

Week 5 – Operating Systems

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Assignment 5.1: Unix-like

- a) Find out what the difference is between UNIX and unix-like operating systems?

= UNIX and unix-like systems are related, but they're not the same thing.

- UNIX (in capital letters) is a **brand name and a certified standard**.

The name is owned by The Open Group, and only operating systems that pass their official tests are allowed to call themselves "UNIX".

Examples:

- modern macOS
- IBM AIX
- HP-UX

- unix-like systems are operating systems that work in a similar way to UNIX, follow similar standards, and feel like UNIX to the user, but they are not officially certified as UNIX.

Examples:

- Linux distributions (Ubuntu, Debian, Fedora, etc.)
- FreeBSD, OpenBSD, NetBSD
- Android and ChromeOS (built on the Linux kernel)

In short:

UNIX = officially certified and allowed to use the name.

unix-like = similar in design and behaviour, but not officially UNIX.

- b) Study the image above named UNIX timeline. Find out who Ken Thompson, Dennis Ritchie, Bill Joy, Richard Stallman, and Linus Torvalds are and what they have contributed to the development of UNIX or unix-like systems and to IT in general. **TIP!** English-language sources often contain more detailed information about these individuals.

= **Ken Thompson** – Co-creator of UNIX at Bell Labs. Wrote the first UNIX kernel and several core tools; also created the B language and introduced key UNIX ideas like simple programs connected with pipes.

Dennis Ritchie – Co-creator of UNIX and inventor of the C programming language. Rewriting UNIX in C made it portable and hugely influenced modern operating systems and software.

Bill Joy – Major developer of BSD UNIX at UC Berkeley. Wrote the vi editor and the C shell, and later co-founded Sun Microsystems. His BSD work strongly influenced networking and later unix-like systems.

Richard Stallman – Founder of the GNU Project and the Free Software Foundation. Created tools like GNU Emacs and GCC and wrote the GPL license. He launched the free software movement and aimed to build a free UNIX-like system.

Linus Torvalds – Creator of the Linux kernel, started in 1991. Linux, combined with GNU tools, powers many modern systems (servers, phones, supercomputers). He also created Git, widely used in software development.

c) What is the philosophy of the GNU movement?

= The philosophy of the GNU movement is centered on software freedom – the idea that users should have control over the software they use rather than being restricted by proprietary licenses.

In this philosophy, “free software” means that the software grants these four essential freedoms:

1. Freedom to run the program for any purpose.
2. Freedom to study how the program works and modify it (access to source code is required).
3. Freedom to redistribute copies of the program.
4. Freedom to distribute modified versions so that others can benefit from the changes.

To protect these freedoms, the GNU project uses copyleft licenses such as the GNU General Public License (GPL), which ensure that modified versions that are shared must also remain free software. The overall goal is a completely free operating system and software ecosystem that respects these user freedoms.

d) Does Ubuntu as a Linux operating system conform to the philosophy of the GNU movement?

Please explain your answer.

= Ubuntu follows the philosophy of the GNU movement only partially.

On one hand, Ubuntu is built on GNU/Linux and includes a large amount of free software: the Linux kernel, GNU tools (like coreutils, GCC, bash), and many applications under free licenses such as GPL, MIT, and BSD. These components respect the GNU idea of software freedom: users can study, modify, and share much of the system’s code.

On the other hand, Ubuntu also includes and promotes non-free (proprietary) software. This applies in particular to some hardware drivers and firmware (e.g. for graphics cards or Wi-Fi), as well as certain codecs and optional closed-source applications. Because of this, the Free Software Foundation does not classify Ubuntu as a fully free distribution and instead recommends distros that remove all proprietary components (such as Trisquel).

In conclusion, Ubuntu supports many goals of the GNU movement but does not fully conform to its strict philosophy, because it still allows and distributes non-free software for practical and compatibility reasons.

e) Find out what is the Windows Subsystem for Linux?

= The Windows Subsystem for Linux (WSL) is a feature in Windows 10 and Windows 11 that allows Linux to run directly on Windows.

It provides a Linux environment inside Windows, so Linux distributions such as Ubuntu or Debian can be installed from the Microsoft Store. Through WSL, Linux command-line tools and applications run alongside normal Windows programs, without needing a separate virtual machine or dual-boot setup.

There are two main versions:

- WSL 1: uses a compatibility layer that translates Linux system calls into Windows system calls.
- WSL 2: runs a real Linux kernel in a lightweight virtual machine, offering better compatibility and performance.

- f) Find out, which operating system family belongs to Android, iOS and ChromeOS?

= **Android**

Android is based on the Linux kernel, so it belongs to the Linux / Unix-like operating system family.

iOS

iOS is built on Darwin, which uses the XNU kernel and includes code from BSD UNIX. It belongs to the Unix / Unix-like family.

ChromeOS

ChromeOS is also built on the Linux kernel (with Gentoo Linux as an early base), so it belongs to the Linux / Unix-like family.

Android, iOS and ChromeOS all belong to the broad Unix-like family of operating systems. Android and ChromeOS are Linux-based, while iOS is based on a BSD/UNIX core.

Assignment 5.2: Supercomputers and gameconsoles

- a) Research on this site what supercomputers are used for and write a short summary of it:
<https://www.computerhistory.org/timeline/search/?q=Supercomputer>

= Supercomputers are extremely powerful machines built to handle problems that are too big and complex for ordinary computers. They are mainly used for tasks that involve huge amounts of calculations and data, often in science, engineering, and national security.

Typical uses include things like weather forecasting and climate modelling, where supercomputers simulate the atmosphere and oceans to predict storms or study climate change. They are also used in physics and engineering to model things such as airflow over aircraft wings, car crash simulations, nuclear reactions, and the behaviour of materials under extreme conditions. Government and military organizations use them for code-breaking and for simulating nuclear weapons tests instead of carrying out real explosions. In addition, supercomputers are used in areas like astronomy (for modelling galaxies and black holes), biology and medicine (for protein folding, genomics, and drug discovery), and more recently for large-scale data analysis and advanced AI and machine learning.

