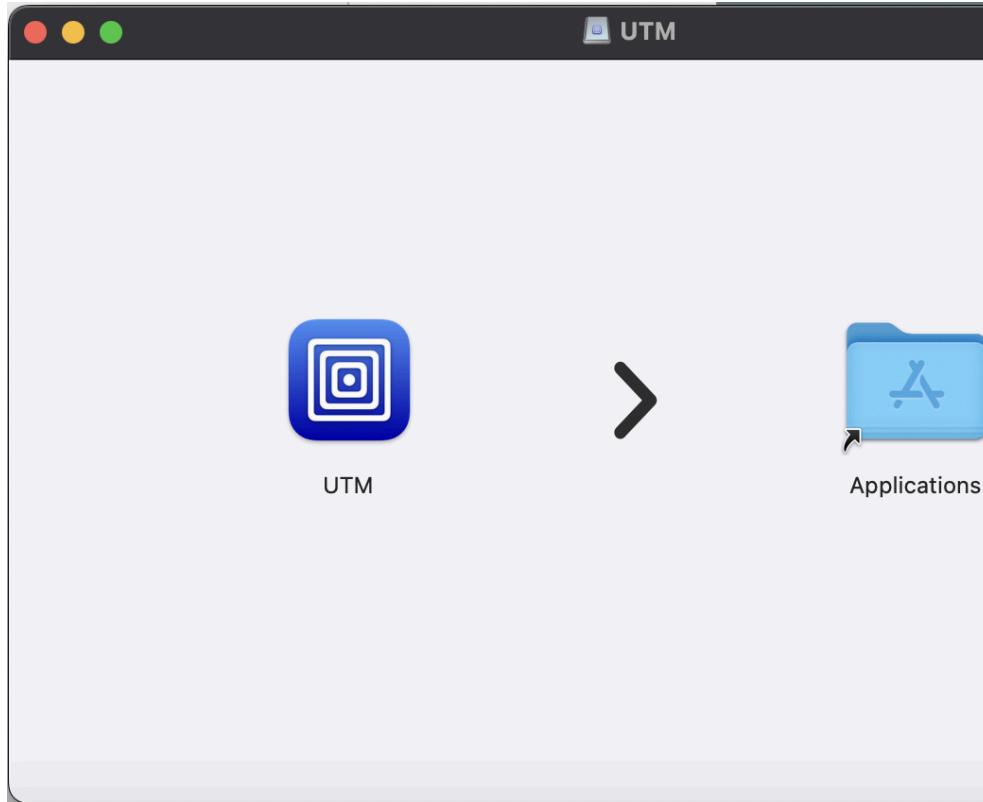
- a. Read Oracle VirtualBox White Paper



- b. Download Oracle VirtualBox 7.0 (UTM)



- c. Install VirtualBox 7.0 (for M1/M2 Apple, use UTM)



- d. Download Ubuntu 22.04 Linux ISO image

A screenshot of the Ubuntu releases page. The main heading is "Ubuntu 22.04.3 LTS (Jammy Jellyfish)". Below it, there is a section titled "Select an image". It says "Ubuntu is distributed on four types of images described below." There are four options: "Server install image", "64-bit ARM (ARMv8/AArch64) server install image", "PowerPC64 Little-Endian server install image", and "IBM System z server install image".

Select an image

Ubuntu is distributed on four types of images described below.

Server install image

The server install image allows you to install Ubuntu permanently on a computer for use as a server. It will not install a graphical user interface.

[64-bit ARM \(ARMv8/AArch64\) server install image](#)

For 64-bit ARMv8 processors and above.

[PowerPC64 Little-Endian server install image](#)

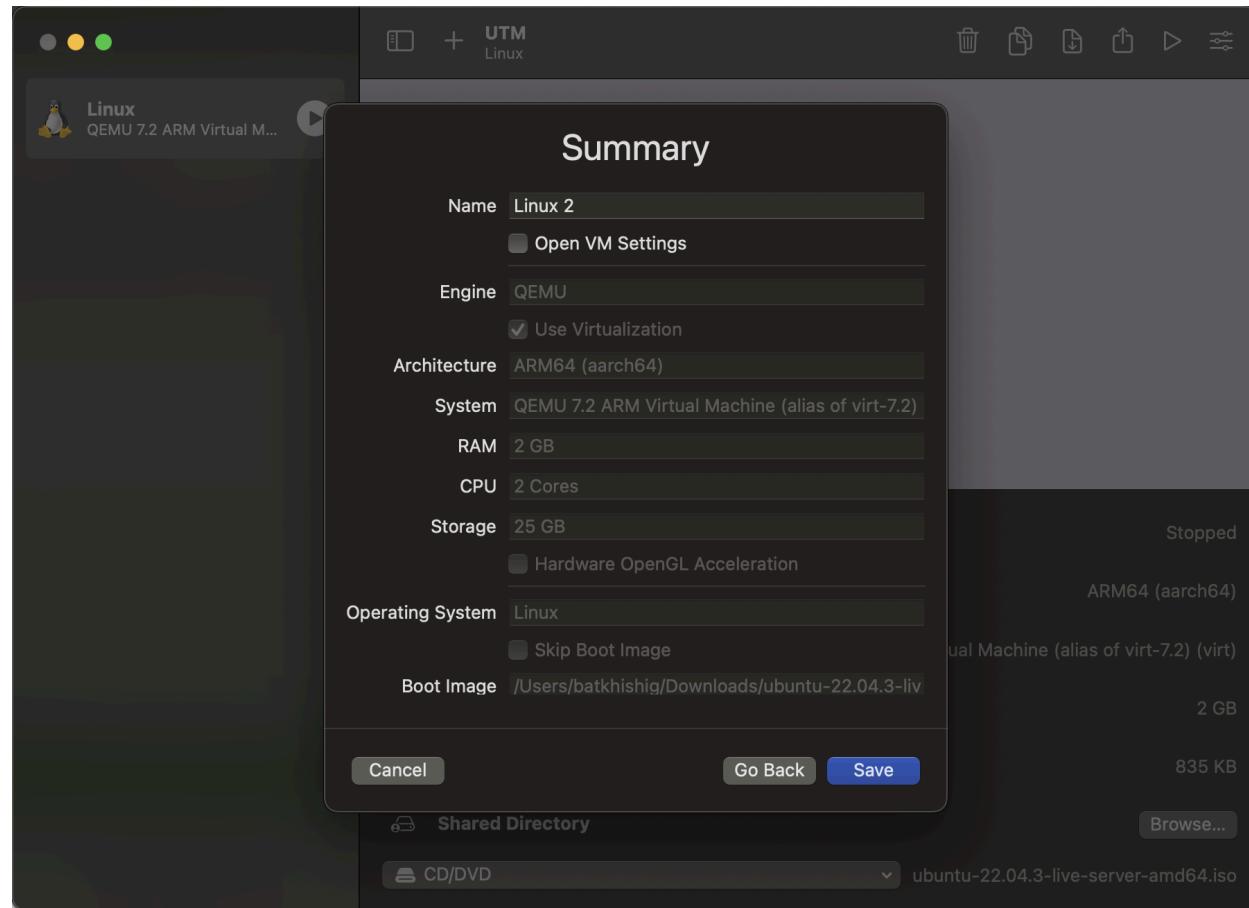
For POWER9 and POWER10 Little-Endian systems.

[IBM System z server install image](#)

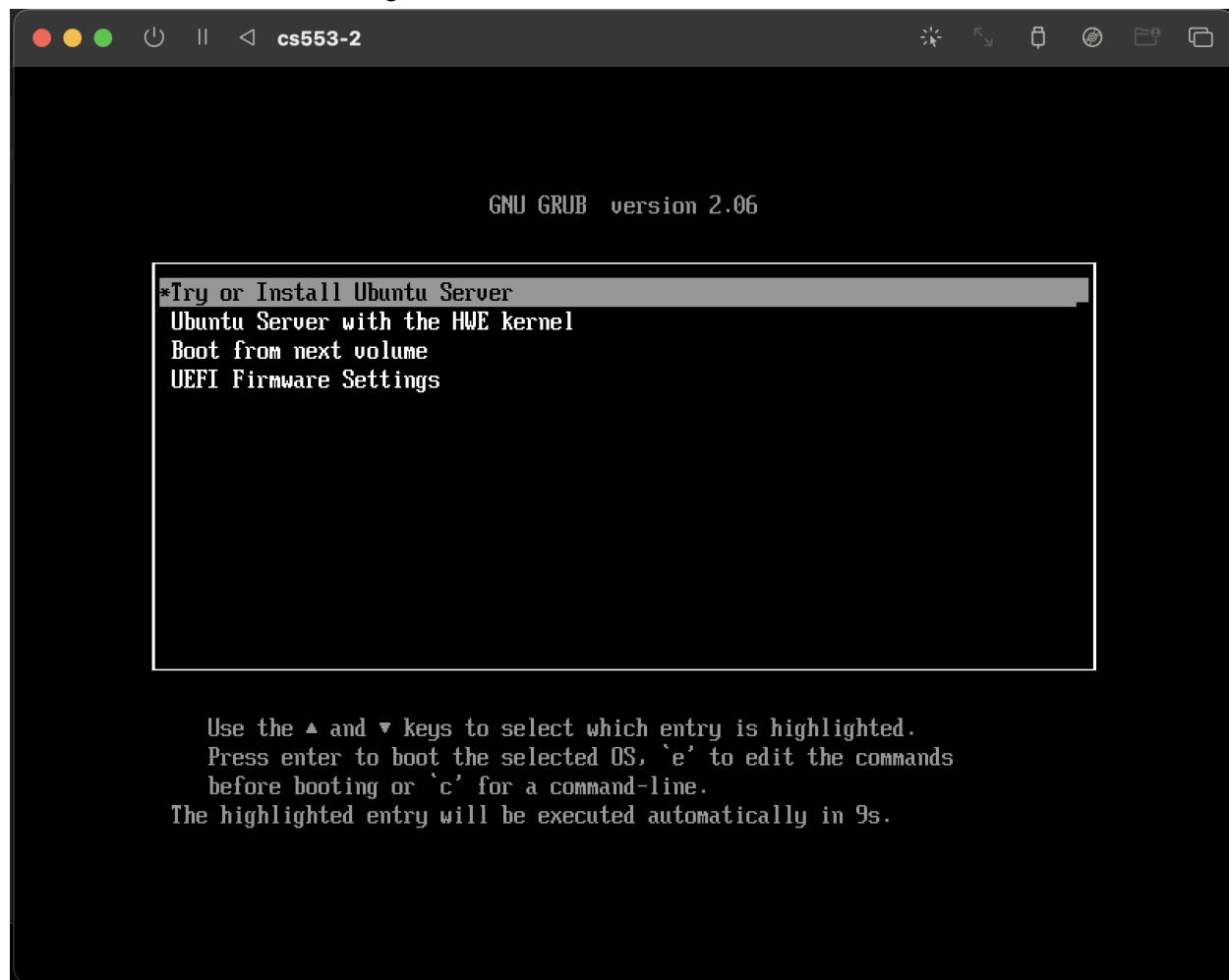
For IBM System z series mainframes, such as IBM LinuxONE.

- 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 Bridged Adapter

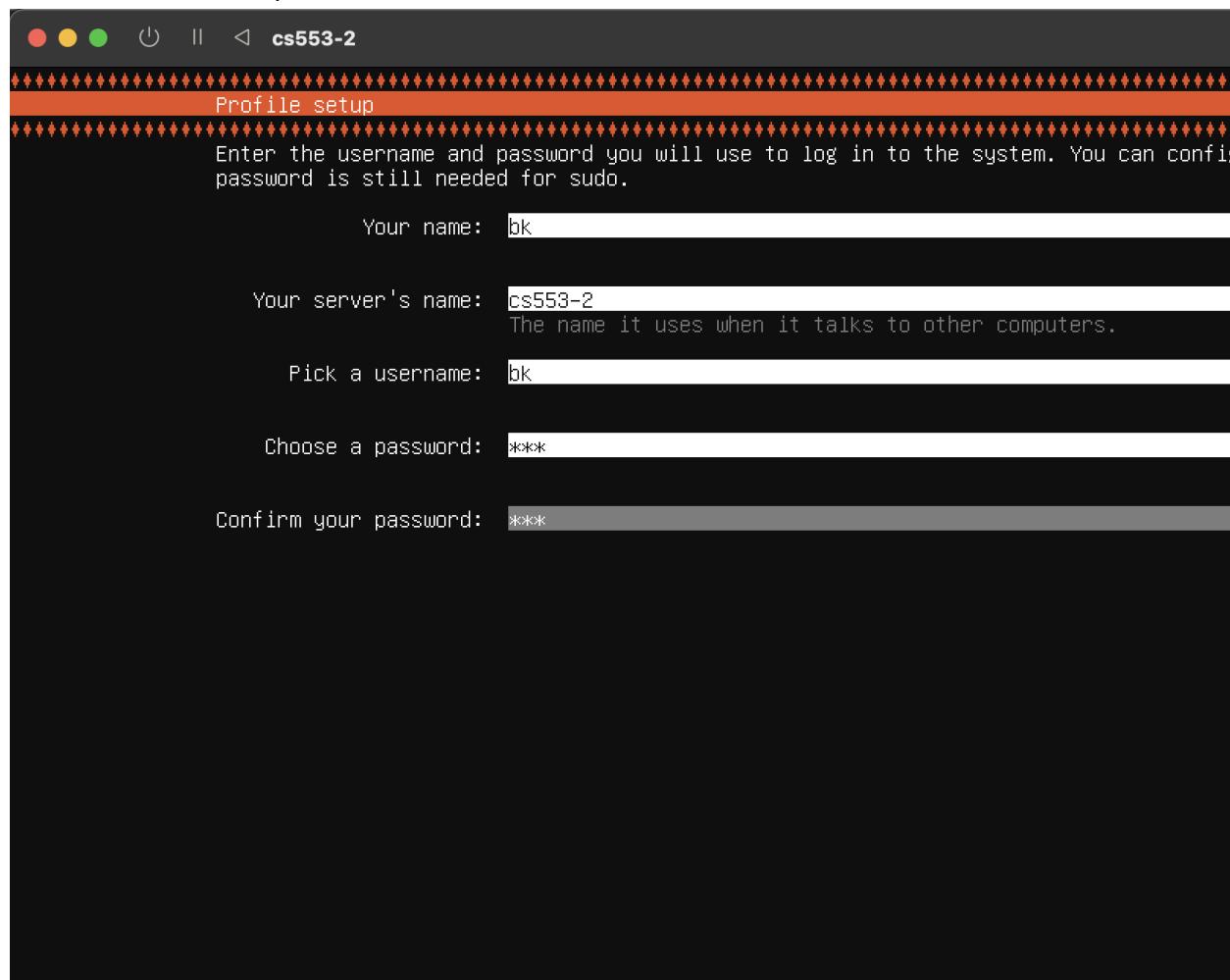
I installed the server version(without GUI). Therefore, I allocated 2GB RAM.



f. Install Linux from the ISO image



g. Create a user id and password



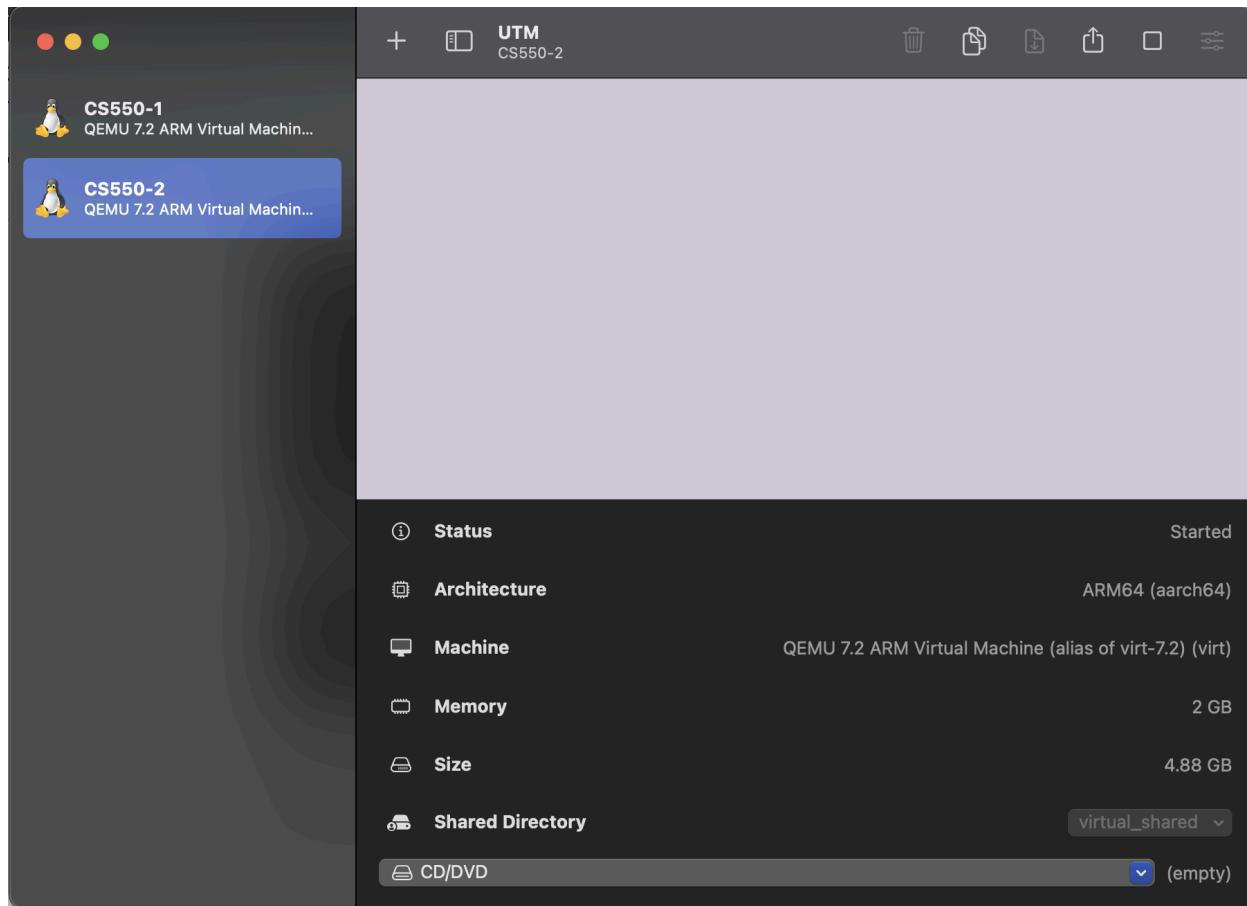
h. Turn on Firewall and block all ports

```
bk@cs553-1:~$ ls
bk@cs553-1:~$ sudo ufw status
[sudo] password for bk:
Status: inactive
bk@cs553-1:~$ sudo ufw enable
Firewall is active and enabled on system startup
bk@cs553-1:~$ sudo ufw default deny incoming
Default incoming policy changed to 'deny'
(be sure to update your rules accordingly)
bk@cs553-1:~$
```

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

```
bk@cs553-1:~$  
bk@cs553-1:~$  
bk@cs553-1:~$  
bk@cs553-1:~$  
bk@cs553-1:~$  
bk@cs553-1:~$  
bk@cs553-1:~$  
bk@cs553-1:~$ sudo ufw allow OpenSSH  
Rule added  
Rule added (v6)  
bk@cs553-1:~$
```

- 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

```

Studies — bk@cs553-1: ~ ssh bk@192.168.64.7 - 80x45
Last login: Fri Jan 19 23:29:53 2024
[bk@cs553-1:~$ ls
[bk@cs553-1:~$ 
[bk@cs553-1:~$ 
[bk@cs553-1:~$ ssh-keygen
Generating public/private rsa key pair.
(Enter file in which to save the key (/home/bk/.ssh/id_rsa):
(Enter passphrase (empty for no passphrase):
(Enter same passphrase again:
Your identification has been saved in /home/bk/.ssh/id_rsa
Your public key has been saved in /home/bk/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:8H05S94x+VqgMNvbhWc+WnW+9sCboXcNyPAPAr6oZmo bk@cs553-1
The key's randomart image is:
+---[RSA 3072]----+
| . . .
| . o . *
| o... o =+
| .S.+.=+.+
| .o.+=oo
| ..=.=B+
| E o . o *+=+
| ...+=. =...
+---[SHA256]----+
[bk@cs553-1:~$ ssh-copy-id bk@192.168.64.8
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/home/bk/.ssh/id_rsa.pub"
The authenticity of host '192.168.64.8 (192.168.64.8)' can't be established.
ED25519 key fingerprint is SHA256:8nspL10EffCsxn/z9gL0wEGK+b19x7/zMchas3edM.
This key is not known by any other names
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 installed
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
[bk@192.168.64.8's password:
Number of key(s) added: 1

Now try logging into the machine, with: "ssh 'bk@192.168.64.8'"
and check to make sure that only the key(s) you wanted were added.
[bk@cs553-1:~$ 

batkhishig — bk@cs553-2: ~ ssh bk@192.168.64.8 - 80x45
[bk@cs553-2:~$ 
[bk@cs553-2:~$ ssh-keygen
Generating public/private rsa key pair.
[Enter file in which to save the key (/home/bk/.ssh/id_rsa): Enter passphrase (empty for no passphrase):
[Enter same passphrase again:
Your identification has been saved in /home/bk/.ssh/id_rsa
Your public key has been saved in /home/bk/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:fzpZnJk0+/+6NQB7Qyas+hdw3KUffP7x+E05G1hA bk@cs553-2
The key's randomart image is:
+---[RSA 3072]----+
| . .
| E+
| .
| o +.o
| S * B= o
| . = # 0B0
| . * +=+
| * .=+
| =+=@|
+---[SHA256]----+
[bk@cs553-2:~$ 
[bk@cs553-2:~$ ssh-copy-id bk@192.168.64.7
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/home/bk/.ssh/id_rsa.pub"
The authenticity of host '192.168.64.7 (192.168.64.7)' can't be established.
ED25519 key fingerprint is SHA256:+Bkh81VU+iu7UiWIDMC5iCP81iP6MqFx8LHBgRJnJKso.
This key is not known by any other names
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 installed
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
[bk@192.168.64.7's password:
Permission denied, please try again.
[bk@192.168.64.7's password:

Number of key(s) added: 1

Now try logging into the machine, with: "ssh 'bk@192.168.64.7'"
and check to make sure that only the key(s) you wanted were added.
[bk@cs553-2:~$ 

```

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

```

Studies — bk@cs553-2: ~ ssh bk@192.168.64.7 - 80x31
[bk@cs553-1:~$ ssh bk@192.168.64.8
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-91-generic aarch64)

 * Documentation: https://help.ubuntu.com
 * Management: https://landscape.canonical.com
 * Support: https://ubuntu.com/advantage

 System information as of Sat Jan 20 12:13:33 AM UTC 2024

 System load: 0.02197265625
 Usage of /: 45.3% of 10.70GB
 Memory usage: 11%
 Swap usage: 0%
 Processes: 113
 Users logged in: 1
 IPv4 address for enp0s1: 192.168.64.8
 IPv6 address for enp0s1: fd6a:f85d:7ca7:ab0c:a841:b7ff:fe6e:166

 Expanded Security Maintenance for Applications is not enabled.
 51 updates can be applied immediately.
 To see these additional updates run: apt list --upgradable

 Enable ESM Apps to receive additional future security updates.
 See https://ubuntu.com/esm or run: sudo pro status

 Last login: Sat Jan 20 00:11:20 2024 from 192.168.64.1
[bk@cs553-1:~$ 

batkhishig — bk@cs553-2: ~ ssh bk@192.168.64.8 - 80x31
[bk@cs553-2:~$ 
[bk@cs553-2:~$ ssh bk@192.168.64.7
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-91-generic aarch64)

 * Documentation: https://help.ubuntu.com
 * Management: https://landscape.canonical.com
 * Support: https://ubuntu.com/advantage

 System information as of Sat Jan 20 12:13:46 AM UTC 2024

 System load: 0.021484375
 Usage of /: 45.7% of 10.70GB
 Memory usage: 11%
 Swap usage: 0%
 Processes: 109
 Users logged in: 1
 IPv4 address for enp0s1: 192.168.64.7
 IPv6 address for enp0s1: fd6a:f85d:7ca7:ab0c:289c:c7ff:fe52:feeb

 Expanded Security Maintenance for Applications is not enabled.
 49 updates can be applied immediately.
 To see these additional updates run: apt list --upgradable

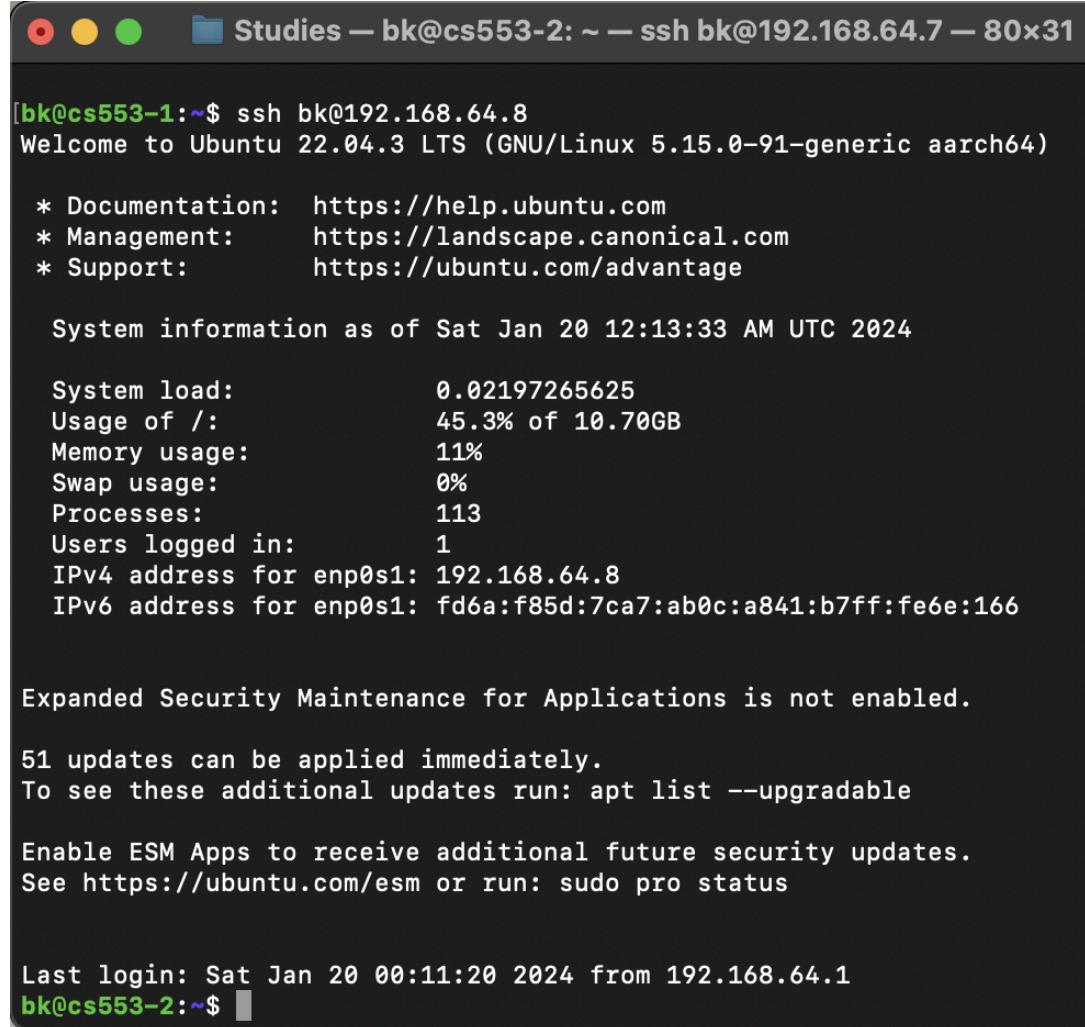
 Enable ESM Apps to receive additional future security updates.
 See https://ubuntu.com/esm or run: sudo pro status

 Last login: Fri Jan 19 23:31:15 2024 from 192.168.64.1
[bk@cs553-2:~$ 

```

2. (25 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 - remotely logins to another machine securely



The screenshot shows a terminal window titled "Studies" with the command "bk@cs553-2: ~ — ssh bk@192.168.64.7 — 80x31". The terminal displays the following output:

```
[bk@cs553-1:~$ ssh bk@192.168.64.8
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-91-generic aarch64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/advantage

 System information as of Sat Jan 20 12:13:33 AM UTC 2024

 System load:          0.02197265625
 Usage of /:           45.3% of 10.70GB
 Memory usage:         11%
 Swap usage:          0%
 Processes:            113
 Users logged in:     1
 IPv4 address for enp0s1: 192.168.64.8
 IPv6 address for enp0s1: fd6a:f85d:7ca7:ab0c:a841:b7ff:fe6e:166

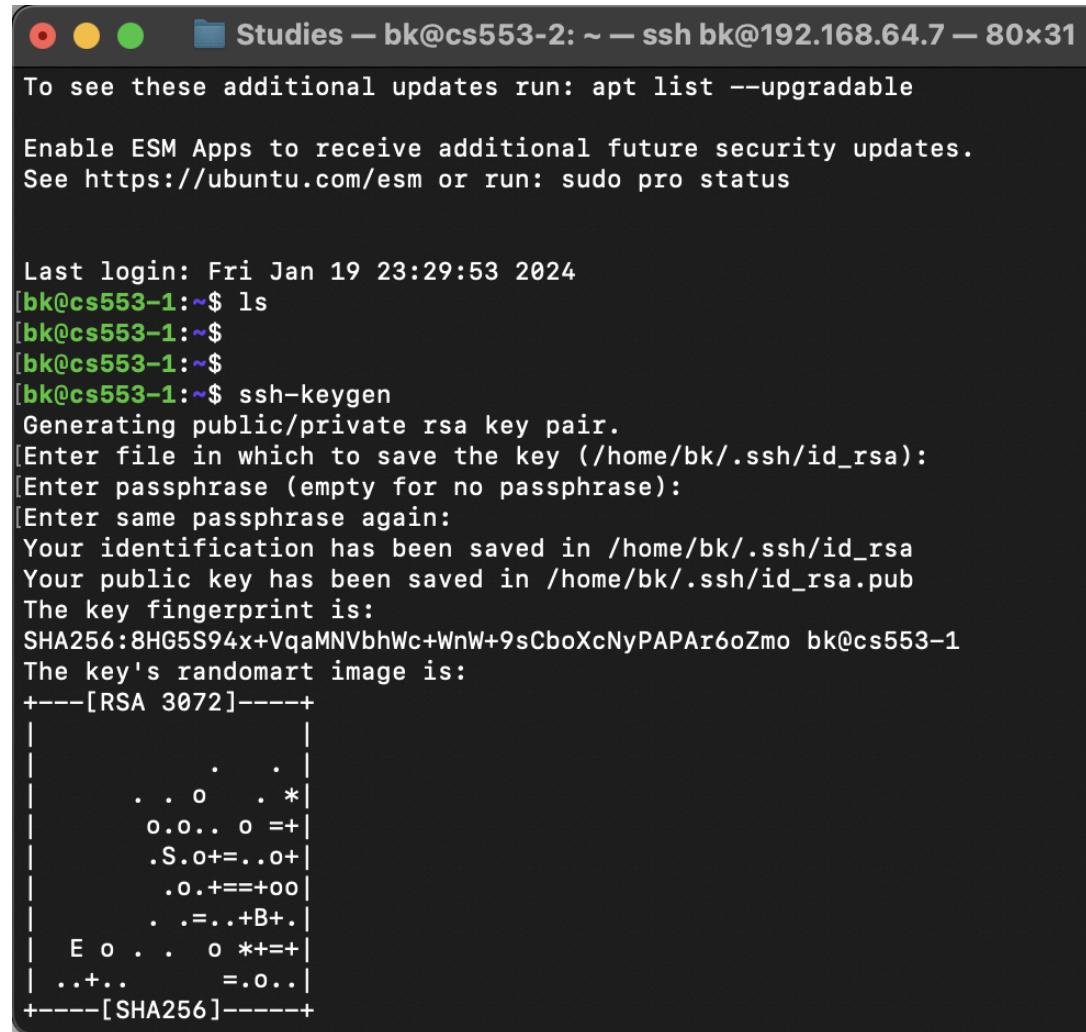
Expanded Security Maintenance for Applications is not enabled.

51 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

Last login: Sat Jan 20 00:11:20 2024 from 192.168.64.1
bk@cs553-2:~$
```

- b. ssh-keygen - generates rsa key pair that can be used to authenticate the user via ssh



```
To see these additional updates run: apt list --upgradable

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

Last login: Fri Jan 19 23:29:53 2024
[|bk@cs553-1:~$ ls
[|bk@cs553-1:~$ 
[|bk@cs553-1:~$ 
[|bk@cs553-1:~$ ssh-keygen
Generating public/private rsa key pair.
[|Enter file in which to save the key (/home/bk/.ssh/id_rsa):
[|Enter passphrase (empty for no passphrase):
[|Enter same passphrase again:
Your identification has been saved in /home/bk/.ssh/id_rsa
Your public key has been saved in /home/bk/.ssh/id_rsa.pub
The key fingerprint is:
SHA256:8HG5S94x+VqaMNVbhWc+WnW+9sCboXcNyPAPAr6oZmo bk@cs553-1
The key's randomart image is:
+---[RSA 3072]---+
| . . .
| . o . *
| o.o.. o =+
| .S.o+=..o+
| .o.+==+oo|
| . .=..+B+.
| E o . . o *+=+
| ..+.. . =.o..
+---[SHA256]---+
```

- c. scp - used to copy files or directories over ssh connection to or from another machine

```
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$ touch some-file.txt  
[bk@cs553-1:~$ scp some-file.txt bk@192.168.64.8:~/  
    some-file.txt  
                                100%      0      0.0KB/s   00:00  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$]
```

- d. history - prints executed command history

```
[bk@cs553-1:~$  
[bk@cs553-1:~$  
[bk@cs553-1:~$ history  
 1  ls  
 2  ssh-keygen  
 3  ssh-copy-id bk@192.168.64.8  
 4  ssh bk@192.168.64.8  
 5  l  
 6  ls  
 7  touch some-file.txt  
 8  scp some-file.txt bk@192.168.64.8  
 9  ls  
10  ls -l  
11  rm  bk@192.168.64.8  
12  rm some-file.txt  
13  ls  
14  touch some-file.txt  
15  scp some-file.txt bk@192.168.64.8:~/  
16  history  
bk@cs553-1:~$
```

- e. sudo - runs commands with administrator privilege

```
Studies — bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x20

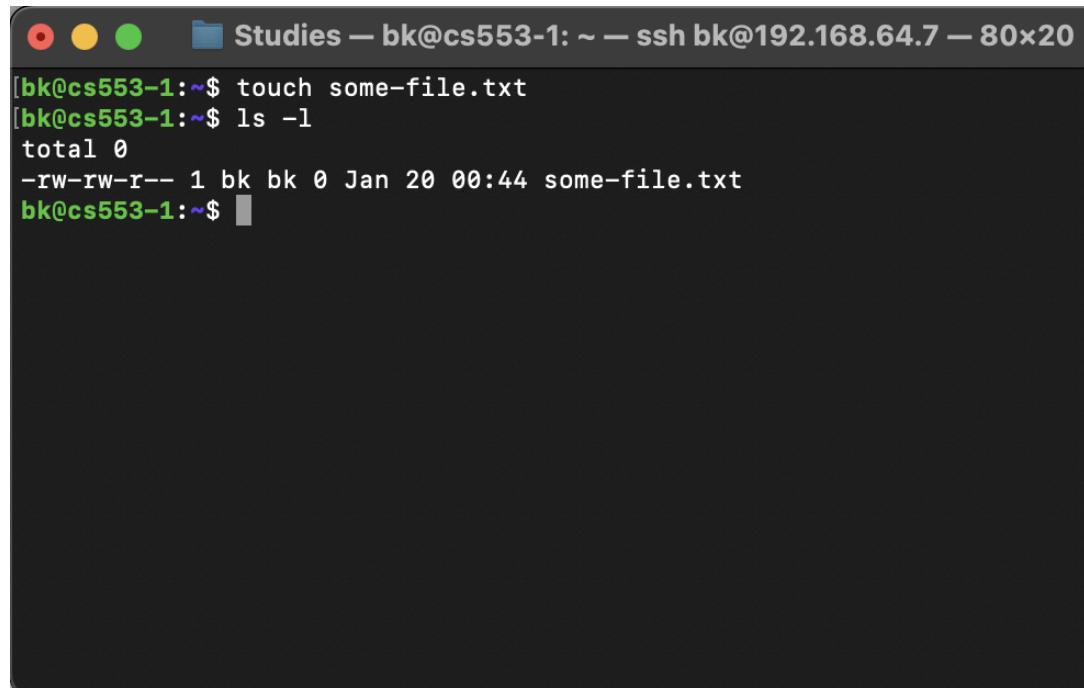
6  ls
7  touch some-file.txt
8  scp some-file.txt bk@192.168.64.8
9  ls
10 ls -l
11 rm bk@192.168.64.8
12 rm some-file.txt
13 ls
14 touch some-file.txt
15 scp some-file.txt bk@192.168.64.8:~
16 history
[bk@cs553-1:~$ sudo apt-get update
[[sudo] password for bk:
Hit:1 http://ports.ubuntu.com/ubuntu-ports jammy InRelease
Get:2 http://ports.ubuntu.com/ubuntu-ports jammy-updates InRelease [119 kB]
Hit:3 http://ports.ubuntu.com/ubuntu-ports jammy-backports InRelease
Get:4 http://ports.ubuntu.com/ubuntu-ports jammy-security InRelease [110 kB]
Fetched 229 kB in 1s (172 kB/s)
Reading package lists... Done
bk@cs553-1:~$ ]
```

- f. ip - used to configure network interface

```
Studies — bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x20

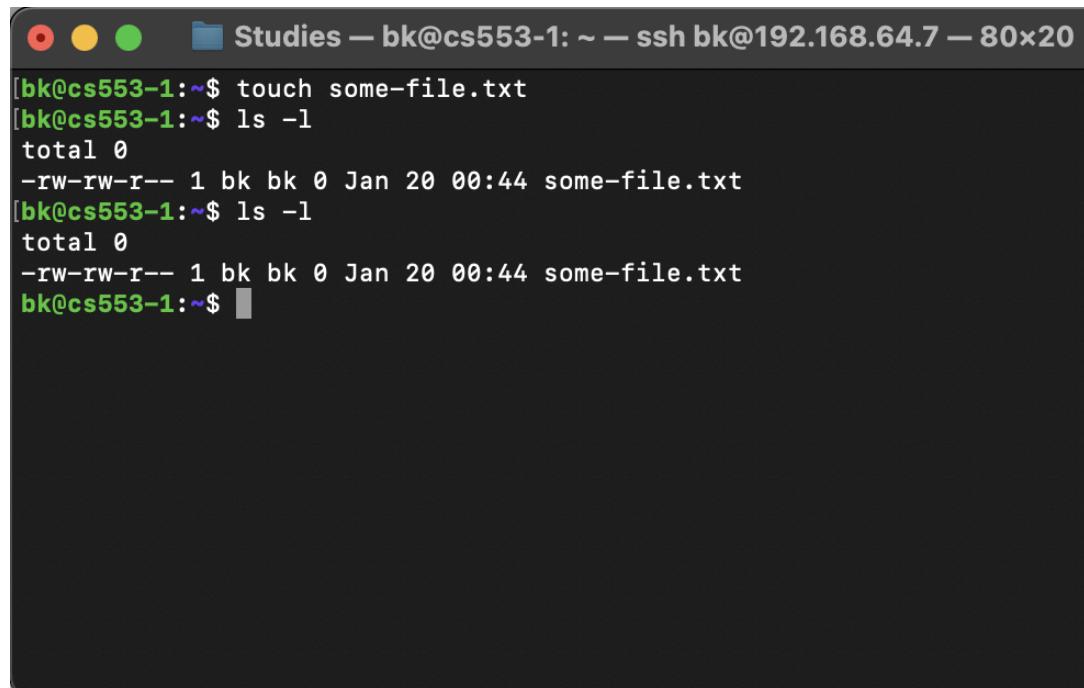
[bk@cs553-1:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 2a:9c:c7:52:fe:eb brd ff:ff:ff:ff:ff:ff
    inet 192.168.64.7/24 metric 100 brd 192.168.64.255 scope global dynamic enp0s1
        valid_lft 82026sec preferred_lft 82026sec
        inet6 fd6a:f85d:7ca7:ab0c:289c:c7ff:fe52:feeb/64 scope global dynamic mngtmp
addr noprefixroute
        valid_lft 2591933sec preferred_lft 604733sec
        inet6 fe80::289c:c7ff:fe52:feeb/64 scope link
            valid_lft forever preferred_lft forever
bk@cs553-1:~$ ]
```

- g. touch - creates a new file or changes timestamp of an existing file



```
[bk@cs553-1:~$ touch some-file.txt
[bk@cs553-1:~$ ls -l
total 0
-rw-rw-r-- 1 bk bk 0 Jan 20 00:44 some-file.txt
[bk@cs553-1:~$ ]
```

- h. ls - shows files and directories in a directory



```
[bk@cs553-1:~$ touch some-file.txt
[bk@cs553-1:~$ ls -l
total 0
-rw-rw-r-- 1 bk bk 0 Jan 20 00:44 some-file.txt
[bk@cs553-1:~$ ls -l
total 0
-rw-rw-r-- 1 bk bk 0 Jan 20 00:44 some-file.txt
[bk@cs553-1:~$ ]
```

- i. mkdir - makes a new directory

The screenshot shows a terminal window titled "Studies — bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x20". The terminal content is as follows:

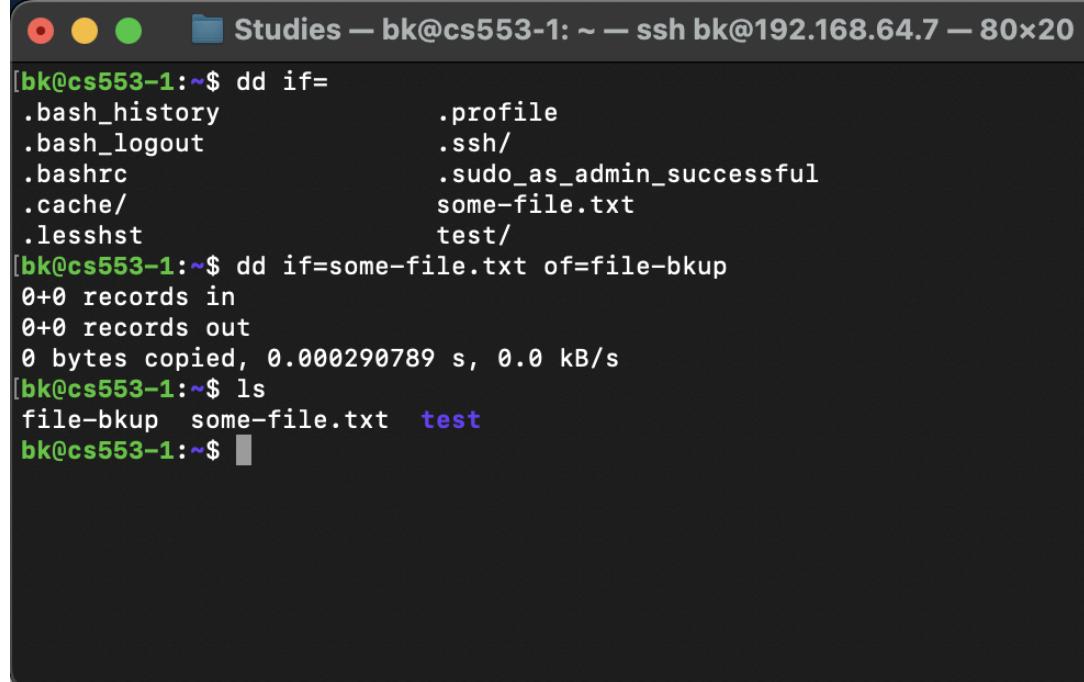
```
[bk@cs553-1:~$ touch some-file.txt
[bk@cs553-1:~$ ls -l
total 0
-rw-rw-r-- 1 bk bk 0 Jan 20 00:44 some-file.txt
[bk@cs553-1:~$ ls -l
total 0
-rw-rw-r-- 1 bk bk 0 Jan 20 00:44 some-file.txt
[bk@cs553-1:~$ mkdir test
[bk@cs553-1:~$ ls
some-file.txt  test
[bk@cs553-1:~$ ls -l
total 4
-rw-rw-r-- 1 bk bk 0 Jan 20 00:44 some-file.txt
drwxrwxr-x 2 bk bk 4096 Jan 20 00:45 test
bk@cs553-1:~$ ]
```

- j. cd - changes current directory

The screenshot shows a terminal window titled "Studies — bk@cs553-1: ~/test — ssh bk@192.168.64.7 — 80x20". The terminal content is as follows:

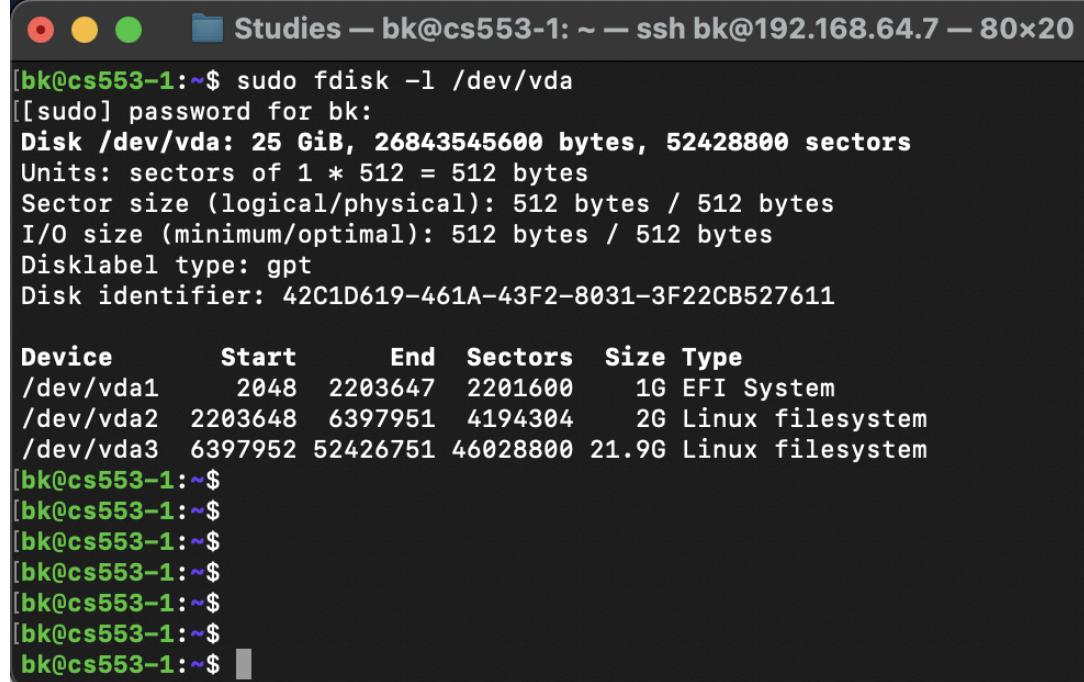
```
[bk@cs553-1:~$ cd test/
[bk@cs553-1:~/test$ ]
```

- k. dd - used to convert and copy a file, usually used for backups



```
[bk@cs553-1:~$ dd if=
.bash_history          .profile
.bash_logout           .ssh/
.bashrc                .sudo_as_admin_successful
.cache/                some-file.txt
.lessht                test/
[bk@cs553-1:~$ dd if=some-file.txt of=file-bkup
0+0 records in
0+0 records out
0 bytes copied, 0.000290789 s, 0.0 kB/s
[bk@cs553-1:~$ ls
file-bkup  some-file.txt  test
bk@cs553-1:~$ ]
```

- l. fdisk - used to manage disk partition table



```
[bk@cs553-1:~$ sudo fdisk -l /dev/vda
[[sudo] password for bk:
Disk /dev/vda: 25 GiB, 26843545600 bytes, 52428800 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: gpt
Disk identifier: 42C1D619-461A-43F2-8031-3F22CB527611

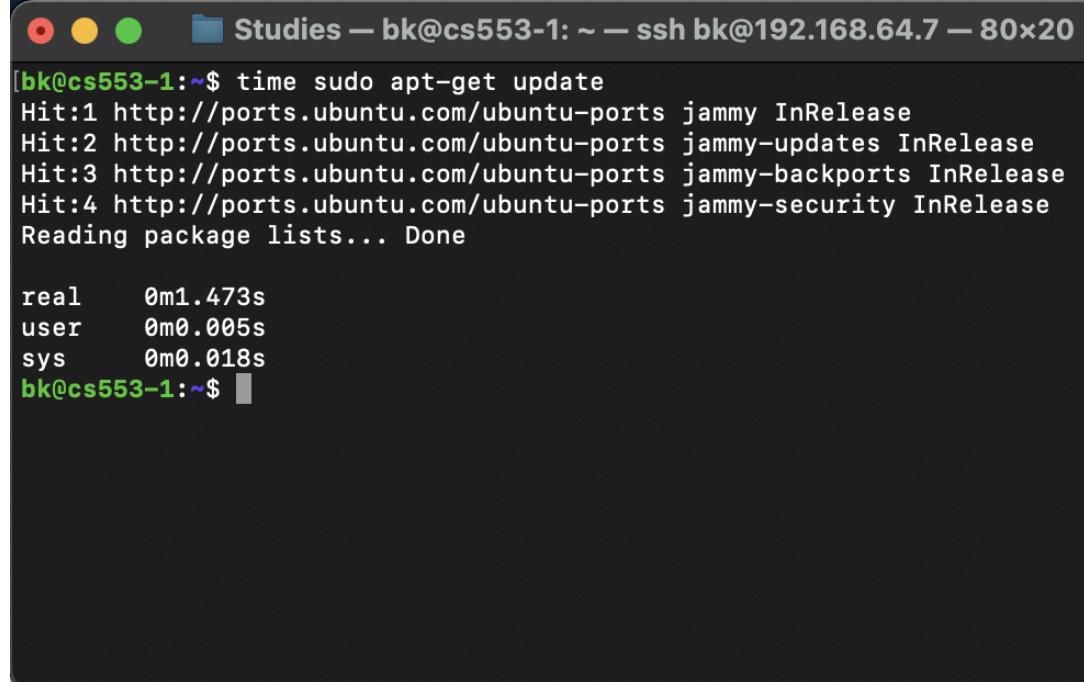
Device      Start    End  Sectors  Size Type
/dev/vda1     2048  2203647  2201600   1G EFI System
/dev/vda2  2203648  6397951  4194304   2G Linux filesystem
/dev/vda3  6397952 52426751 46028800 21.9G Linux filesystem
[bk@cs553-1:~$ ]
```

- m. apt - a high-level package management tool for debian based linux systems

```
[bk@cs553-1:~]$ sudo apt-get update
Hit:1 http://ports.ubuntu.com/ubuntu-ports jammy InRelease
Hit:2 http://ports.ubuntu.com/ubuntu-ports jammy-updates InRelease
Hit:3 http://ports.ubuntu.com/ubuntu-ports jammy-backports InRelease
Hit:4 http://ports.ubuntu.com/ubuntu-ports jammy-security InRelease
Reading package lists... Done
bk@cs553-1:~$
```

- n. vi - used to edit files, a file-editor

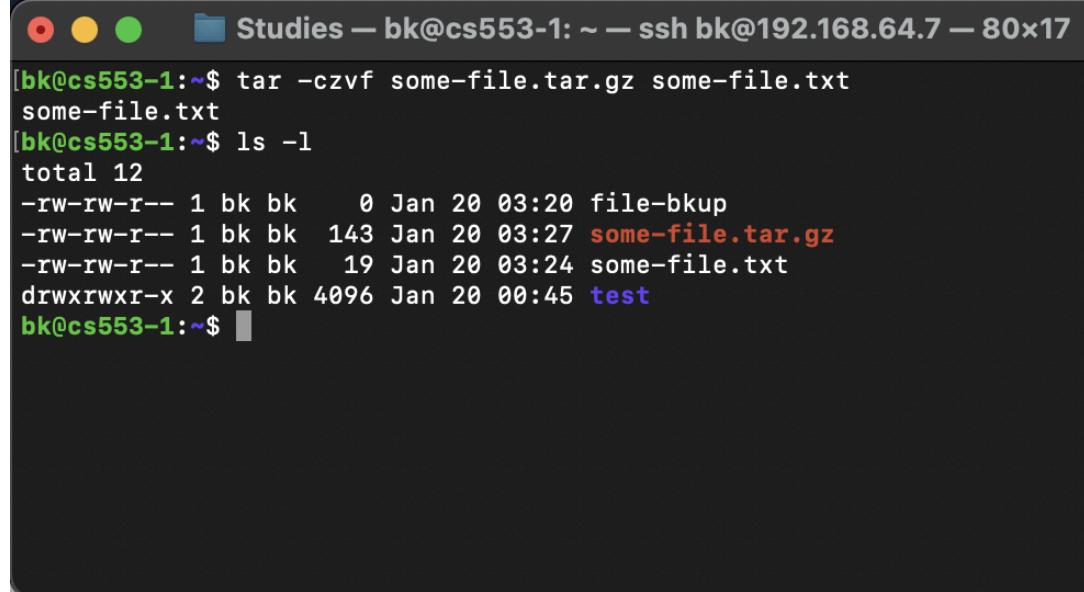
- o. time - measures time and resource to execute a command written after it



```
[bk@cs553-1:~$ time sudo apt-get update
Hit:1 http://ports.ubuntu.com/ubuntu-ports jammy InRelease
Hit:2 http://ports.ubuntu.com/ubuntu-ports jammy-updates InRelease
Hit:3 http://ports.ubuntu.com/ubuntu-ports jammy-backports InRelease
Hit:4 http://ports.ubuntu.com/ubuntu-ports jammy-security InRelease
Reading package lists... Done

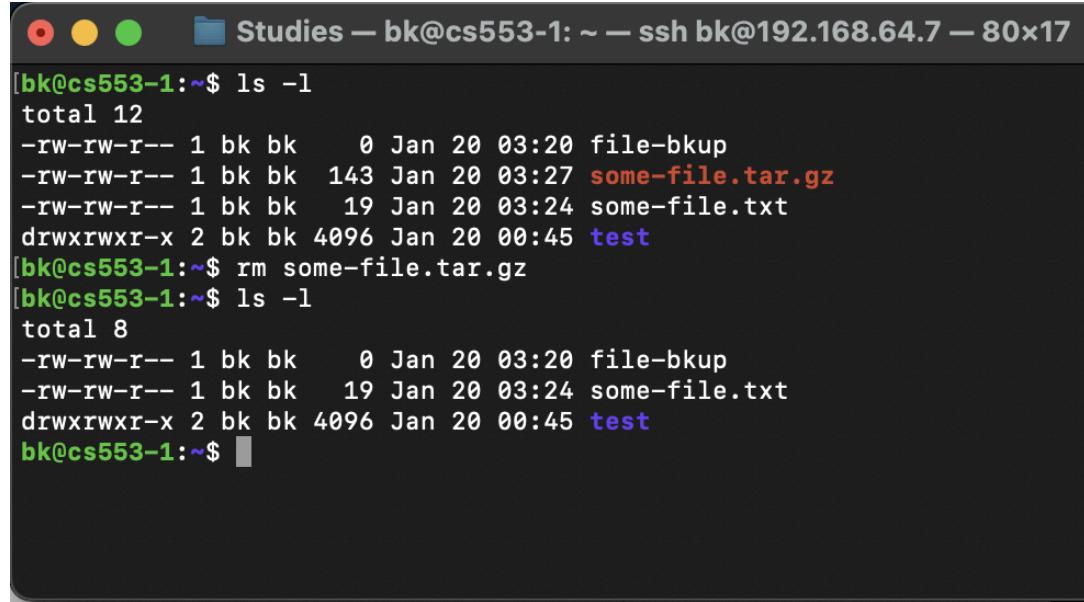
real    0m1.473s
user    0m0.005s
sys     0m0.018s
bk@cs553-1:~$ ]
```

- p. tar - an archive tool



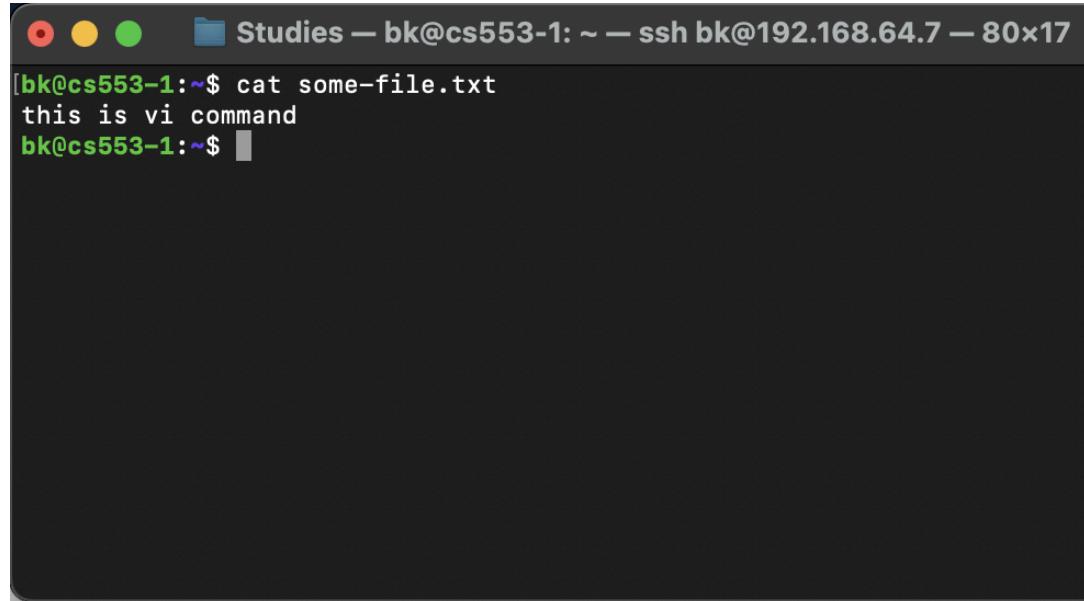
```
[bk@cs553-1:~$ tar -czvf some-file.tar.gz some-file.txt
some-file.txt
[bk@cs553-1:~$ ls -l
total 12
-rw-rw-r-- 1 bk bk      0 Jan 20 03:20 file-bkup
-rw-rw-r-- 1 bk bk   143 Jan 20 03:27 some-file.tar.gz
-rw-rw-r-- 1 bk bk     19 Jan 20 03:24 some-file.txt
drwxrwxr-x 2 bk bk  4096 Jan 20 00:45 test
bk@cs553-1:~$ ]
```

- q. rm - deletes files or directories



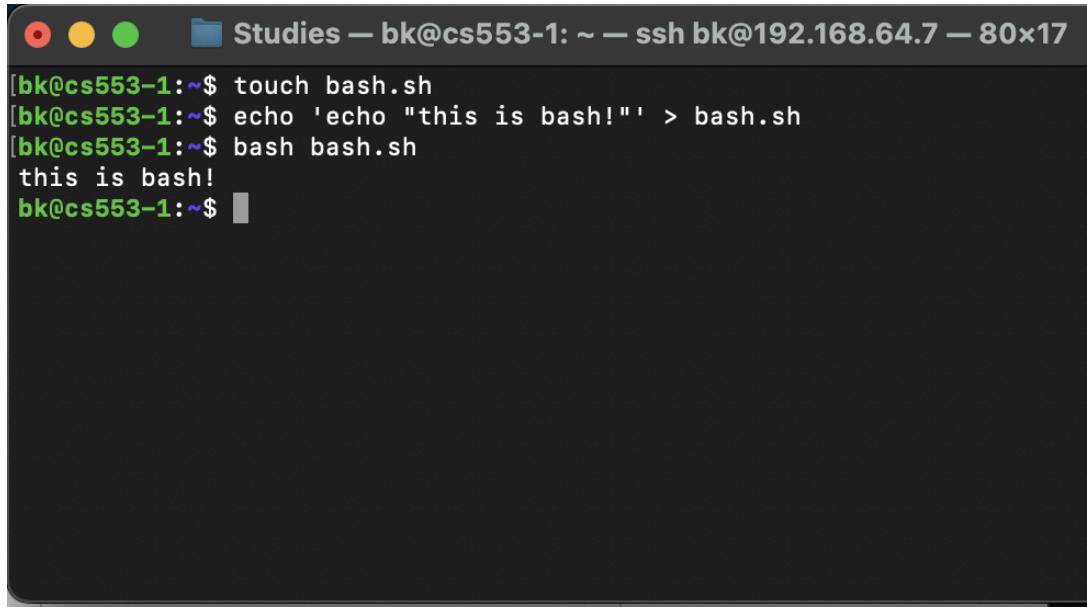
```
[bk@cs553-1:~$ ls -l
total 12
-rw-rw-r-- 1 bk bk      0 Jan 20 03:20 file-bkup
-rw-rw-r-- 1 bk bk    143 Jan 20 03:27 some-file.tar.gz
-rw-rw-r-- 1 bk bk     19 Jan 20 03:24 some-file.txt
drwxrwxr-x 2 bk bk  4096 Jan 20 00:45 test
[bk@cs553-1:~$ rm some-file.tar.gz
[bk@cs553-1:~$ ls -l
total 8
-rw-rw-r-- 1 bk bk      0 Jan 20 03:20 file-bkup
-rw-rw-r-- 1 bk bk     19 Jan 20 03:24 some-file.txt
drwxrwxr-x 2 bk bk  4096 Jan 20 00:45 test
bk@cs553-1:~$ ]
```

- r. cat - prints content of a file



```
[bk@cs553-1:~$ cat some-file.txt
this is vi command
bk@cs553-1:~$ ]
```

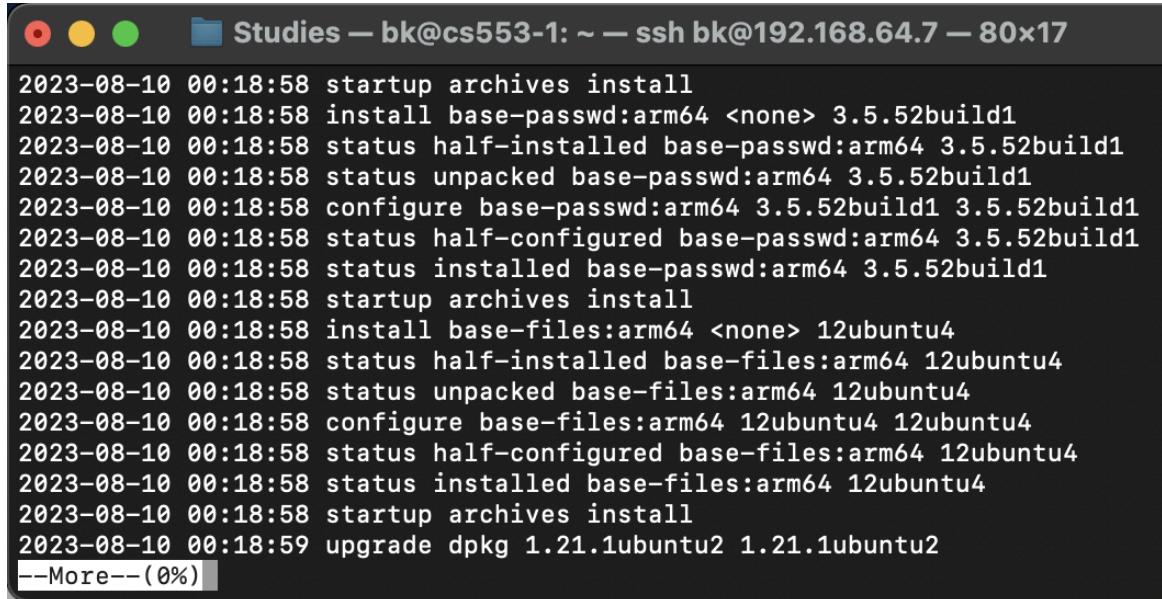
- s. bash - bourne-again shell, used to run bash scripts



A screenshot of a terminal window titled "Studies — bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x17". The terminal shows the following command sequence:

```
[bk@cs553-1:~$ touch bash.sh
[bk@cs553-1:~$ echo 'echo "this is bash!"' > bash.sh
[bk@cs553-1:~$ bash bash.sh
this is bash!
bk@cs553-1:~$ ]
```

- t. more - views text one page at a time. Useful for logs.