Overall, the main point is that supercomputers let researchers and engineers run extremely detailed simulations and calculations that would be impossible or take far too long on normal computers.

- b) IBM is a company that has already built a number of supercomputers. One of them is IBM's Roadrunner. The CPU developed for this supercomputer was further developed at a later stage as the CPU for the PlayStation 3 console. Find out what a **PlayStation 3 cluster** is and what it was used for?

= A PlayStation 3 cluster is basically a bunch of PS3 consoles linked together and used as one big, powerful computer.

The reason this works is that the PS3 uses the Cell processor, which is related to the one used in IBM's Roadrunner supercomputer. For a while, you could install Linux on a PS3, so people connected many PS3s on a network, ran Linux on them, and treated them like a cheap supercomputer.

What it was used for:

Scientific research

Universities and research labs used PS3 clusters to run heavy calculations, for example in physics and astronomy (like simulating black holes or other complex models), because the Cell processor was very good at number-crunching.

Military and government projects

The U.S. Air Force, for example, built a large PS3 cluster (often called the Condor Cluster) with over a thousand PS3s. They used it for things like processing high-resolution images and video, pattern recognition, and other tasks that need a lot of parallel computing power.

Overall, a PlayStation 3 cluster is just many PS3s working together as a low-cost supercomputer for serious scientific and technical work.

- c) You can build a supercomputer by putting a few computers together in a cluster. Here's what Oracle did with a collection of Raspberry Pi's, for example:

<https://blogs.oracle.com/developers/post/building-the-worlds-largest-raspberry-pi-cluster>

What specific operating system is running on this cluster?

= They're running Oracle Linux 7 for ARM on the Raspberry Pi cluster.

- d) Does Oracle's Raspberry Pi supercomputer appear in the list of the 500 fastest supercomputers in the world? Make a logical decision for this, without going through the entire list.

<https://www.top500.org/lists/top500/list/2023/06/>

= No, Oracle's Raspberry Pi "supercomputer" won't be in the TOP500 list.

The TOP500 only includes the fastest supercomputers in the world, and today those machines reach petaflop performance (and above) – that's millions of billions of calculations per second.

A Raspberry Pi is a low-power mini computer meant for learning and small projects, not raw speed. Even if you connect a lot of them together, their combined performance is still far below what TOP500 systems achieve.

On top of that, Oracle's Raspberry Pi cluster is clearly more of a demonstration and educational project than a serious attempt to build a top-ranked supercomputer.

So, logically, it's not on the list of the 500 fastest supercomputers.

- e) What CPU architecture is used for the PlayStation 5 and Xbox Series X?

What operating systems run on these consoles?

What conclusion can you draw from the answer to the previous question?

= 1. CPU architecture in PS5 and Xbox Series X

- **PlayStation 5:** Uses a custom AMD Zen 2 processor, 8 cores, based on 64-bit x86-64 architecture.

- **Xbox Series X:** Also uses a custom AMD Zen 2 processor, 8 cores, also 64-bit x86-64.

So both consoles use very similar PC-style 64-bit x86 CPUs from AMD.

2. Operating systems on these consoles

- **PlayStation 5:** Runs a proprietary Sony OS that is based on FreeBSD, which is a Unix-like operating system.

- **Xbox Series X:** Runs a customized version of Microsoft's Windows NT (basically a special Xbox-tuned version of Windows).

3. Conclusion

Both modern consoles:

- Use PC-like x86-64 CPUs, and

- Run OSes closely related to desktop/server systems (Unix-like for PS5, Windows NT for Xbox).

The clear conclusion is that today's consoles are essentially specialized, locked-down PCs, which makes it much easier to develop and port games between PC, PlayStation, and Xbox.

Assignment 5.3: Working with Windows

Take relevant screenshots of the assignments below

- a) Practice for about 10 minutes with the  keyboard shortcuts combinations, skip the general shortcuts in this exercise. Take a look at which screens are opened.