A screenshot of a terminal window titled "Studies — bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x17". The terminal shows the output of the "more" command displaying a log file:

```
2023-08-10 00:18:58 startup archives install
2023-08-10 00:18:58 install base-passwd:arm64 <none> 3.5.52build1
2023-08-10 00:18:58 status half-installed base-passwd:arm64 3.5.52build1
2023-08-10 00:18:58 status unpacked base-passwd:arm64 3.5.52build1
2023-08-10 00:18:58 configure base-passwd:arm64 3.5.52build1 3.5.52build1
2023-08-10 00:18:58 status half-configured base-passwd:arm64 3.5.52build1
2023-08-10 00:18:58 status installed base-passwd:arm64 3.5.52build1
2023-08-10 00:18:58 startup archives install
2023-08-10 00:18:58 install base-files:arm64 <none> 12ubuntu4
2023-08-10 00:18:58 status half-installed base-files:arm64 12ubuntu4
2023-08-10 00:18:58 status unpacked base-files:arm64 12ubuntu4
2023-08-10 00:18:58 configure base-files:arm64 12ubuntu4 12ubuntu4
2023-08-10 00:18:58 status half-configured base-files:arm64 12ubuntu4
2023-08-10 00:18:58 status installed base-files:arm64 12ubuntu4
2023-08-10 00:18:58 startup archives install
2023-08-10 00:18:59 upgrade dpkg 1.21.1ubuntu2 1.21.1ubuntu2
--More--(0%)
```

- u. watch - periodically executes command and displays its output

```
● ● ● └─ Studies ─ bk@cs553-1: ~ ─ ssh bk@192.168.64.7 ─ 80x17
Every 2.0s: df -h                                         cs553-1: Sat Jan 20 03:37:01 2024

Filesystem          Size  Used Avail Use% Mounted on
tmpfs              197M  1.4M  196M  1% /run
/dev/mapper/ubuntu--vg-ubuntu--lv   11G  4.9G  5.3G  49% /
tmpfs              984M    0  984M  0% /dev/shm
tmpfs              5.0M    0  5.0M  0% /run/lock
/dev/vda2           2.0G 129M  1.7G  8% /boot
/dev/vda1           1.1G  6.4M  1.1G  1% /boot/efi
tmpfs              197M  4.0K  197M  1% /run/user/1000
```

- v. ps - shows current snapshot of working processes

```
● ● ● └─ Studies ─ bk@cs553-1: ~ ─ ssh bk@192.168.64.7 ─ 80x17
root      767  0.0  1.0 109560 20156 ?          Ssl  00:03  0:00 /usr/bin/python
bk        1036  0.0  0.4 17224  9072 ?          Ss   00:03  0:00 /lib/systemd/
bk        1037  0.0  0.2 105236  5196 ?          S    00:03  0:00 (sd-pam)
bk        1043  0.0  0.2   8248  5060 tty1        S+   00:03  0:00 -bash
root     1325  0.0  0.9 297068 19008 ?          Ssl  00:04  0:00 /usr/libexec/
root     1692  0.0  0.4 18396  9792 ?          Ss   00:05  0:00 sshd: bk [pri
bk        1747  0.0  0.3 18532  6508 ?          S    00:05  0:00 sshd: bk@pts/
bk        1748  0.0  0.3 10436  6484 pts/0        Ss   00:05  0:00 -bash
root     2059  0.0  0.0     0     0 ?          I    00:53  0:03 [kworker/0:1-
root     2086  0.0  0.0     0     0 ?          I    01:13  0:04 [kworker/0:0-
root     2625  0.0  0.0     0     0 ?          I    02:56  0:00 [kworker/u4:3
root     2627  0.0  0.0     0     0 ?          I    03:04  0:00 [kworker/u4:1-
root     3121  0.0  0.0     0     0 ?          I    03:23  0:00 [kworker/1:1-
root     3521  0.0  0.0     0     0 ?          I    03:25  0:00 [kworker/1:3-
root     4052  0.0  0.0     0     0 ?          I    03:38  0:00 [kworker/u4:0
bk        4054  0.0  0.1 10740  3144 pts/0        R+   03:39  0:00 ps -aux
bk@cs553-1:~$
```

- w. top - shows current resource usages, updates real-time, similar to task manager in windows, or activity manager in mac

```

top - 19:18:15 up 3:27, 1 user, load average: 0.04, 0.02, 0.00
Tasks: 120 total, 1 running, 119 sleeping, 0 stopped, 0 zombie
%Cpu(s): 0.1 us, 0.1 sy, 0.0 ni, 99.8 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
MiB Mem : 1967.1 total, 944.4 free, 216.4 used, 806.4 buff/cache
MiB Swap: 2048.0 total, 2048.0 free, 0.0 used. 1656.3 avail Mem

      PID USER      PR  NI    VIRT    RES    SHR S %CPU %MEM TIME+ COMMAND
        14 root      20   0      0      0      0 I  0.3  0.0  0:00.27 rcu_sch+
        27 root      rt   0      0      0      0 S  0.3  0.0  0:00.17 migrati+
  3295 bk      20   0 10372  3292  2692 R  0.3  0.2  0:00.02 top
        1 root      20   0 167952 11260  7508 S  0.0  0.6  0:01.30 systemd
        2 root      20   0      0      0      0 S  0.0  0.0  0:00.01 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+
        5 root      0 -20      0      0      0 I  0.0  0.0  0:00.00 slub_flt+
        6 root      0 -20      0      0      0 I  0.0  0.0  0:00.00 netns
        8 root      0 -20      0      0      0 I  0.0  0.0  0:00.00 kworker+
       10 root      0 -20      0      0      0 I  0.0  0.0  0:00.00 mm_perc+
       11 root      20   0      0      0      0 S  0.0  0.0  0:00.00 rcu_tas+
       12 root      20   0      0      0      0 S  0.0  0.0  0:00.00 rcu_tas+
       13 root      20   0      0      0      0 S  0.0  0.0  0:00.07 ksoftir+
       15 root      rt   0      0      0      0 S  0.0  0.0  0:00.16 migrati+
       16 root     -51   0      0      0      0 S  0.0  0.0  0:00.00 idle_in+

```

- x. htop - more user-friendly version of top command, has colors and easier to examine processes

```

0[          0.7%] Tasks: 29, 32 thr; 1 running
1[          0.0%] Load average: 0.00 0.00 0.00
Mem[||||| 185M/1.92G] Uptime: 03:39:26
Swp[          0K/2.00G]

      PID USER      PRI  NI    VIRT    RES    SHR S CPU% MEM% TIME+ Command
  4086 bk      20   0  7616  3256  2720 R  0.0  0.2  0:00.04 htop
    1 root      20   0   98M 10812  7500 S  0.0  0.5  0:01.41 /sbin/init
  393 root      19  -1 48200 15456 14376 S  0.0  0.8  0:00.35 /lib/systemd/sy
  436 root      RT   0 282M 25664  7388 S  0.0  1.3  0:03.15 /sbin/multipath
  439 root      20   0 26244  6832  4184 S  0.0  0.3  0:00.40 /lib/systemd/sy
  441 root      20   0 282M 25664  7388 S  0.0  1.3  0:00.00 /sbin/multipath
  442 root      RT   0 282M 25664  7388 S  0.0  1.3  0:00.00 /sbin/multipath
  443 root      RT   0 282M 25664  7388 S  0.0  1.3  0:00.00 /sbin/multipath
  444 root      RT   0 282M 25664  7388 S  0.0  1.3  0:00.05 /sbin/multipath

F1Help F2Setup F3Search F4Filter F5Tree F6SortByF7Nice -F8Nice +F9Kill F10Quit

```

- y. gcc - compiles C and C++ language files and generates build files.

```
[bk@cs553-1:~$ touch main.c
[bk@cs553-1:~$ vi main.c
[bk@cs553-1:~$ gcc main.c
[bk@cs553-1:~$ ls -l
total 28
-rwxrwxr-x 1 bk bk 8872 Jan 20 03:45 a.out
-rw-rw-r-- 1 bk bk    21 Jan 20 03:31 bash.sh
-rw-rw-r-- 1 bk bk     0 Jan 20 03:20 file-bkup
-rw-rw-r-- 1 bk bk   127 Jan 20 03:45 main.c
-rw-rw-r-- 1 bk bk    19 Jan 20 03:24 some-file.txt
drwxrwxr-x 2 bk bk 4096 Jan 20 00:45 test
[bk@cs553-1:~$ a.out
a.out: command not found
[bk@cs553-1:~$ ./a.out
Hello, World!bk@cs553-1:~$ ]
```

- z. tail - prints the last lines of a file. Can show real-time file updates

```
[bk@cs553-1:~$ QEMU CD-ROM      2.5+ PQ: 0 ANSI: 5
Jan 19 23:29:45 cs553-1 kernel: [    4.396814] sr 0:0:0:0: [sr0] scsi3-mmc drive
: 16x/50x cd/rw xa/form2 cdda tray
Jan 19 23:29:45 cs553-1 kernel: [    4.396821] cdrom: Uniform CD-ROM driver Revi
sion: 3.20
Jan 19 23:29:45 cs553-1 kernel: [    4.397723] sr 0:0:0:0: Attached scsi CD-ROM
sr0
Jan 19 23:29:45 cs553-1 kernel: [    4.397859] sr 0:0:0:0: Attached scsi generic
sg0 type 5
Jan 19 23:29:49 cs553-1 kernel: [    9.928778] loop3: detected capacity change f
rom 0 to 8
Jan 19 23:29:50 cs553-1 kernel: [   10.735032] fbcon: Taking over console
Jan 19 23:29:50 cs553-1 kernel: [   10.735121] virtio_gpu virtio1: [drm] drm_pla
ne_enable_fb_damage_clips() not called
Jan 19 23:29:50 cs553-1 kernel: [   10.737292] Console: switching to colour fram
e buffer device 160x50
[ ]
```

aa. grep - searches a certain pattern in text files or stream

```
[bk@cs553-1:~$ history | grep sudo
17 sudo apt-get update
41 sudo fdisk -l /dev/vda
43 sudo apt-get update
45 sudo apt-get update
52 time sudo apt-get update
85 sudo apt install gcc
99 history | grep sudo
bk@cs553-1:~$
```

bb. kill - used to end a process with PID

```
[bk@cs553-1:~]$ ps aux
  PID  %CPU  %MEM   VSZ   RSS   TTY  STAT  START  TIME  COMMAND
  bk      0.0    0.3  10436  6484 pts/0    Ss   00:05  0:01 -bash
root    2059  0.0    0.0      0      0 ?        I    00:53  0:04 [kworker/0:1-
root    2086  0.0    0.0      0      0 ?        I    01:13  0:04 [kworker/0:0-
root    3121  0.0    0.0      0      0 ?        I    03:23  0:00 [kworker/1:1-
root    3521  0.0    0.0      0      0 ?        I    03:25  0:01 [kworker/1:3-
root    4052  0.0    0.0      0      0 ?        I    03:38  0:00 [kworker/u4:0
root    4794  0.0    0.0      0      0 ?        I    03:52  0:00 [kworker/u4:3
root    4797  0.0    0.0      0      0 ?        I    03:57  0:00 [kworker/u4:1
root    4839  0.0    0.4  18396  9668 ?        Ss   04:00  0:00 sshd: bk [pri
bk      4935  0.0    0.3  18532  6524 ?        S    04:00  0:00 sshd: bk@pts/
bk      4936  0.0    0.2   8776  5452 pts/1    Ss   04:00  0:00 -bash
root    4962  0.0    0.0      0      0 ?        I    04:03  0:00 [kworker/u4:2
bk      4967  0.0    0.1   7268  2996 pts/1    S+   04:04  0:00 /bin/bash ./s
bk      4968  0.0    0.0   5600   788 pts/1    S+   04:04  0:00 sleep 60
bk      4970  0.0    0.1  10740  3140 pts/0    R+   04:04  0:00 ps -aux
[bk@cs553-1:~]$ kill 4968
[bk@cs553-1:~]$
```

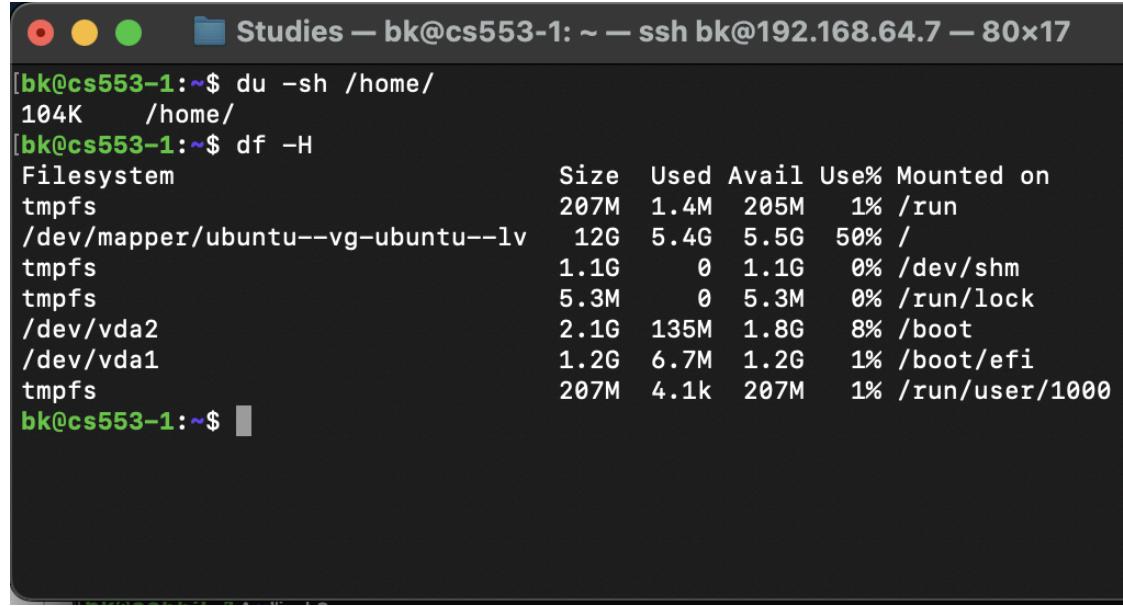
cc. killall - kills all processes using specified command

```
Studies — bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x17
root      4052  0.0  0.0      0      0 ?          I    03:38  0:00 [kworker/u4:0
root      4794  0.0  0.0      0      0 ?          I    03:52  0:00 [kworker/u4:3
root      4797  0.0  0.0      0      0 ?          I    03:57  0:00 [kworker/u4:1
root      4839  0.0  0.4  18396  9668 ?          Ss   04:00  0:00 sshd: bk [pri
bk        4935  0.0  0.3  18532  6524 ?          S    04:00  0:00 sshd: bk@pts/
bk        4936  0.0  0.2    8776  5452 pts/1     Ss   04:00  0:00 -bash
root      4962  0.0  0.0      0      0 ?          I    04:03  0:00 [kworker/u4:2
bk        4967  0.0  0.1    7268  2996 pts/1     S+   04:04  0:00 /bin/bash ./s
bk        4968  0.0  0.0    5600   788 pts/1     S+   04:04  0:00 sleep 60
bk        4970  0.0  0.1   10740  3140 pts/0     R+   04:04  0:00 ps -aux
[bk@cs553-1:~$ kill 4968
[bk@cs553-1:~$ 
[bk@cs553-1:~$ 
[bk@cs553-1:~$ 
[bk@cs553-1:~$ man kill
[bk@cs553-1:~$ killall sleep
bk@cs553-1:~$ ]
```

dd. du - prints disk usage

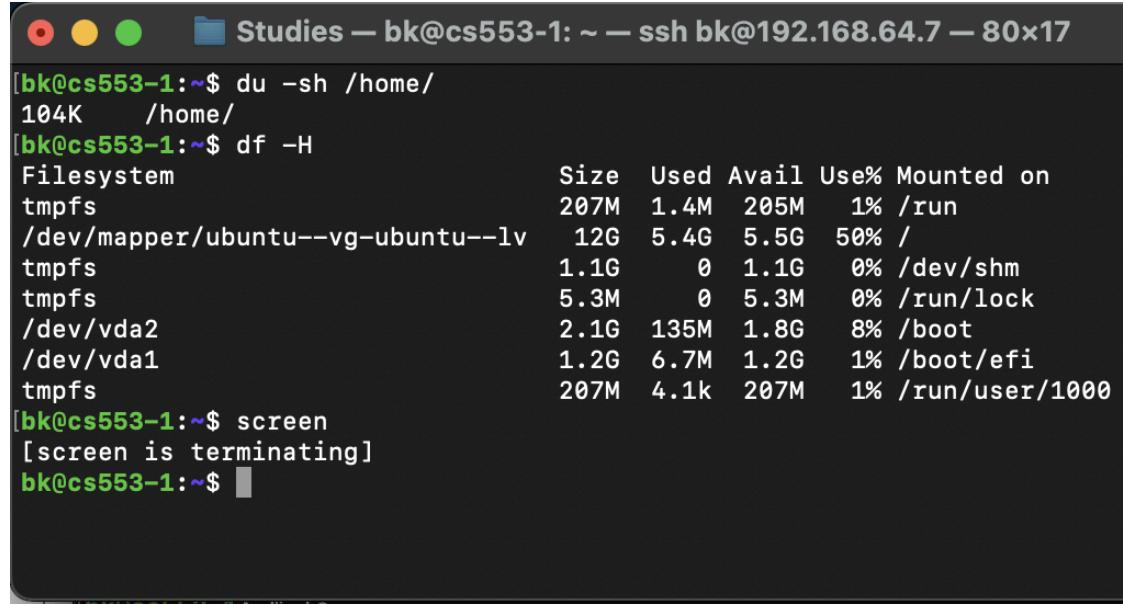
```
Studies — bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x17
[bk@cs553-1:~$ du -sh /home/
104K   /home/
bk@cs553-1:~$ ]
```

ee. df - shows available disk space



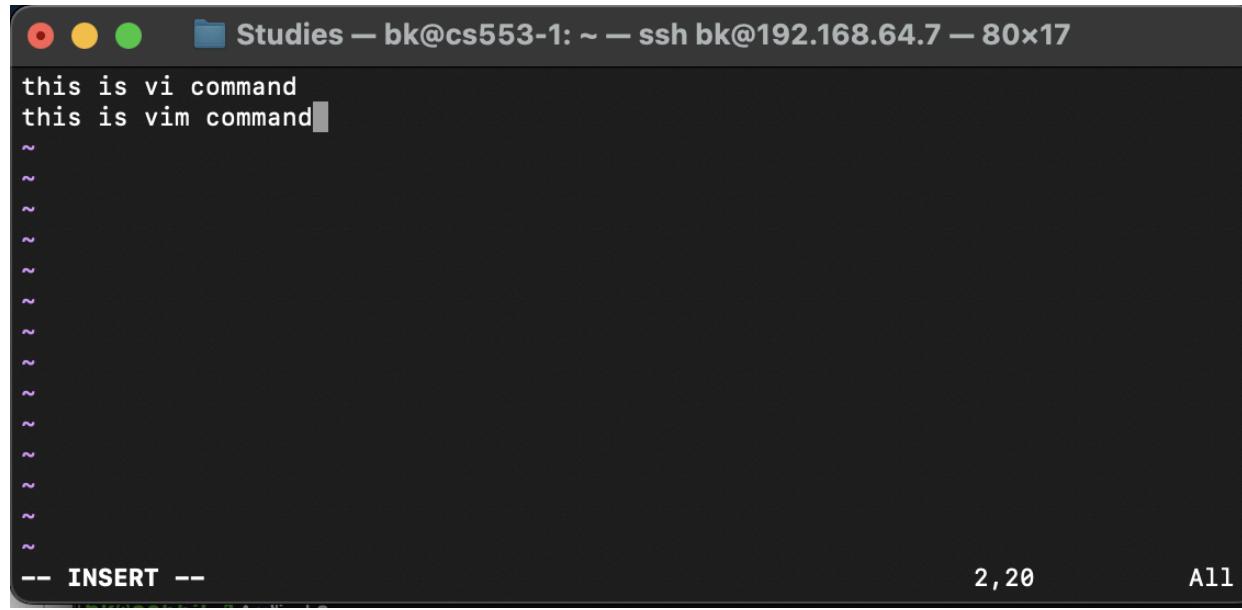
```
[bk@cs553-1:~$ du -sh /home/
104K    /home/
[bk@cs553-1:~$ df -H
Filesystem              Size  Used  Avail Use% Mounted on
tmpfs                  207M  1.4M  205M  1% /run
/dev/mapper/ubuntu--vg-ubuntu--lv  12G  5.4G  5.5G  50% /
tmpfs                  1.1G   0   1.1G  0% /dev/shm
tmpfs                  5.3M   0   5.3M  0% /run/lock
/dev/vda2                2.1G 135M  1.8G  8% /boot
/dev/vda1                1.2G  6.7M  1.2G  1% /boot/efi
tmpfs                  207M  4.1k  207M  1% /run/user/1000
[bk@cs553-1:~$ ]
```

- ff. screen - used to create new terminal sessions within the terminal. It is possible to move between screens, attach and detach them.