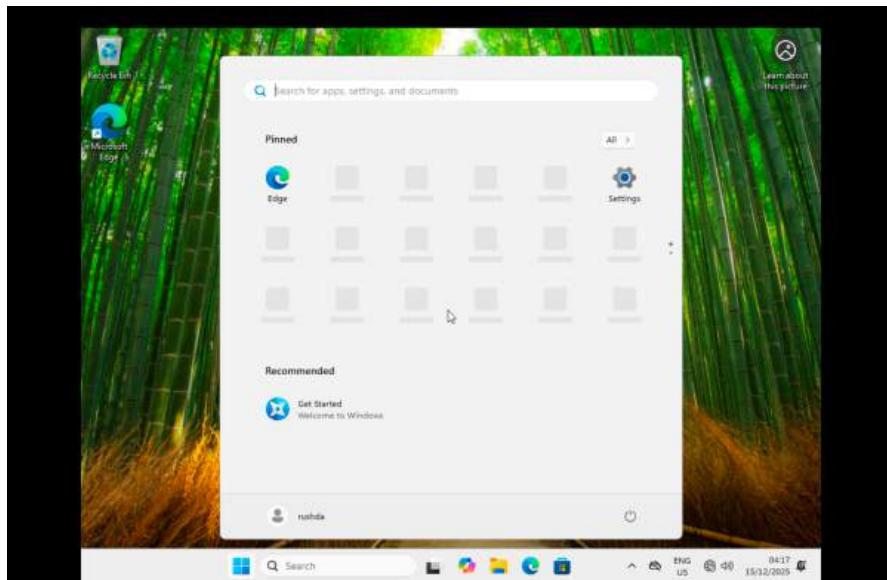


Fig 1: Command = Start Menu



Fig 2: Command + B

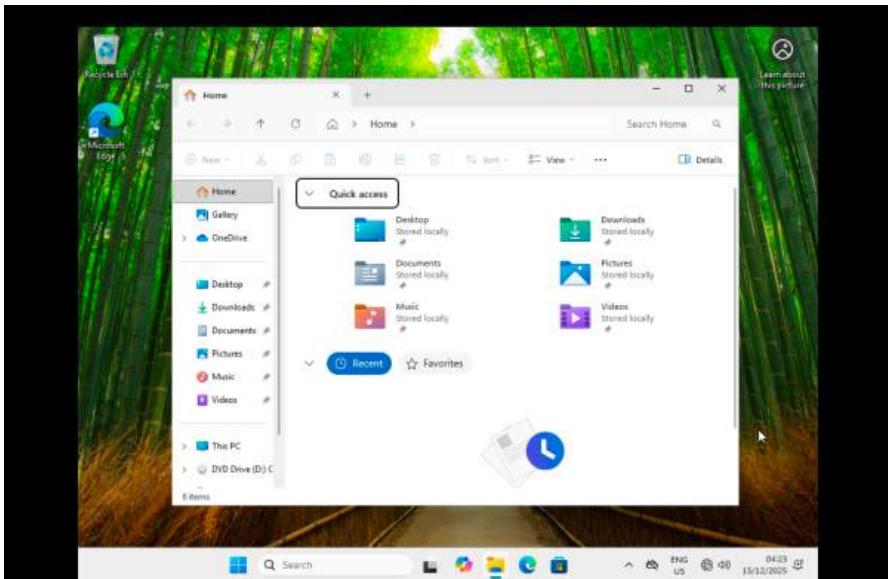


Fig 3: Command + E

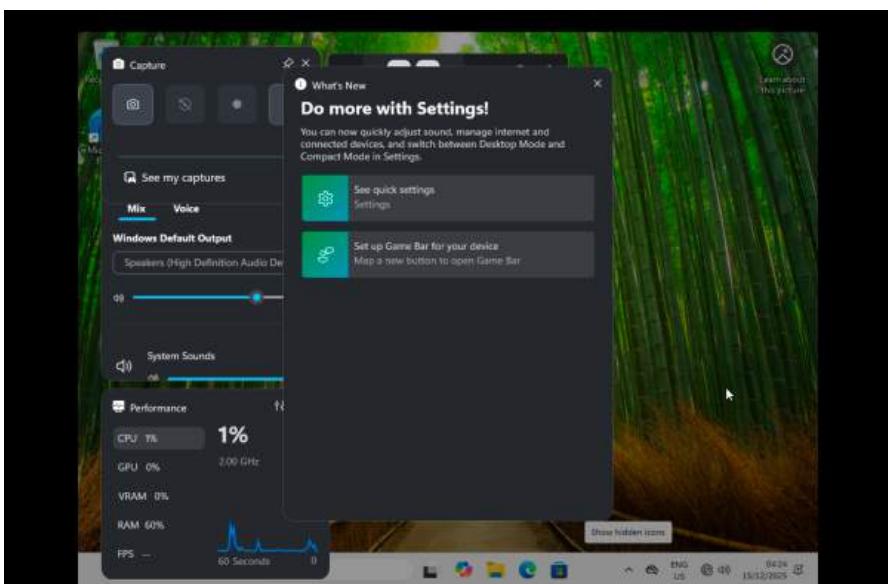


Fig 4: Command + G

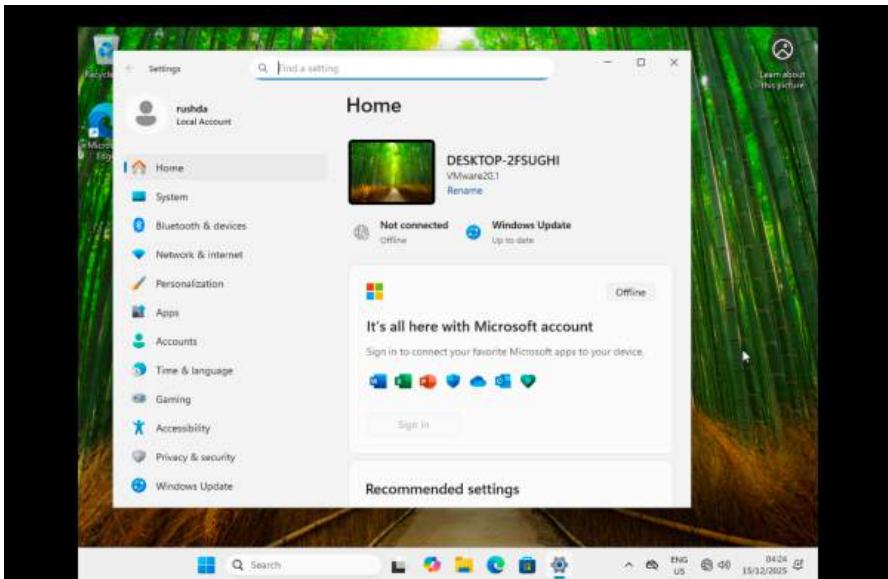