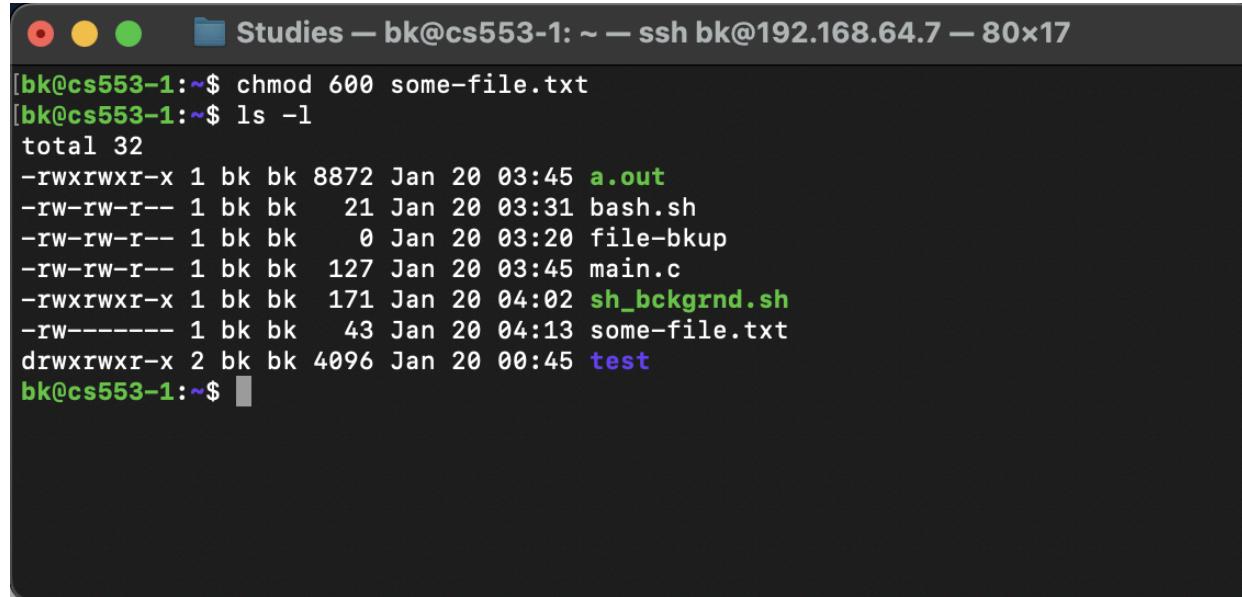
```
[bk@cs553-1:~$ du -sh /home/
104K    /home/
[bk@cs553-1:~$ df -H
Filesystem              Size  Used  Avail Use% Mounted on
tmpfs                  207M  1.4M  205M  1% /run
/dev/mapper/ubuntu--vg-ubuntu--lv  12G  5.4G  5.5G  50% /
tmpfs                  1.1G   0   1.1G  0% /dev/shm
tmpfs                  5.3M   0   5.3M  0% /run/lock
/dev/vda2                2.1G 135M  1.8G  8% /boot
/dev/vda1                1.2G  6.7M  1.2G  1% /boot/efi
tmpfs                  207M  4.1k  207M  1% /run/user/1000
[bk@cs553-1:~$ screen
[screen is terminating]
[bk@cs553-1:~$ ]
```

gg. vim - vim is a text editor similar to vi but has more feature. Much like top and htop.



A screenshot of a terminal window titled "Studies" on a Linux system. The window shows the command "this is vi command" followed by "this is vim command". Below these lines are approximately 20 blank lines starting with a tilde (~). At the bottom of the screen, the status bar displays "-- INSERT --" on the left, "2,20" in the center, and "All" on the right. The terminal window has a dark background with light-colored text and a standard Linux window title bar.

hh. chmod - changes permissions of a file or a directory, permissions for read, write and execute permissions of a file.



A screenshot of a terminal window titled "Studies" on a Linux system. The user runs the command "chmod 600 some-file.txt" and then lists files with "ls -l". The output shows the following file permissions:

File	Permissions	User	Group	Last Modified	Size
a.out	-rwxrwxr-x	bk	bk	Jan 20 03:45	8872
bash.sh	-rwxr--r--	bk	bk	Jan 20 03:31	21
file-bkup	-rwxr--r--	bk	bk	Jan 20 03:20	0
main.c	-rwxr--r--	bk	bk	Jan 20 03:45	127
sh_bckgrnd.sh	-rwxrwxr-x	bk	bk	Jan 20 04:02	171
some-file.txt	-rw----	bk	bk	Jan 20 04:13	43
test	drwxrwxr-x	bk	bk	Jan 20 00:45	4096

The terminal window has a dark background with light-colored text and a standard Linux window title bar.

- ii. chown - used to change ownership of a file or a directory

```
Studies — bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x17

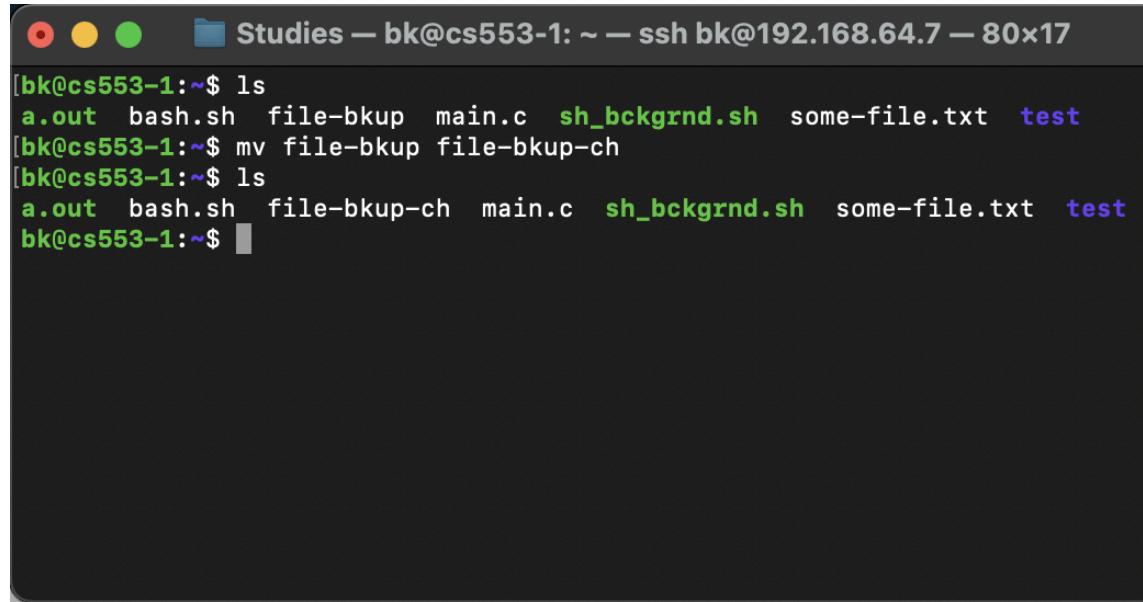
-rw-rw-r-- 1 bk bk 0 Jan 20 03:20 file-bkup
-rw-rw-r-- 1 bk bk 127 Jan 20 03:45 main.c
-rwxrwxr-x 1 bk bk 171 Jan 20 04:02 sh_bckgrnd.sh
-rw----- 1 bk bk 43 Jan 20 04:13 some-file.txt
drwxrwxr-x 2 bk bk 4096 Jan 20 00:45 test
[bk@cs553-1:~$ sudo chown root main.c
[[sudo] password for bk:
[bk@cs553-1:~$ ls -l
total 32
-rwxrwxr-x 1 bk bk 8872 Jan 20 03:45 a.out
-rw-rw-r-- 1 bk bk 21 Jan 20 03:31 bash.sh
-rw-rw-r-- 1 bk bk 0 Jan 20 03:20 file-bkup
-rw-rw-r-- 1 root bk 127 Jan 20 03:45 main.c
-rwxrwxr-x 1 bk bk 171 Jan 20 04:02 sh_bckgrnd.sh
-rw----- 1 bk bk 43 Jan 20 04:13 some-file.txt
drwxrwxr-x 2 bk bk 4096 Jan 20 00:45 test
bk@cs553-1:~$
```

- jj. useradd - adds new user to the machine

```
Studies — bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x17

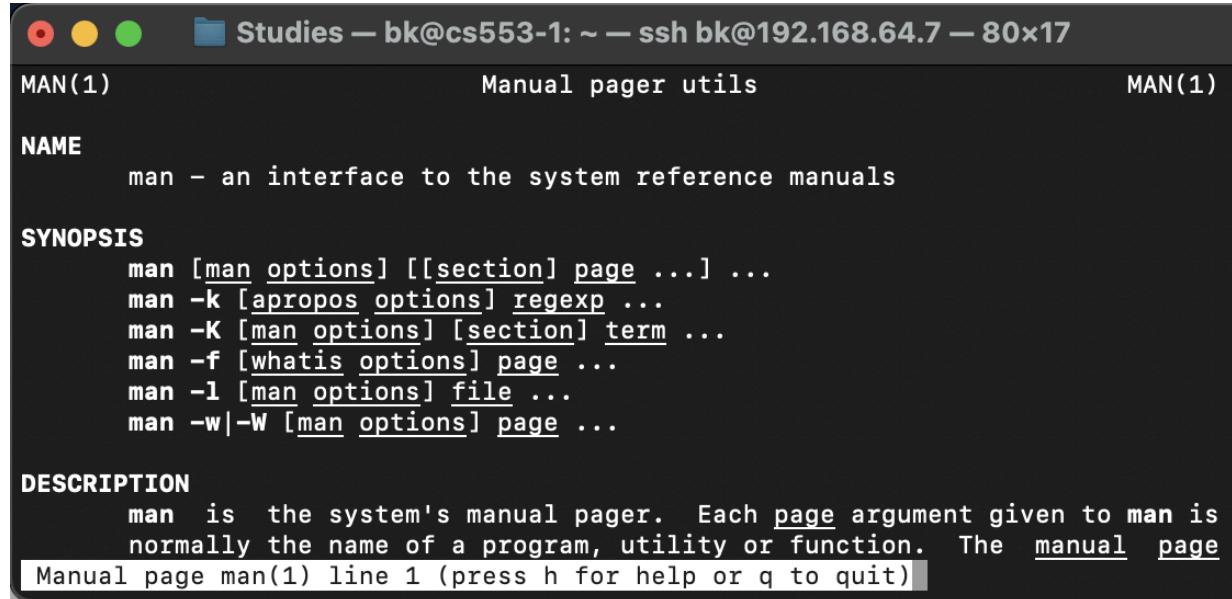
[bk@cs553-1:~$ sudo useradd guest
[bk@cs553-1:~$ getent passwd
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
bin:x:2:2:bin:/bin:/usr/sbin/nologin
sys:x:3:3:sys:/dev:/usr/sbin/nologin
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
```

kk. mv - used to change a file name or move it from one directory to another



```
[bk@cs553-1:~$ ls
a.out bash.sh file-bkup main.c sh_bckrnd.sh some-file.txt test
[bk@cs553-1:~$ mv file-bkup file-bkup-ch
[bk@cs553-1:~$ ls
a.out bash.sh file-bkup-ch main.c sh_bckrnd.sh some-file.txt test
bk@cs553-1:~$ ]
```

II. man - basically help instruction for commands in linux



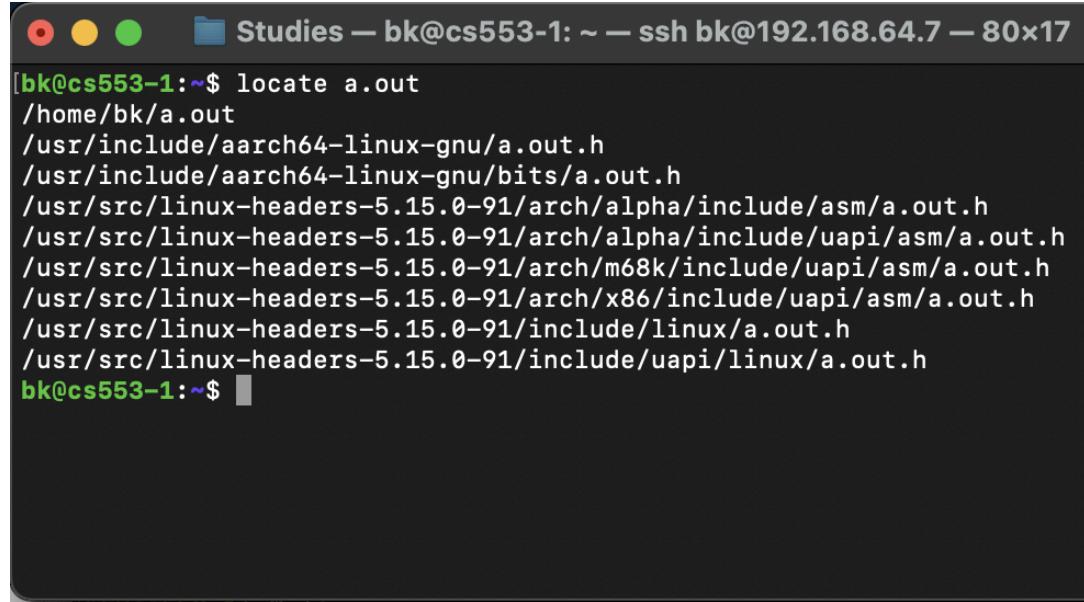
```
MAN(1)                                         Manual pager utils                                         MAN(1)

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 ...

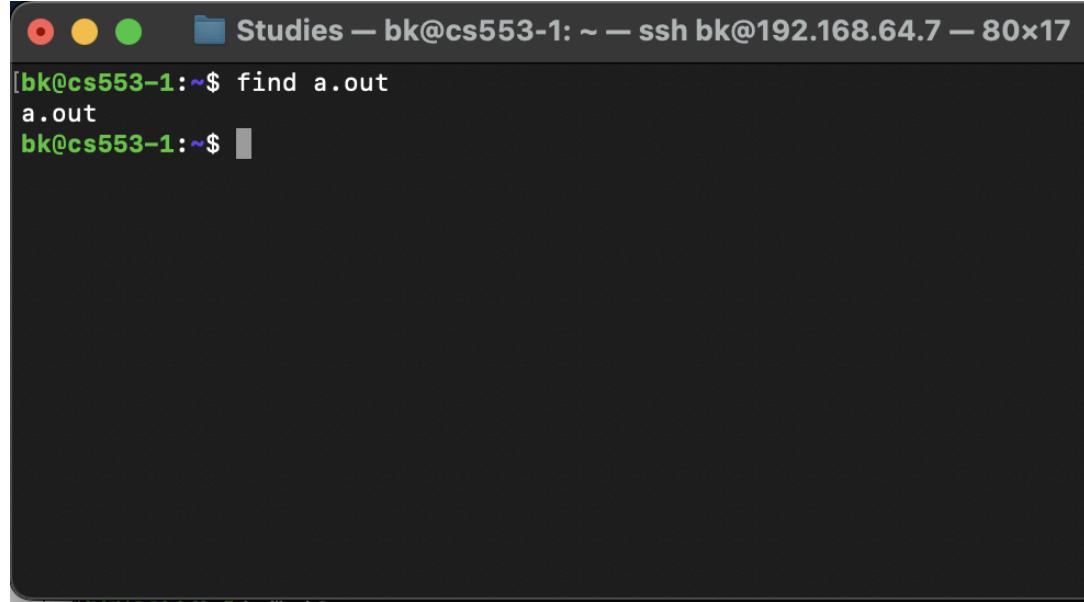
DESCRIPTION
man is the system's manual pager. Each page argument given to man is
normally the name of a program, utility or function. The manual page
Manual page man(1) line 1 (press h for help or q to quit)
```

mm. locate - searches for files on the system with a given pattern



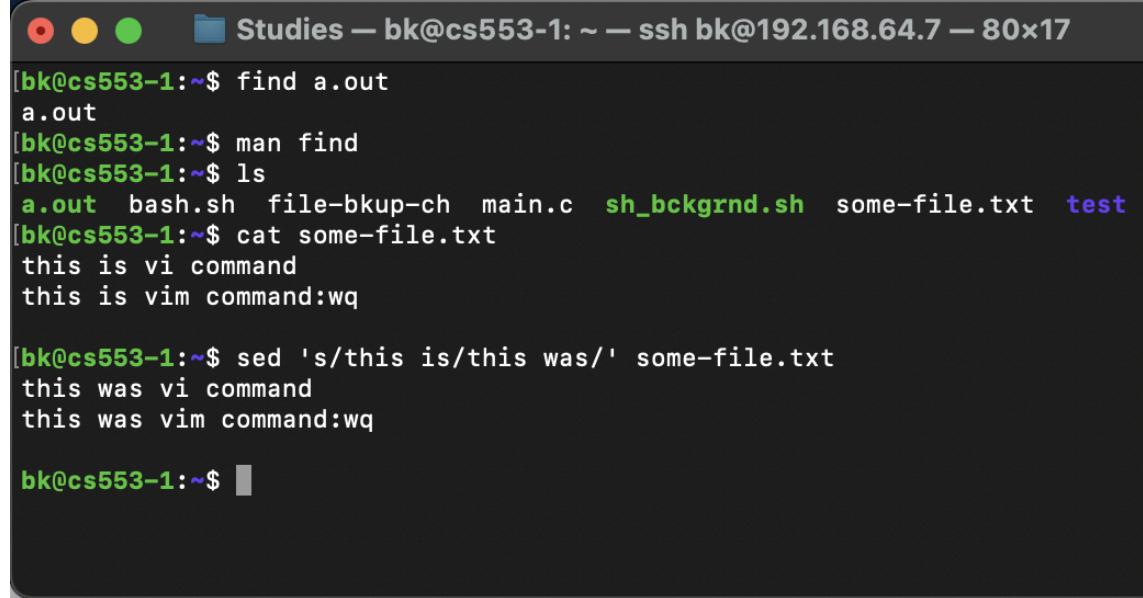
```
[bk@cs553-1:~$ locate a.out
/home/bk/a.out
/usr/include/aarch64-linux-gnu/a.out.h
/usr/include/aarch64-linux-gnu/bits/a.out.h
/usr/src/linux-headers-5.15.0-91/arch/alpha/include/asm/a.out.h
/usr/src/linux-headers-5.15.0-91/arch/alpha/include/uapi/asm/a.out.h
/usr/src/linux-headers-5.15.0-91/arch/m68k/include/uapi/asm/a.out.h
/usr/src/linux-headers-5.15.0-91/arch/x86/include/uapi/asm/a.out.h
/usr/src/linux-headers-5.15.0-91/include/linux/a.out.h
/usr/src/linux-headers-5.15.0-91/include/uapi/linux/a.out.h
bk@cs553-1:~$ ]
```

nn. find - traverses through directory tree rooted at the current location



```
[bk@cs553-1:~$ find a.out
a.out
bk@cs553-1:~$ ]
```