Fig 5: Command + I

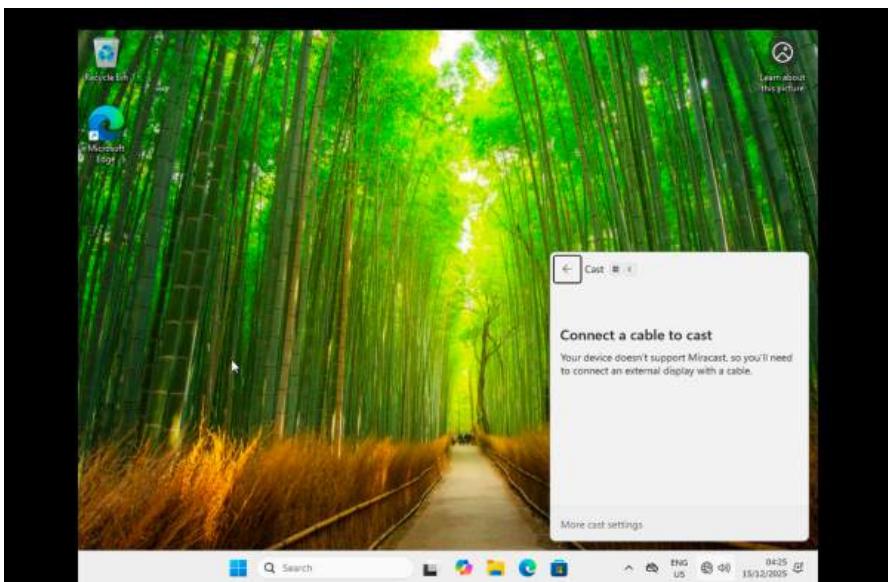


Fig 6: Command + K

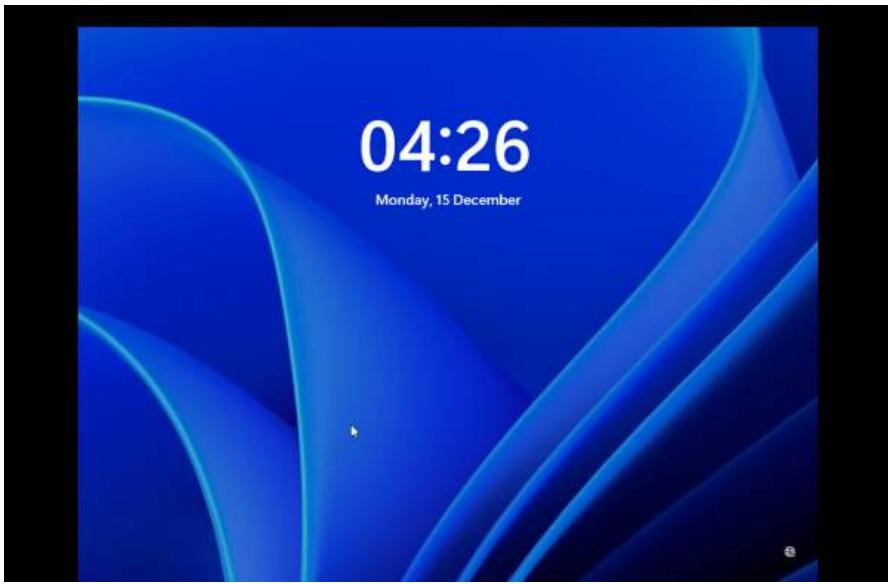


Fig 7: Command + L

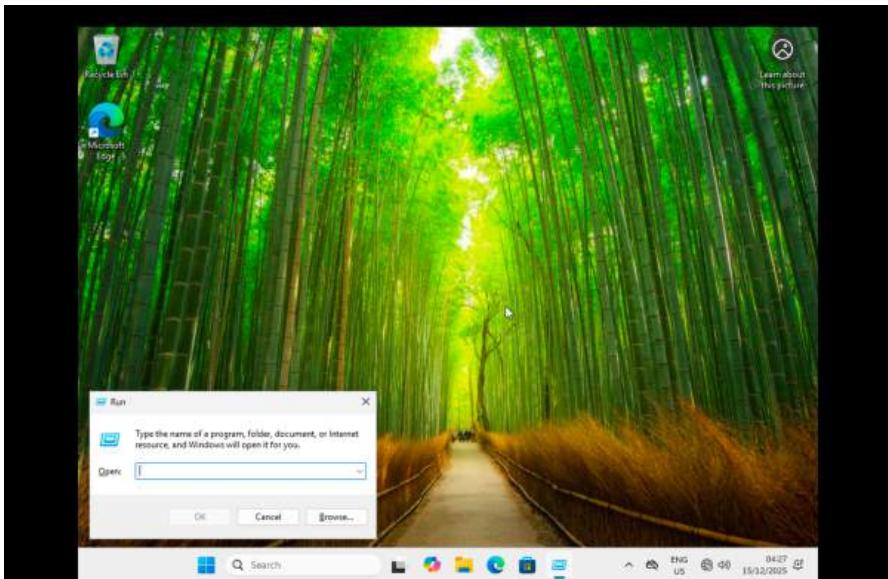
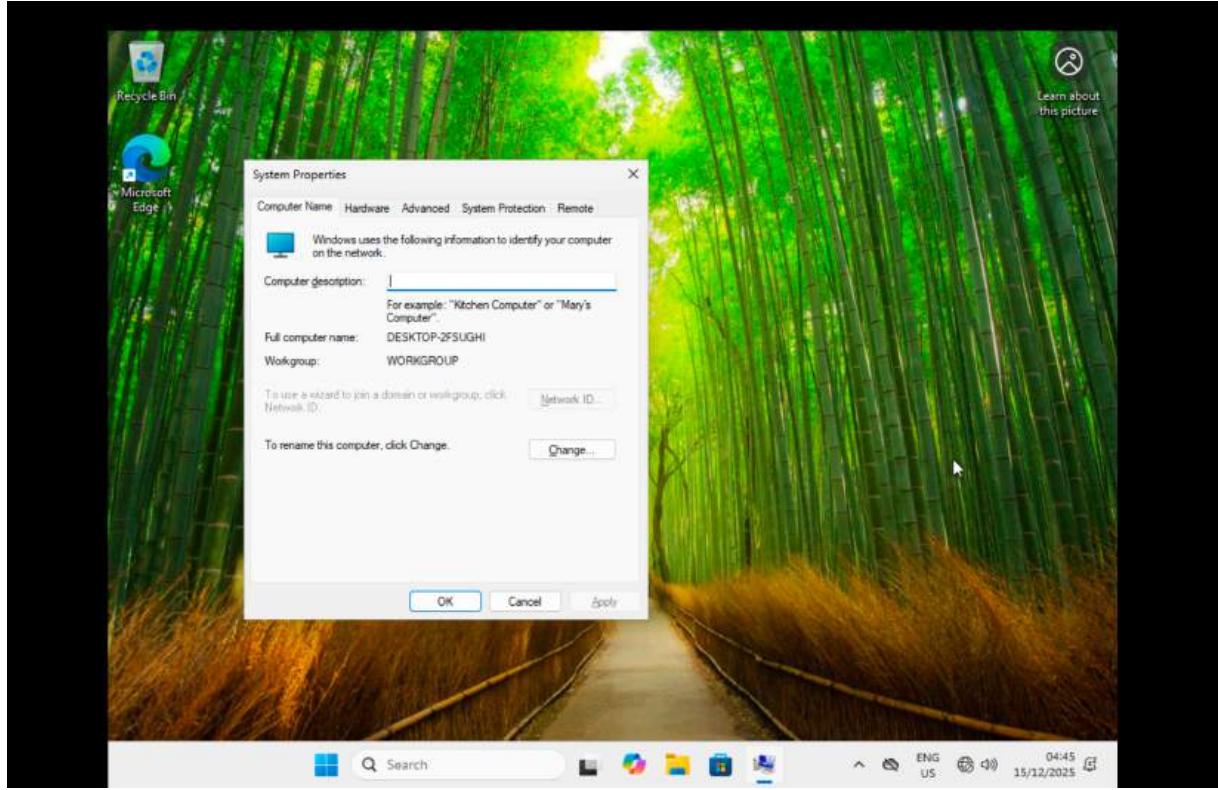