oo. sed - stream file content editor, goes through file once

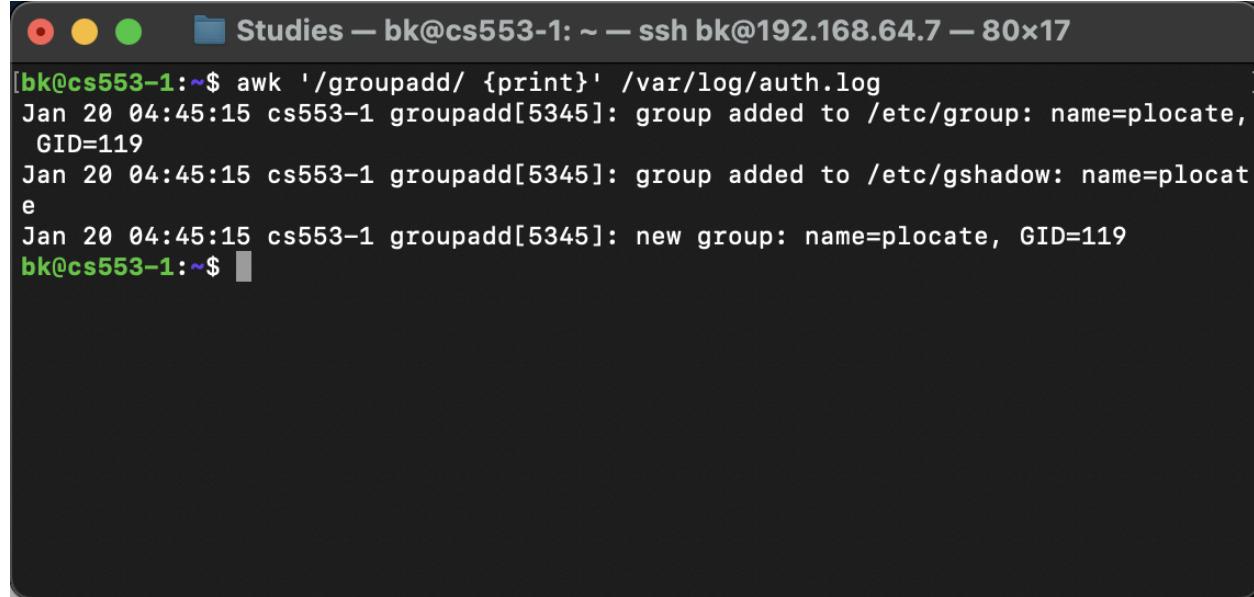


```
[bk@cs553-1:~$ find a.out
a.out
[bk@cs553-1:~$ man find
[bk@cs553-1:~$ ls
a.out bash.sh file-bkup-ch main.c sh_bckgrnd.sh some-file.txt test
[bk@cs553-1:~$ cat some-file.txt
this is vi command
this is vim command:wq

[bk@cs553-1:~$ sed 's/this is/this was/' some-file.txt
this was vi command
this was vim command:wq

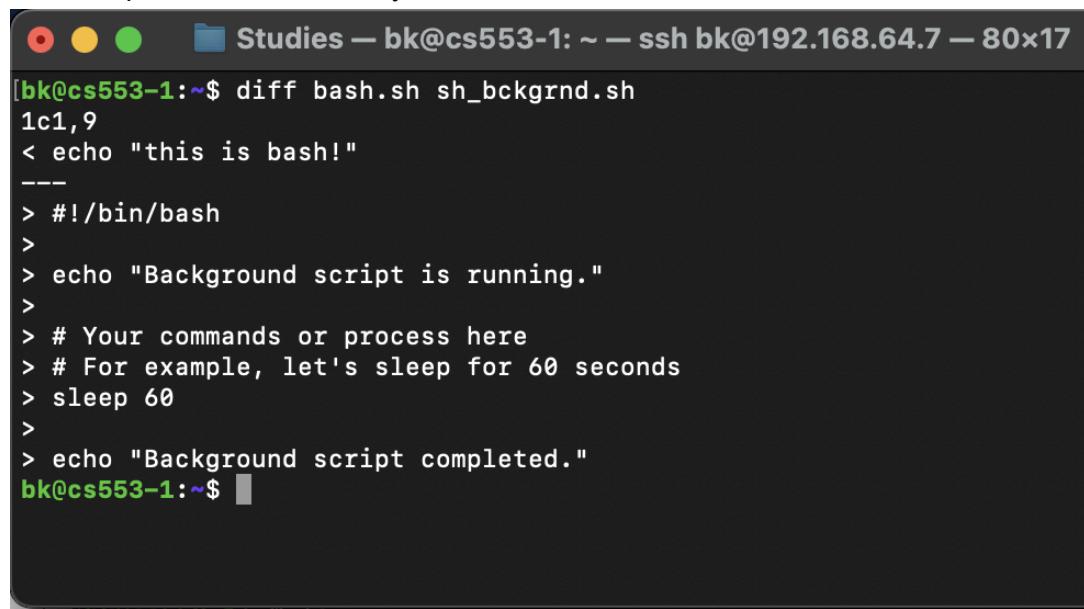
bk@cs553-1:~$ ]
```

pp. awk - a tool used to scan and process files, like csv



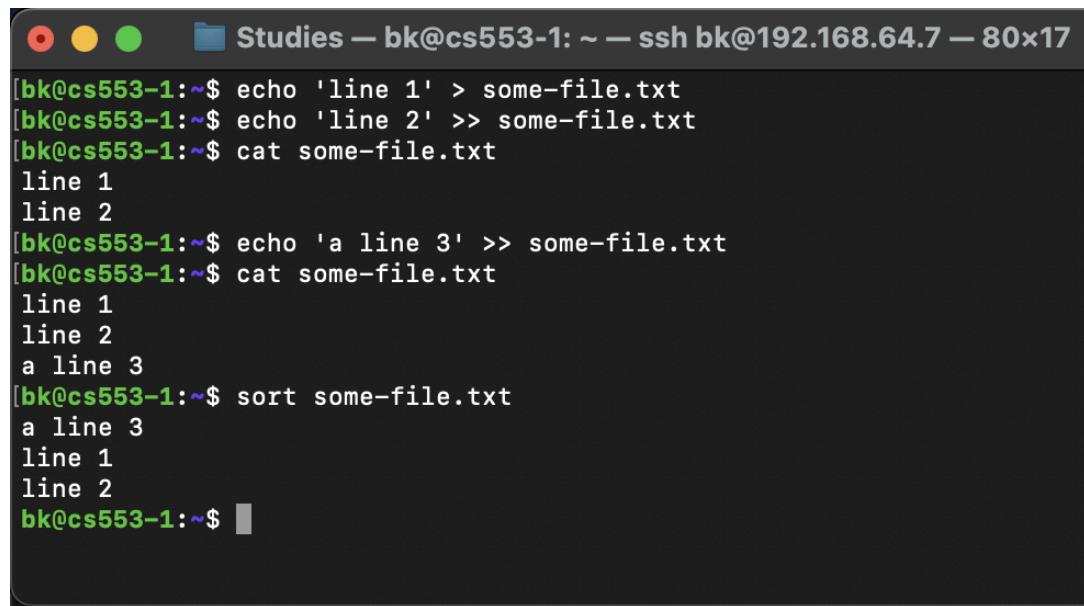
```
[bk@cs553-1:~$ awk '/groupadd/ {print}' /var/log/auth.log
Jan 20 04:45:15 cs553-1 groupadd[5345]: group added to /etc/group: name=plocate,
GID=119
Jan 20 04:45:15 cs553-1 groupadd[5345]: group added to /etc/gshadow: name=plocate
Jan 20 04:45:15 cs553-1 groupadd[5345]: new group: name=plocate, GID=119
bk@cs553-1:~$ ]
```

qq. diff - compares two files line by line, a diff tool



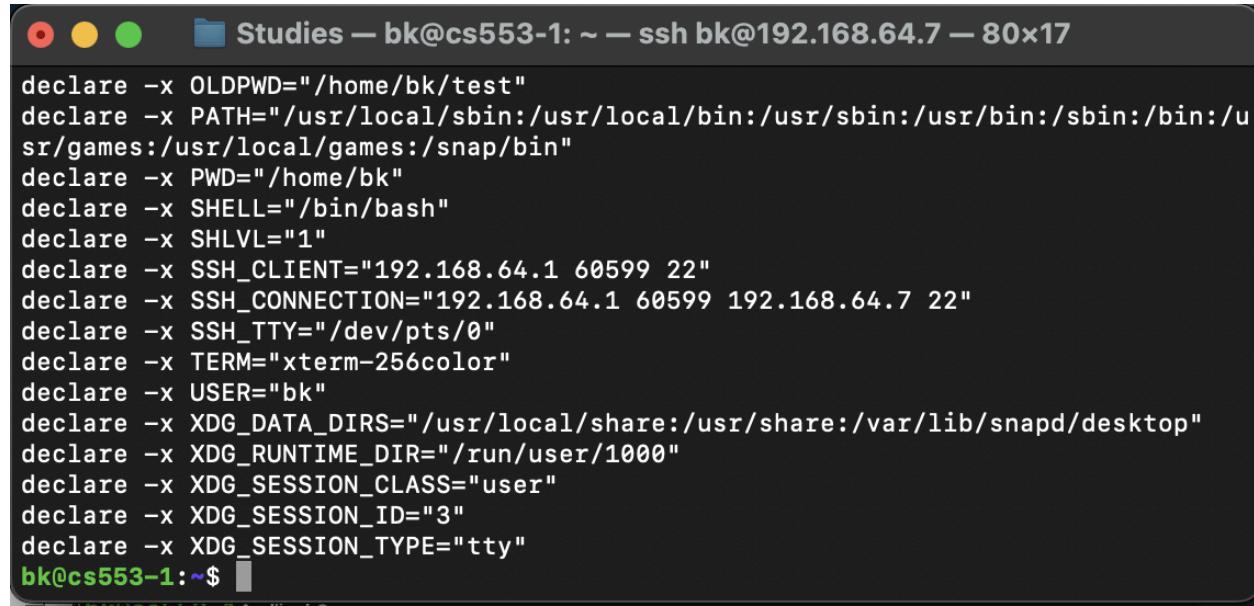
```
[bk@cs553-1:~$ diff bash.sh sh_bckgrnd.sh
1c1,9
< echo "this is bash!"
---
>#!/bin/bash
>
> echo "Background script is running."
>
> # Your commands or process here
> # For example, let's sleep for 60 seconds
> sleep 60
>
> echo "Background script completed."
bk@cs553-1:~$ ]
```

rr. sort - prints sorted lines of a file



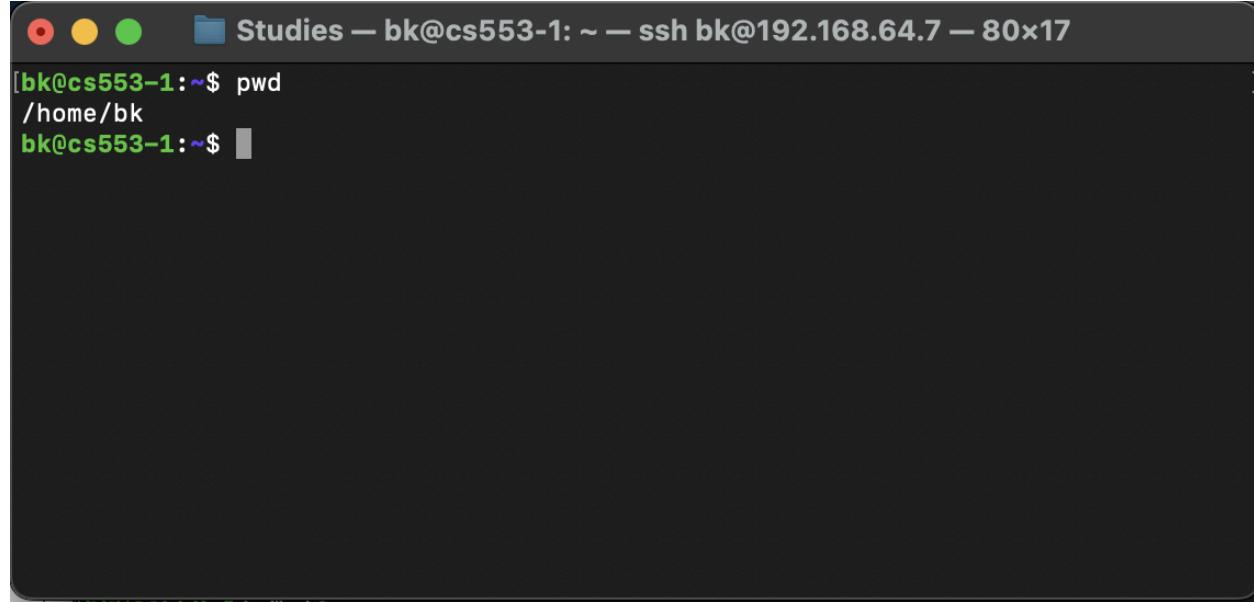
```
[bk@cs553-1:~$ echo 'line 1' > some-file.txt
[bk@cs553-1:~$ echo 'line 2' >> some-file.txt
[bk@cs553-1:~$ cat some-file.txt
line 1
line 2
[bk@cs553-1:~$ echo 'a line 3' >> some-file.txt
[bk@cs553-1:~$ cat some-file.txt
line 1
line 2
a line 3
[bk@cs553-1:~$ sort some-file.txt
a line 3
line 1
line 2
bk@cs553-1:~$ ]
```

ss. export - shows list of environment variables



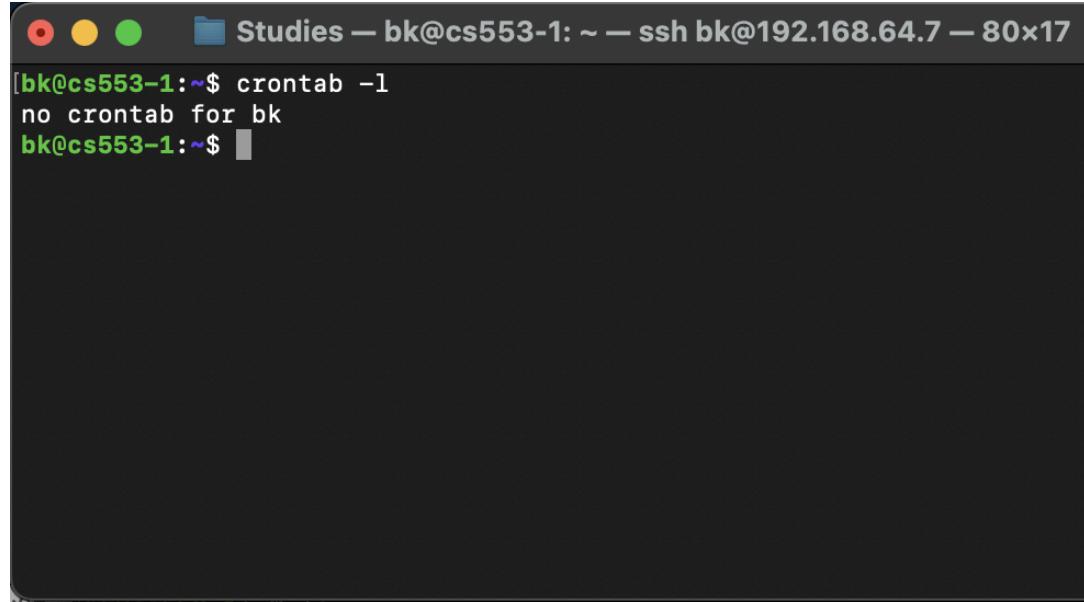
```
declare -x OLDPWD="/home/bk/test"
declare -x PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/usr/games:/usr/local/games:/snap/bin"
declare -x PWD="/home/bk"
declare -x SHELL="/bin/bash"
declare -x SHLVL="1"
declare -x SSH_CLIENT="192.168.64.1 60599 22"
declare -x SSH_CONNECTION="192.168.64.1 60599 192.168.64.7 22"
declare -x SSH_TTY="/dev/pts/0"
declare -x TERM="xterm-256color"
declare -x USER="bk"
declare -x XDG_DATA_DIRS="/usr/local/share:/usr/share:/var/lib/snapd/desktop"
declare -x XDG_RUNTIME_DIR="/run/user/1000"
declare -x XDG_SESSION_CLASS="user"
declare -x XDG_SESSION_ID="3"
declare -x XDG_SESSION_TYPE="tty"
bk@cs553-1:~$
```

tt. pwd - prints current working directory



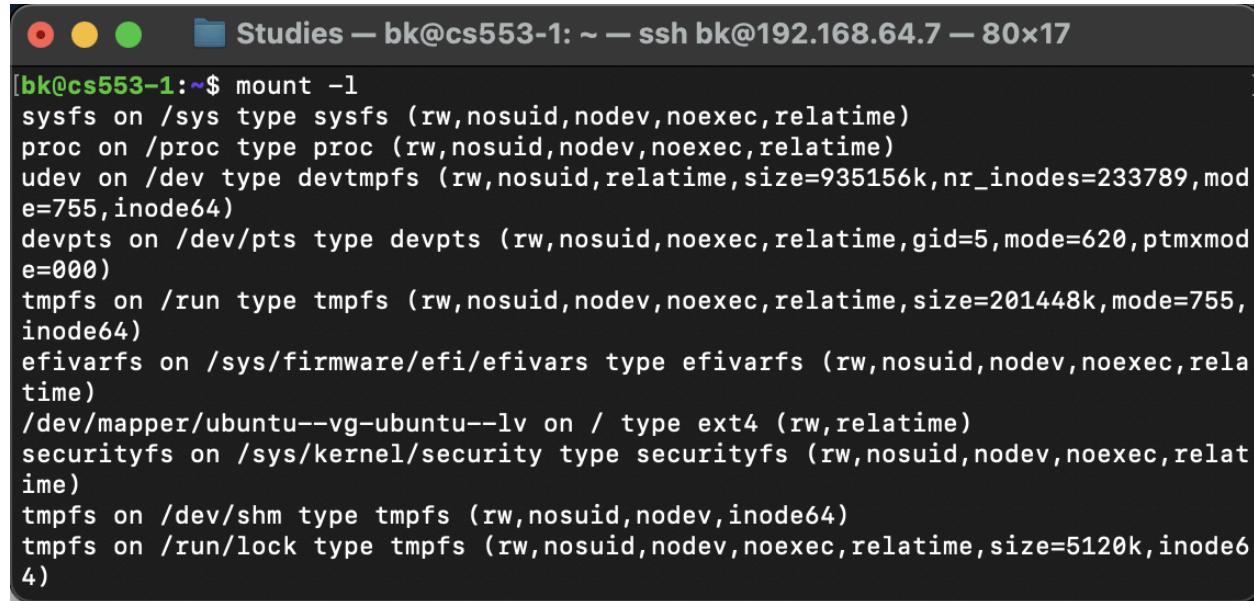
```
[bk@cs553-1:~$ pwd
/home/bk
bk@cs553-1:~$
```

uu. crontab - schedules cron job in the system



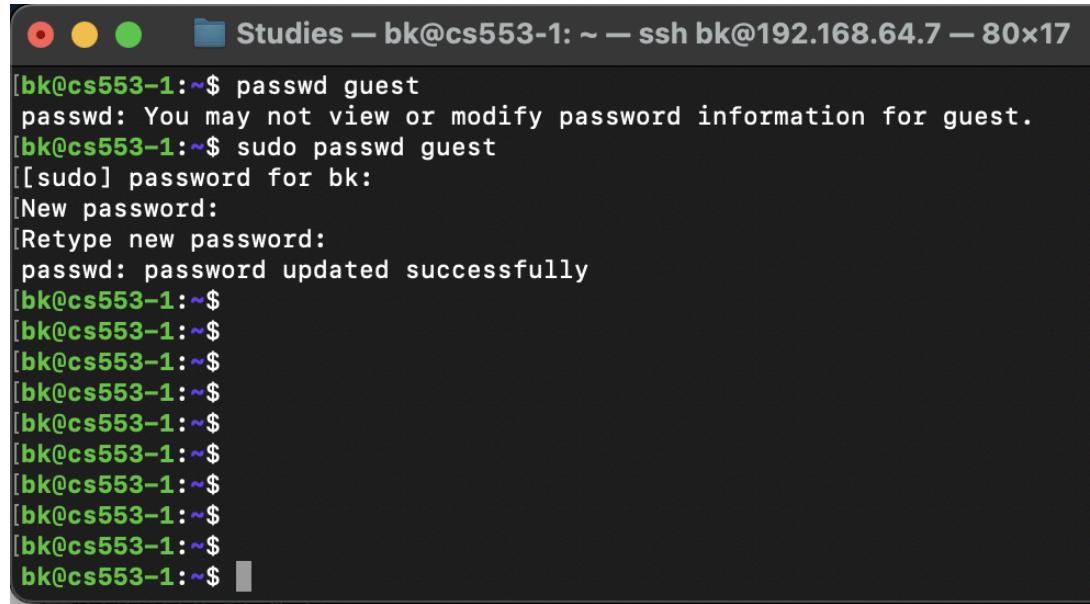
```
[bk@cs553-1:~$ crontab -l
no crontab for bk
bk@cs553-1:~$ ]
```

vv. mount - mounts folders and filesystems. Enables sharing directories among several devices.