Fig 8: Command + R

- b) The file explorer can be opened with **Shift + E**, Which key combination could you also use?
=Command+X+E (All these 3 keys at the same time).

- c) Open the system properties with a **Windows** key combination, take a screenshot of the open screen. Paste this screenshot into this template.



There is no pause button in my mac, so I pressed Command + R and then typed sysdm.cpl and pressed enter.

- d) Open task manager with a key combination. Take screenshots of the tabs: processes (shows active processes), performance, and users. Place these three screenshots in this template.

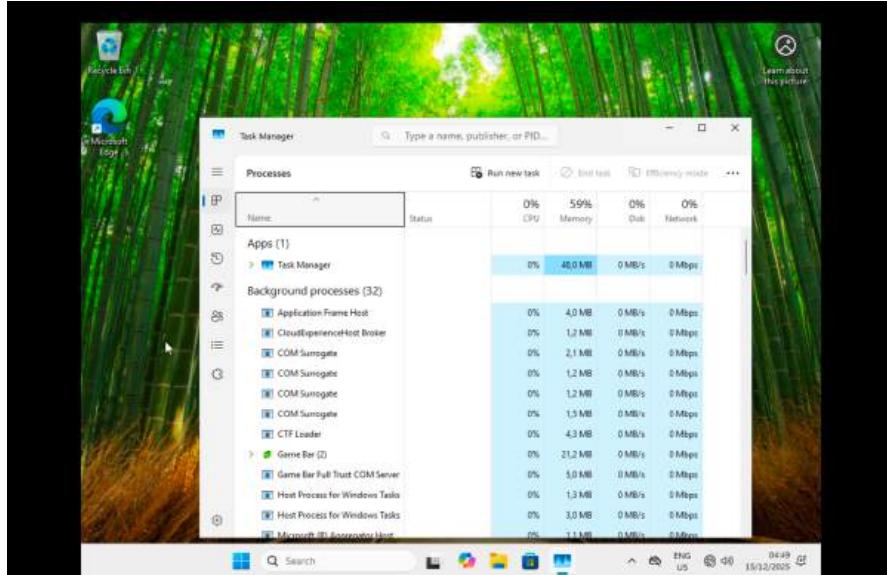


Fig 1: Processes

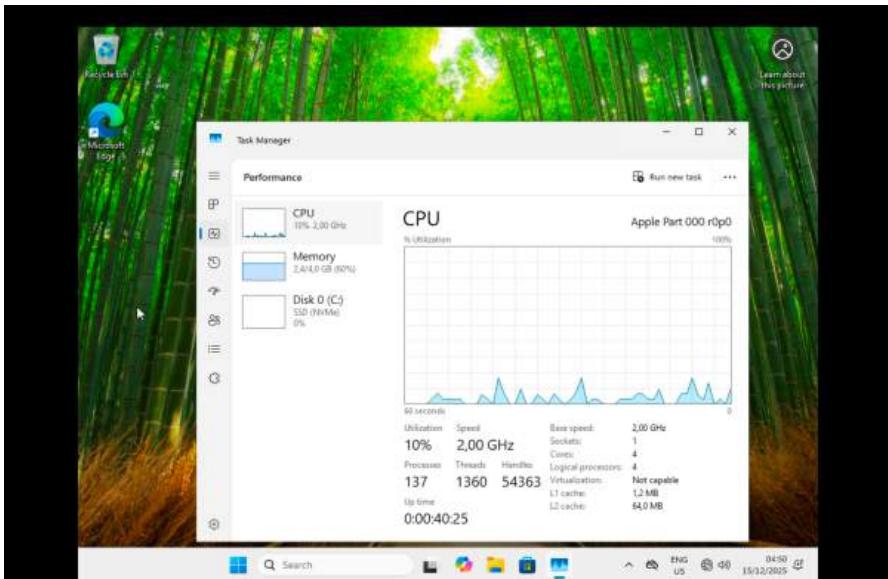


Fig 2: Performance

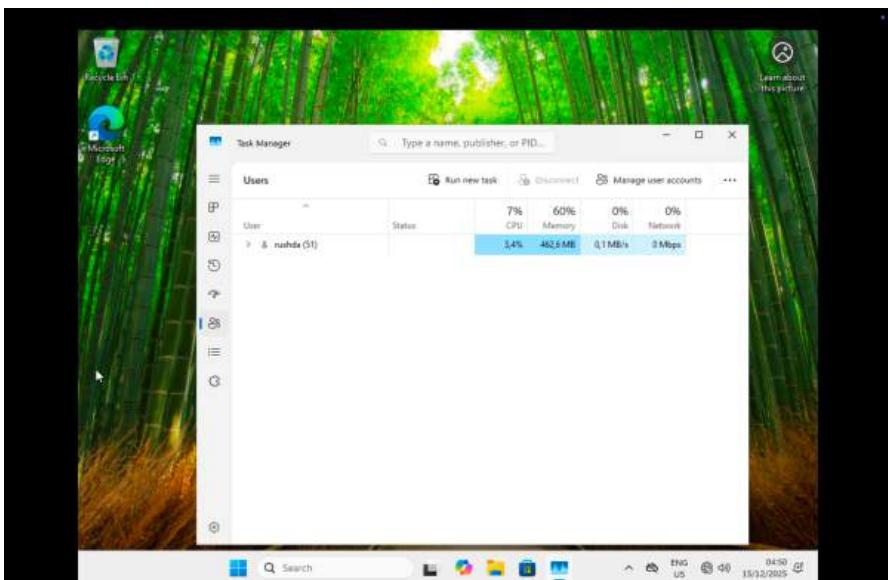