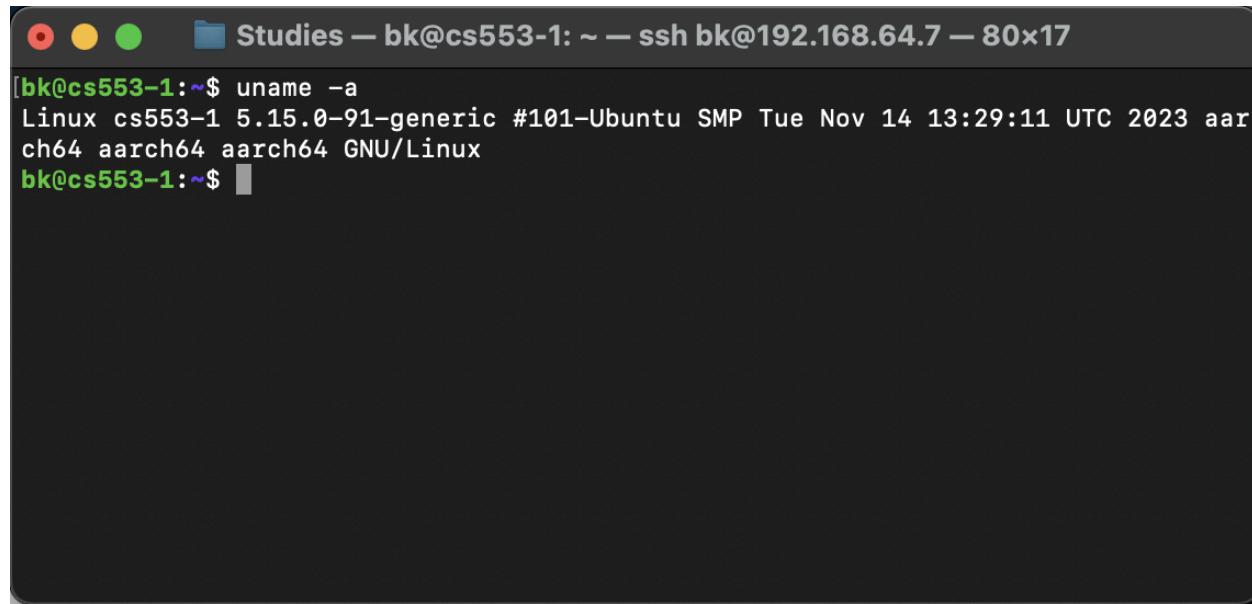
```
[bk@cs553-1:~$ mount -l
sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime)
proc on /proc type proc (rw,nosuid,nodev,noexec,relatime)
udev on /dev type devtmpfs (rw,nosuid,relatime,size=935156k,nr_inodes=233789,mode=755,inode64)
devpts on /dev/pts type devpts (rw,nosuid,noexec,relatime,gid=5,mode=620,ptmxmode=000)
tmpfs on /run type tmpfs (rw,nosuid,nodev,noexec,relatime,size=201448k,mode=755,inode64)
efivarfs on /sys/firmware/efi/efivars type efivarfs (rw,nosuid,nodev,noexec,relatime)
/dev/mapper/ubuntu--vg-ubuntu--lv on / type ext4 (rw,relatime)
securityfs on /sys/kernel/security type securityfs (rw,nosuid,nodev,noexec,relatime)
tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev,inode64)
tmpfs on /run/lock type tmpfs (rw,nosuid,nodev,noexec,relatime,size=5120k,inode64)
```

ww. passwd - used to change password of a user



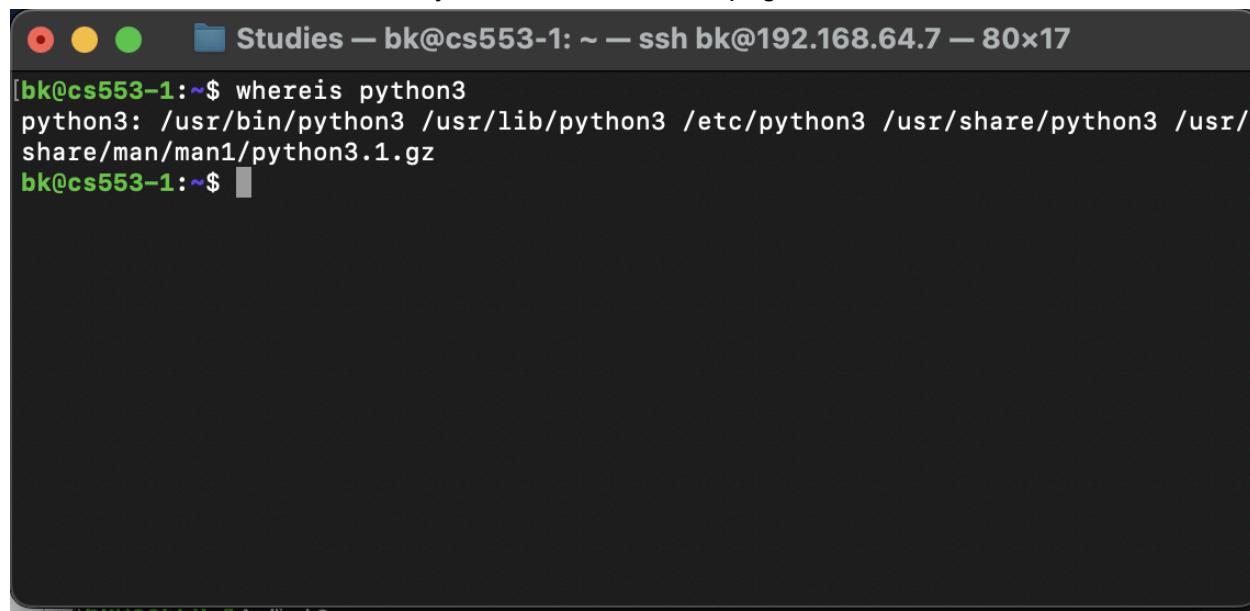
```
[bk@cs553-1:~$ passwd guest
passwd: You may not view or modify password information for guest.
[bk@cs553-1:~$ sudo passwd guest
[sudo] password for bk:
[New password:
[Retype new password:
passwd: password updated successfully
[bk@cs553-1:~$
```

xx. uname - shows information on the current system



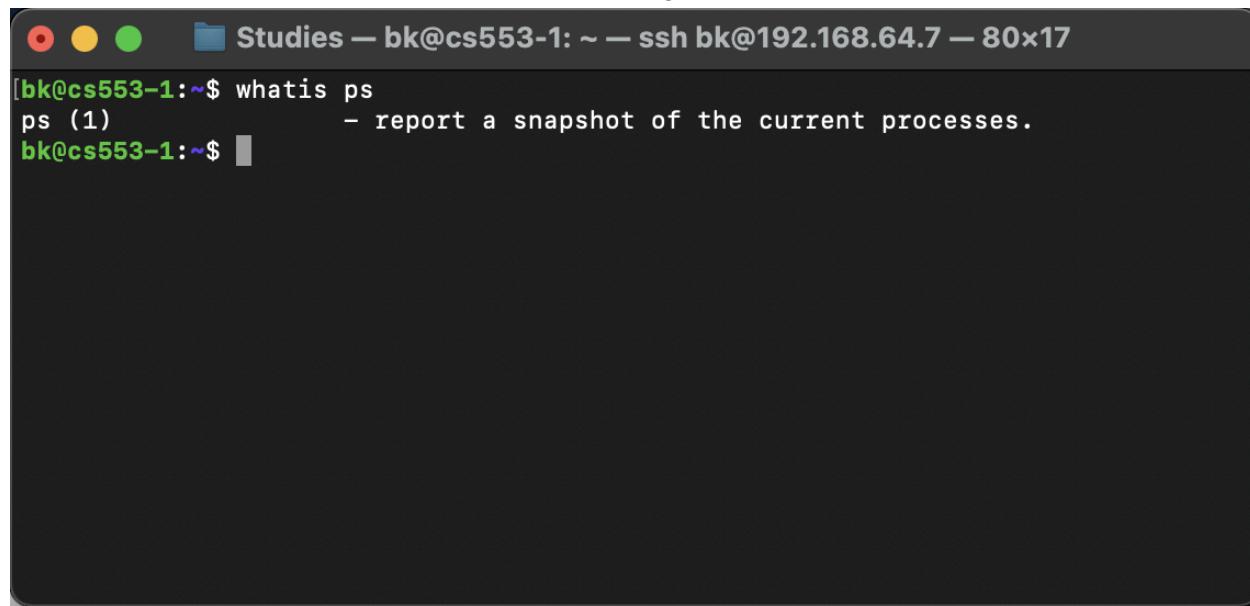
```
[bk@cs553-1:~$ uname -a
Linux cs553-1 5.15.0-91-generic #101-Ubuntu SMP Tue Nov 14 13:29:11 UTC 2023 aarch64 aarch64 aarch64 GNU/Linux
bk@cs553-1:~$
```

yy. whereis - finds location of a binary, source, and manual page of a command



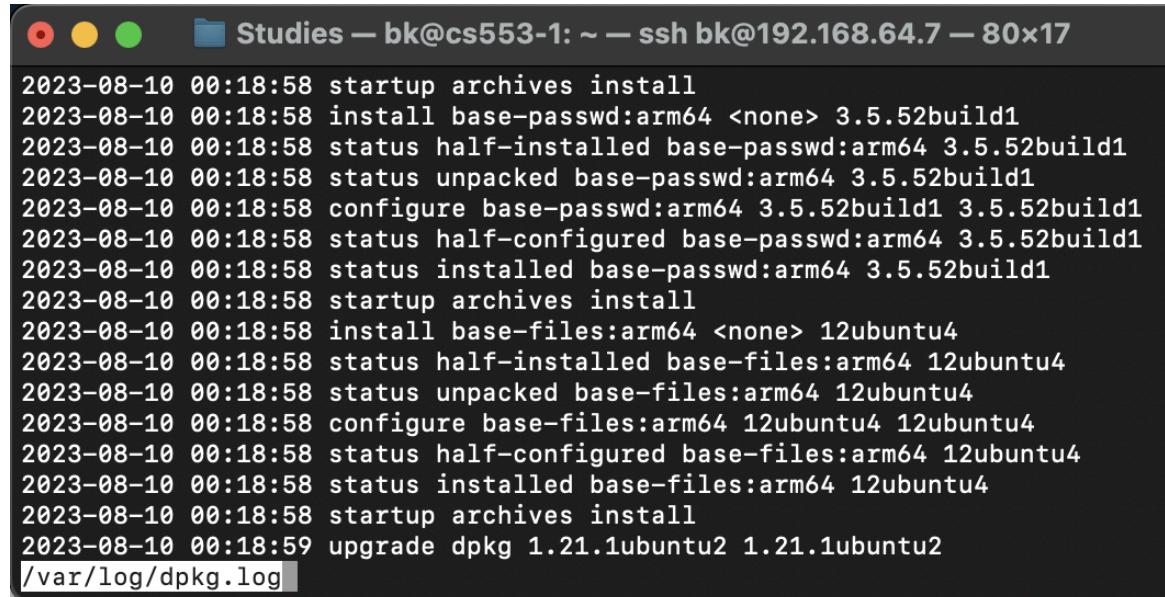
```
[bk@cs553-1:~$ whereis python3
python3: /usr/bin/python3 /usr/lib/python3 /etc/python3 /usr/share/python3 /usr/
share/man/man1/python3.1.gz
bk@cs553-1:~$ ]
```

zz. whatis - shows one line description of a manual page, short version for man



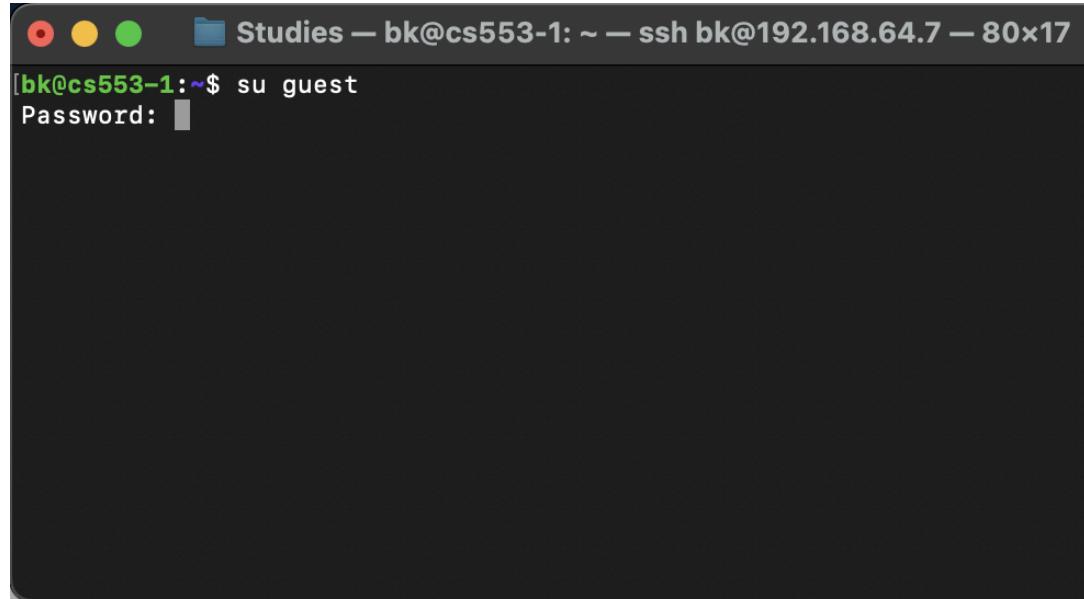
```
[bk@cs553-1:~$ whatis ps
ps (1)                         - report a snapshot of the current processes.
bk@cs553-1:~$ ]
```

aaa. less - the opposite of more



```
2023-08-10 00:18:58 startup archives install
2023-08-10 00:18:58 install base-passwd:arm64 <none> 3.5.52build1
2023-08-10 00:18:58 status half-installed base-passwd:arm64 3.5.52build1
2023-08-10 00:18:58 status unpacked base-passwd:arm64 3.5.52build1
2023-08-10 00:18:58 configure base-passwd:arm64 3.5.52build1 3.5.52build1
2023-08-10 00:18:58 status half-configured base-passwd:arm64 3.5.52build1
2023-08-10 00:18:58 status installed base-passwd:arm64 3.5.52build1
2023-08-10 00:18:58 startup archives install
2023-08-10 00:18:58 install base-files:arm64 <none> 12ubuntu4
2023-08-10 00:18:58 status half-installed base-files:arm64 12ubuntu4
2023-08-10 00:18:58 status unpacked base-files:arm64 12ubuntu4
2023-08-10 00:18:58 configure base-files:arm64 12ubuntu4 12ubuntu4
2023-08-10 00:18:58 status half-configured base-files:arm64 12ubuntu4
2023-08-10 00:18:58 status installed base-files:arm64 12ubuntu4
2023-08-10 00:18:58 startup archives install
2023-08-10 00:18:59 upgrade dpkg 1.21.1ubuntu2 1.21.1ubuntu2
/var/log/dpkg.log
```

bbb. su - allows user to run command with another user or group ID



```
[bk@cs553-1:~$ su guest
Password:
```

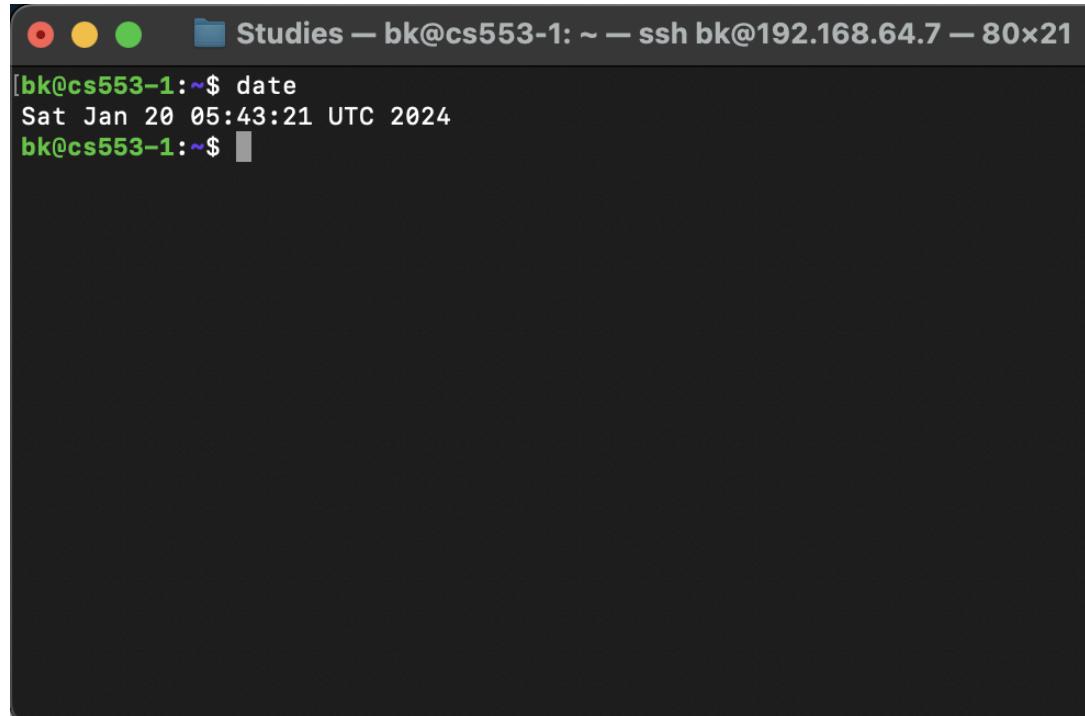
ccc. ping - sends icmp echo request checks network connection with a server

```
[bk@cs553-1:~$ ping google.com
PING google.com (142.250.191.174) 56(84) bytes of data.
64 bytes from ord38s30-in-f14.1e100.net (142.250.191.174): icmp_seq=1 ttl=55 time=5.41 ms
64 bytes from ord38s30-in-f14.1e100.net (142.250.191.174): icmp_seq=2 ttl=55 time=4.39 ms
64 bytes from ord38s30-in-f14.1e100.net (142.250.191.174): icmp_seq=3 ttl=55 time=4.98 ms
^C
--- google.com ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2007ms
rtt min/avg/max/mdev = 4.387/4.926/5.414/0.420 ms
bk@cs553-1:~$ ]
```

ddd. traceroute - as the name suggests, it traces route to the destination host

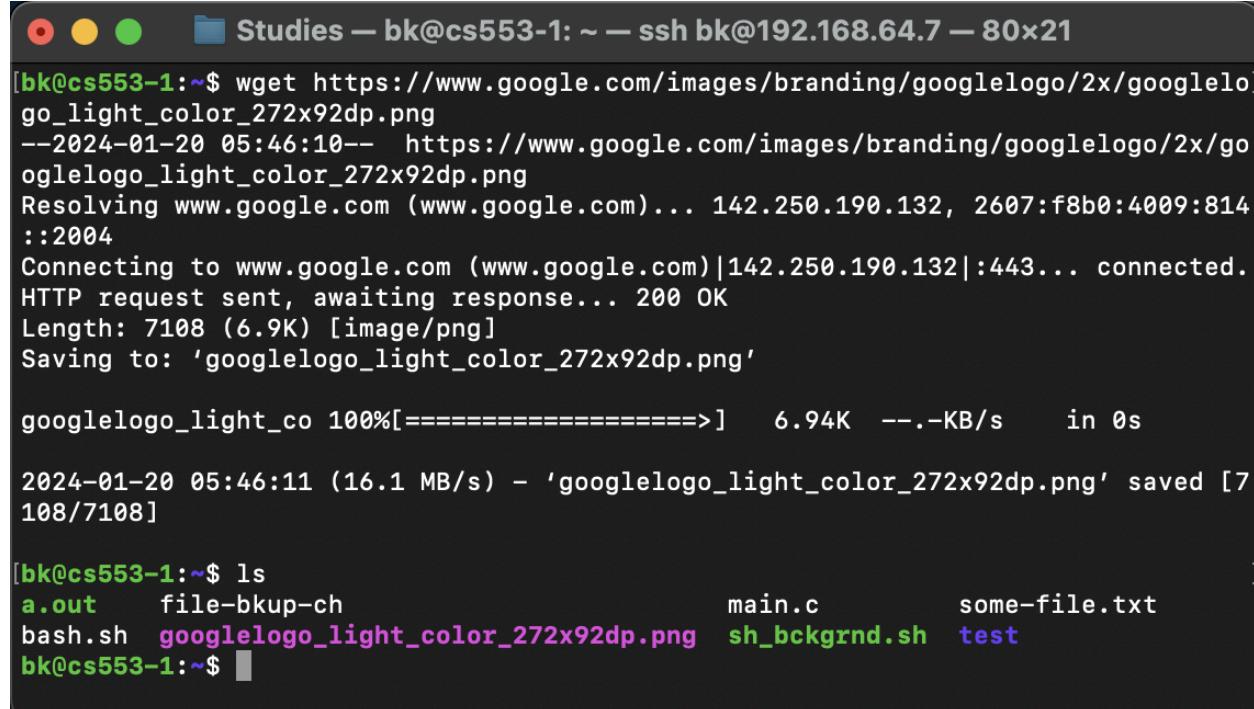
```
[bk@cs553-1:~$ traceroute google.com
traceroute to google.com (142.250.191.174), 30 hops max, 60 byte packets
1 _gateway (192.168.64.1) 1.176 ms 1.057 ms 1.029 ms
2 104.194.112.1 (104.194.112.1) 3.162 ms 3.135 ms 6.025 ms
3 216.47.159.165 (216.47.159.165) 5.999 ms 5.986 ms 5.973 ms
4 host-131-239-179-217.customer.veroxity.net (131.239.179.217) 5.935 ms 5.78
5 ms 5.649 ms
5 160.72.249.3.lightower.net (160.72.249.3) 5.693 ms 5.495 ms 5.458 ms
6 144.121.109.123.lightower.net (144.121.109.123) 5.363 ms * *
7 * *
8 ae2.3601.edge3.Chicago10.level3.net (4.69.206.246) 27.553 ms ae1.3501.edge3
.Chicago10.level3.net (4.69.206.242) 31.457 ms 31.424 ms
9 Google-level3-Chicago10.Level3.net (4.68.127.114) 92.360 ms Google-level3-C
hicago10.Level3.net (4.68.63.130) 5.768 ms 6.991 ms
10 * *
11 108.170.243.225 (108.170.243.225) 16.195 ms 16.186 ms 142.251.60.4 (142.25
1.60.4) 7.582 ms
12 142.251.60.9 (142.251.60.9) 6.798 ms 4.033 ms 3.971 ms
13 ord38s30-in-f14.1e100.net (142.250.191.174) 3.972 ms 209.85.250.146 (209.85
.250.146) 4.642 ms ord38s30-in-f14.1e100.net (142.250.191.174) 14.547 ms
bk@cs553-1:~$ ]
```