Fig 3: Users

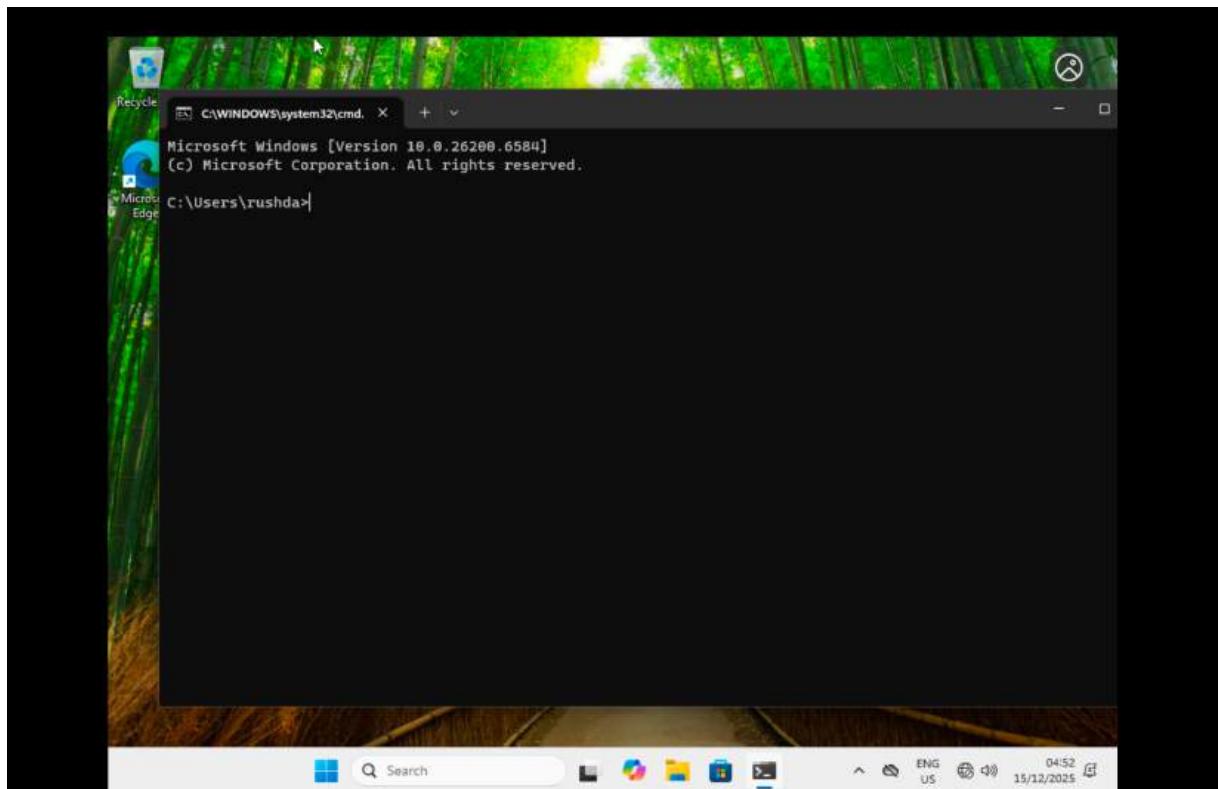
- e) If you're giving a PowerPoint presentation and you connect your laptop to a projector, Windows can use the projector as a second screen. For example, you may have Outlook open on your first screen that you don't show over the projector, while the PowerPoint presentation is displayed on the projector, or the second screen. Which key combination should you use for this?

=Command + P

- f) If you leave the classroom for a while and you leave your laptop behind, it is wise to lock the screen. Your Apps will continue to run in the background. So, for example, if you're waiting for a download that takes a while, lock the screen and get a cup of coffee. Which key combination do you use for this?