eee. date - prints current datetime of the system



```
[bk@cs553-1:~$ date
Sat Jan 20 05:43:21 UTC 2024
bk@cs553-1:~$ ]
```

fff. wget - downloads a file over network



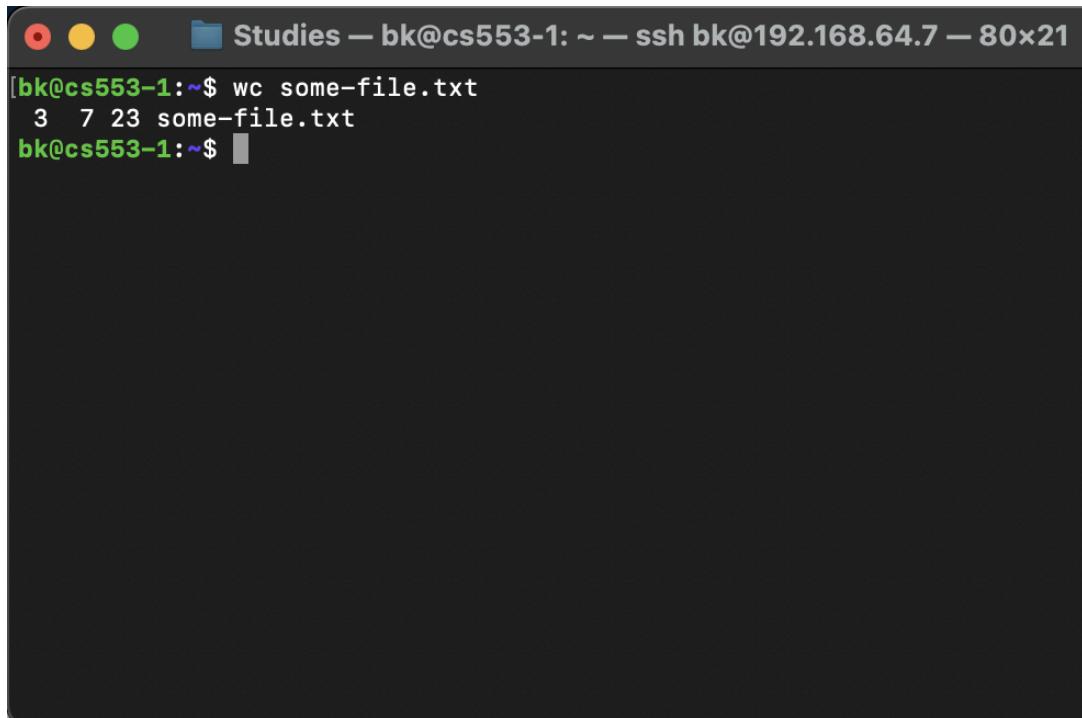
```
[bk@cs553-1:~$ wget https://www.google.com/images/branding/googlelogo/2x/googlelogo_light_color_272x92dp.png
--2024-01-20 05:46:10-- https://www.google.com/images/branding/googlelogo/2x/googlelogo_light_color_272x92dp.png
Resolving www.google.com (www.google.com)... 142.250.190.132, 2607:f8b0:4009:814
::2004
Connecting to www.google.com (www.google.com)|142.250.190.132|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 7108 (6.9K) [image/png]
Saving to: 'googlelogo_light_color_272x92dp.png'

googlelogo_light_co 100%[=====] 6.94K --.-KB/s   in 0s

2024-01-20 05:46:11 (16.1 MB/s) - 'googlelogo_light_color_272x92dp.png' saved [7108/7108]

[bk@cs553-1:~$ ls
a.out      file-bkup-ch                      main.c          some-file.txt
bash.sh    googlelogo_light_color_272x92dp.png sh_bckgrnd.sh test
bk@cs553-1:~$ ]
```

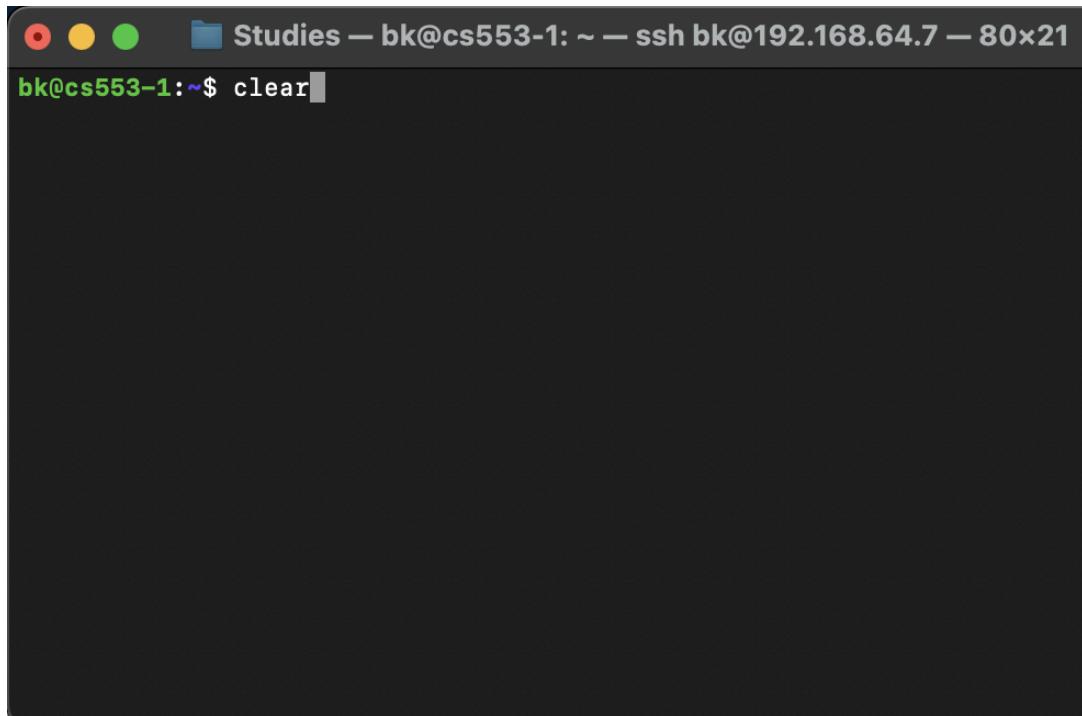
ggg. wc - returns newline, word and byte count of a file



```
[bk@cs553-1:~$ wc some-file.txt
 3 7 23 some-file.txt
bk@cs553-1:~$ ]
```

A screenshot of a terminal window titled "Studies" on a Linux system. The title bar shows the session details: "bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x21". The terminal prompt is "bk@cs553-1:~\$". The user has run the command "wc some-file.txt", which outputs three lines: "3", "7", and "23", followed by the filename "some-file.txt". The terminal window has a dark background with light-colored text.

hhh. clear - clears the screen

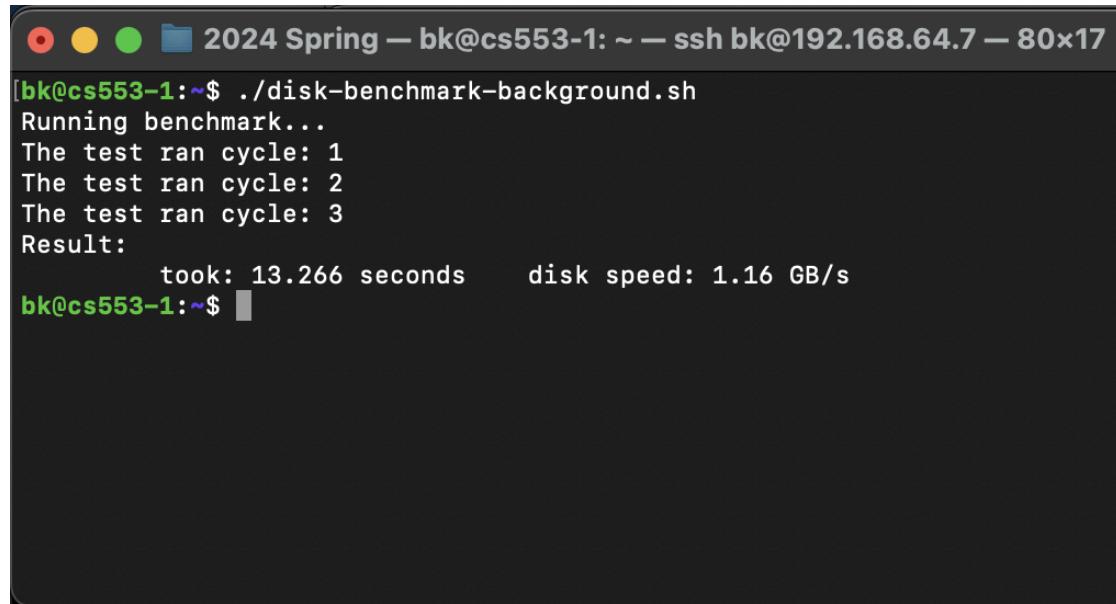


```
[bk@cs553-1:~$ clear]
```

A screenshot of a terminal window titled "Studies" on a Linux system. The title bar shows the session details: "bk@cs553-1: ~ — ssh bk@192.168.64.7 — 80x21". The terminal prompt is "bk@cs553-1:~\$". The user has run the command "clear", which is shown at the bottom of the terminal window. The terminal window has a dark background with light-colored text.

3. (25 points) Write bash scripts to do the following:

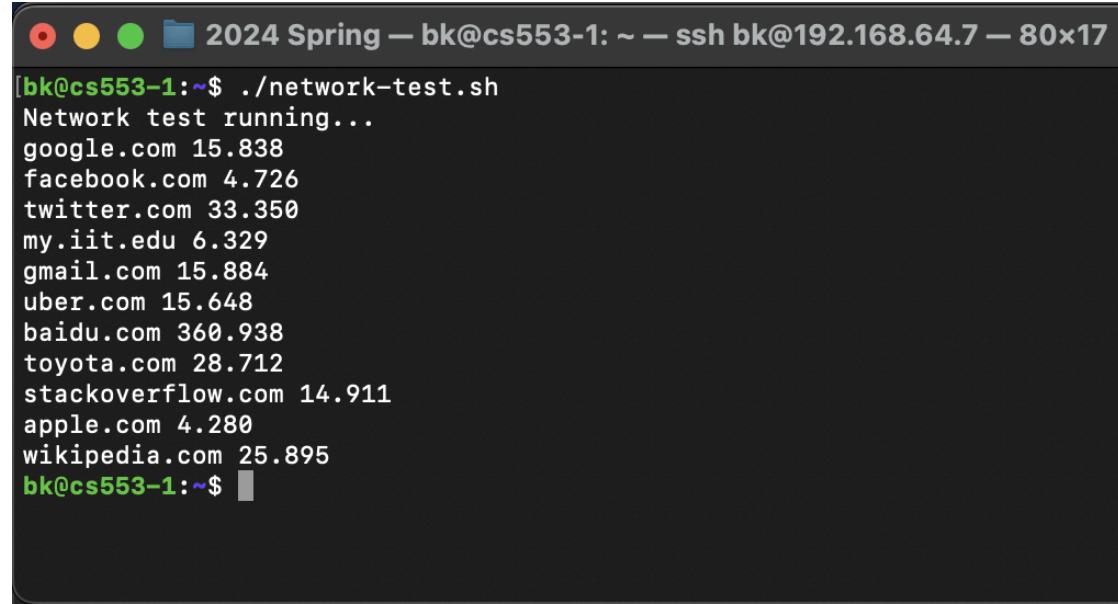
- a. Write a script called “disk-benchmark-background.sh” that uses the dd command to run a benchmark against the local disk in the background, that captures all the output (both standard out and error output) to a file “disk-benchmark-background-log.txt”. Use the “time” command to show how long the 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.



```
[bk@cs553-1:~$ ./disk-benchmark-background.sh
Running benchmark...
The test ran cycle: 1
The test ran cycle: 2
The test ran cycle: 3
Result:
    took: 13.266 seconds    disk speed: 1.16 GB/s
bk@cs553-1:~$ ]
```

The test script and output is attached in the repo.

- b. Write a script called “network-test.sh” that takes input a file “network-test-machinelist.txt” with a list of DNS names (e.g. google.com, iit.edu, anl.gov), each name on a separate line, and runs the ping utility collecting 3 samples from each DNS name, and writing the RTT (round trip time) average latency into a file “network-test-latency.txt” where each line will have the DNS name and average RTT separated by a space. Make sure it works with at least 10 DNS names, but it should work for an unspecified number of DNS names

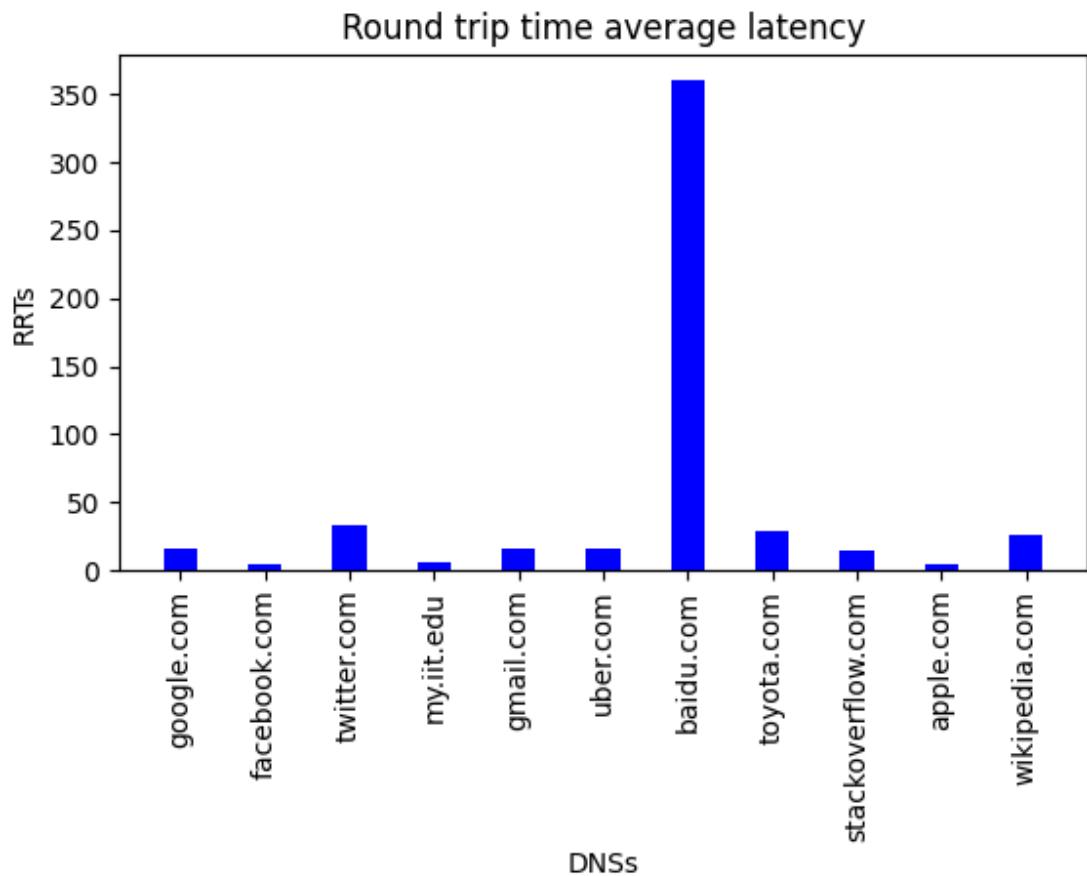


The screenshot shows a terminal window titled "2024 Spring – bk@cs553-1: ~ – ssh bk@192.168.64.7 – 80x17". The command "../network-test.sh" is run, followed by a list of websites and their corresponding latencies. The output is as follows:

```
[bk@cs553-1:~$ ../network-test.sh
Network test running...
google.com 15.838
facebook.com 4.726
twitter.com 33.350
my.iit.edu 6.329
gmail.com 15.884
uber.com 15.648
baidu.com 360.938
toyota.com 28.712
stackoverflow.com 14.911
apple.com 4.280
wikipedia.com 25.895
bk@cs553-1:~$ ]
```

The test script and output is attached in the repo.

- c. Write a Python matplotlib script to generate a graph of the “network-test-latency.txt” data. The graph should automatically adjust to the number of entries, and the scale of the data.



The script is attached in the repo.

4. (15 points) Answer the following questions about VMs:

- 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?

Changing the number of cores in the VM has a critical performance impact for the VM and the host machine. If the VM has a graphical user interface and runs CPU intensive tasks such as encrypting/decrypting information or parallel computing, it may be a good idea to increase the number of cores. However, if the task relies more on disk and RAM rather than CPU computations, the number of cores can be kept minimum. The reason why maximizing the core count for VMs is a bad idea is that the host machine might lack CPU resources to operate which can degrade performance for both the VMs and the host machine.

- 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.

- i. None - No virtualization.
- ii. Legacy - Older virtualization method.
- iii. Minimal - mandatory for MacOS users.
- iv. Hyper-V - Enables paravirtualization features for Microsoft's Hyper-V hypervisor, recommended for windows users
- v. KVM - Presents a Linux KVM hypervisor interface. This implementation currently supports paravirtualized clocks and SMP spinlocks, and is recommended for Linux users

KVM is the best option for Ubuntu Linux because it offers almost bare-metal performance advantage with its own independent resources. It results in apps running with better performance and lower latency.

- 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.
 - i. IDE - is an older storage controller that supports old hard drives, CD/DVD-ROMs etc. When working with older hardwares, using IDE controller would be a good option.
 - ii. SATA - is a more widely used and newer storage controller standard. It performs better than IDE. For general purpose virtualization, SATA is a good option since it has an interface with a lot of modern hardwares and better performance than IDE.
 - iii. NVMe - is a more modern storage controller standard, and outperforms SATA. While SATA is dedicated for spinning harddrives, NVMe is for SSDs and takes advantage of parallel operations. NVMe is used in high performance computing, multicloud and mainframes.
- 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.
 - i. NAT - masks all network activity from VM, as if it is accessing an outside network from the host. It is a good option when you want to access the internet but want to keep the VM hidden from the external network.
 - ii. Bridged Adapter - replicates another node on the physical network, making the VM look like a separate machine from the external network. When deploying systems separately on multiple VMs on the same host

- and accessible from outside, Bridged Adapter is used. Like deploying a web server.
- iii. Internal Network - VMs on the same host can talk to each other, but not the outside network or the host. So VMs in Internal Network can't communicate with the internet and the host. Can be used when setting up a test environment for a development project.
 - iv. Host-Only Network - VMs on the same host can talk to each other, but not the network beyond the host itself. It is a good configuration for a web server where only the host and the VMs on it can access the database for example, but not the external network.
- e. For the USB configuration of the VM, explain the difference between USB 1.1, 2.0, and 3.0 controllers.
- i. USB 1.1 - is the initial USB standard. It can transfer data up to 12Mbps. Compared to newer versions, it is slower and now mainly used for mouse and printers etc.
 - ii. USB 2.0 - is a newer USB standard and transfers data up to 480Mbps. It is widely used for storage devices, web cameras and speakers etc.
 - iii. USB 3.0 - can transfer data up to 5Gbps, much higher compared to USB 1.1 and USB 2.0. It is suitable for high-bandwidth devices and is also backward compatible with previous versions of USB.