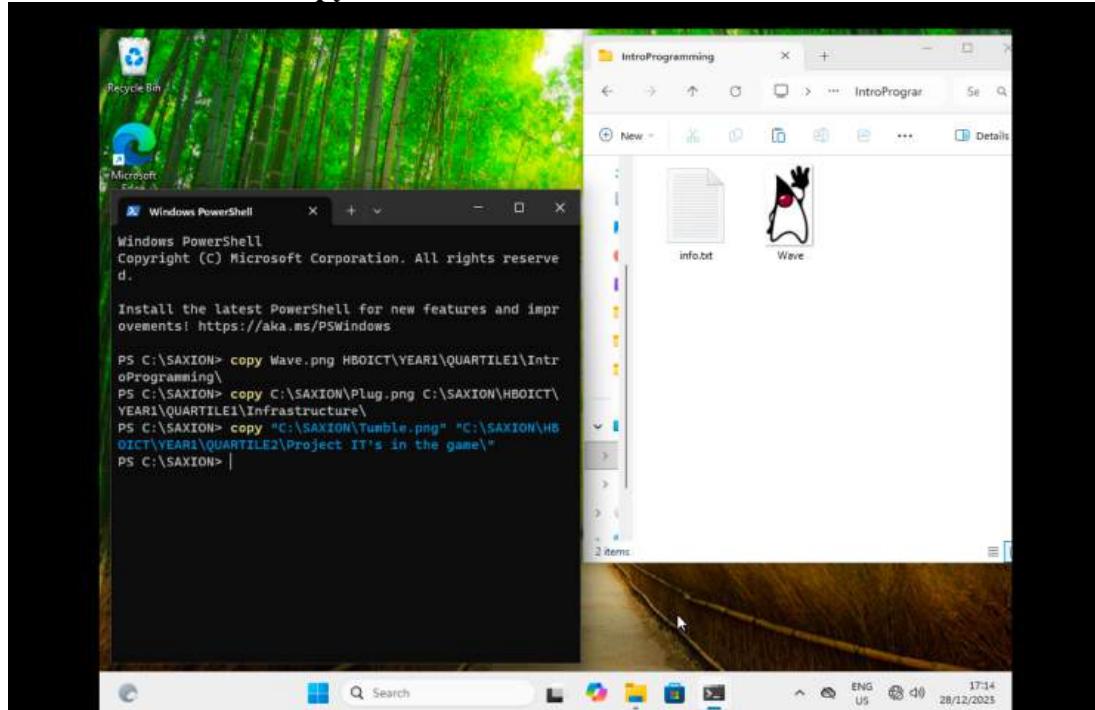
= Command + L

- g) Open the Run screen with a key combination. On this screen, type CMD and press <enter>. Take a screenshot of this result and paste it into this template.

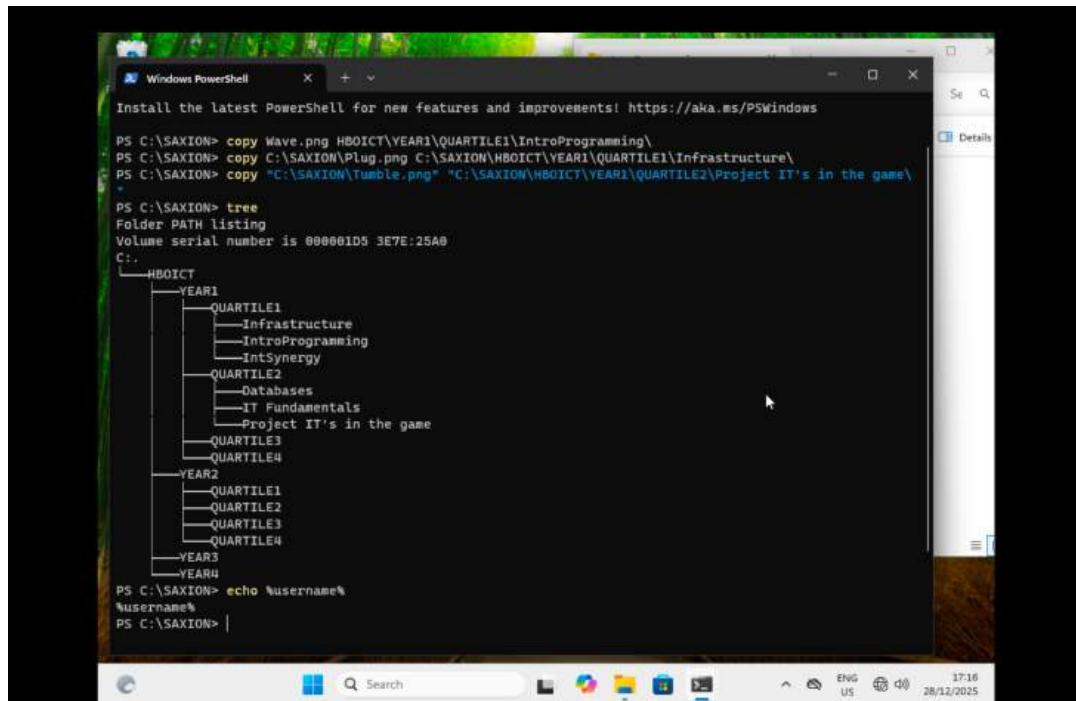


Working in the File Explorer

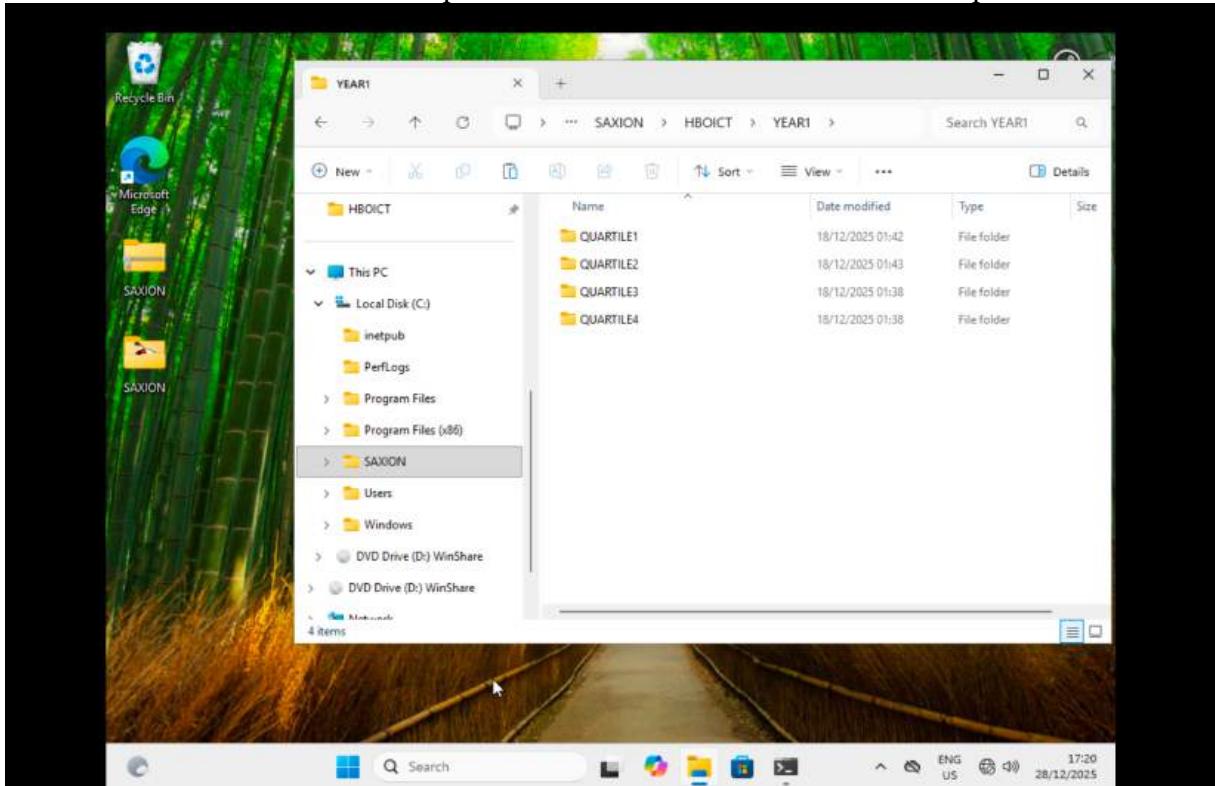
Relevant screenshots **copy** command:



Relevant screenshots **tree** command:

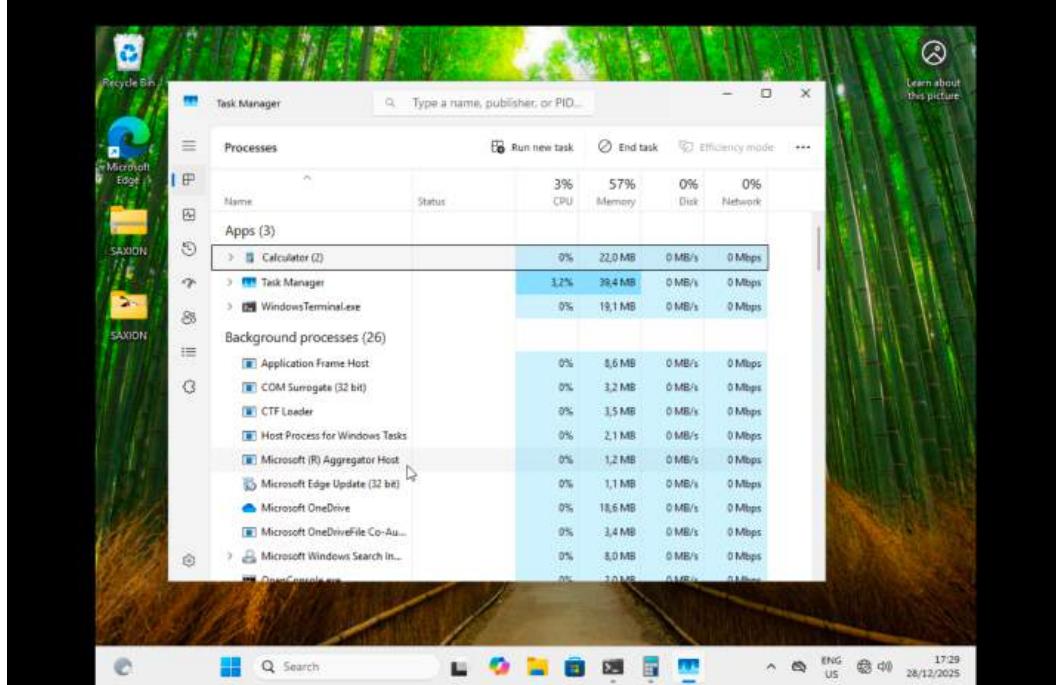


Relevant screenshots in the file explorer of the folder c:\Saxion + created zip file.



Terminating Processes

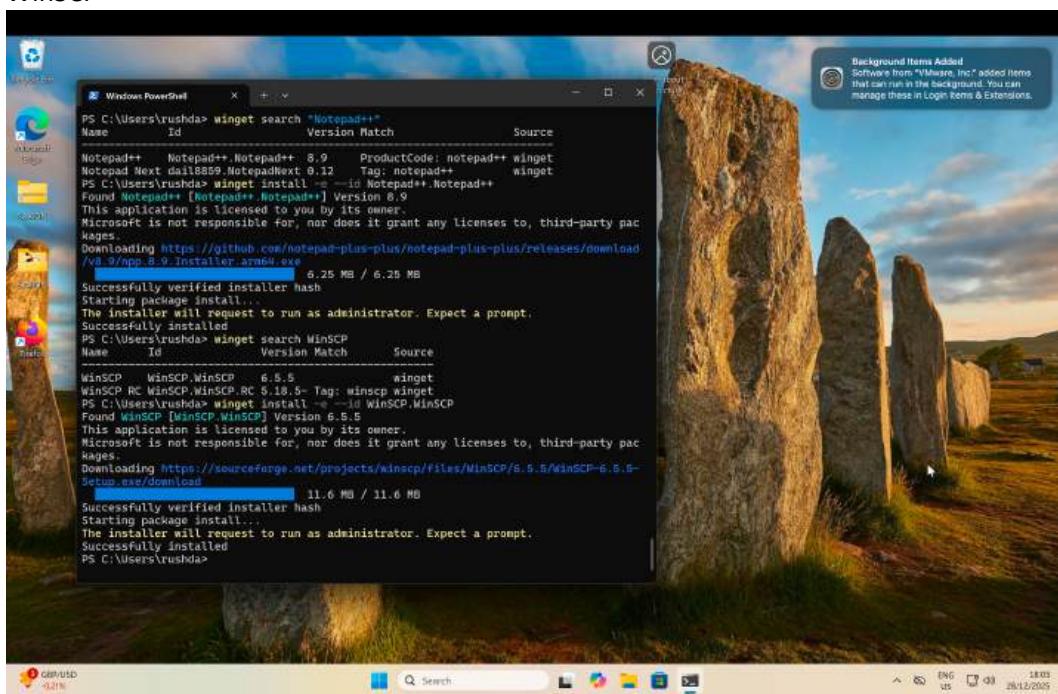
Relevant Screenshots Task Manager Window:



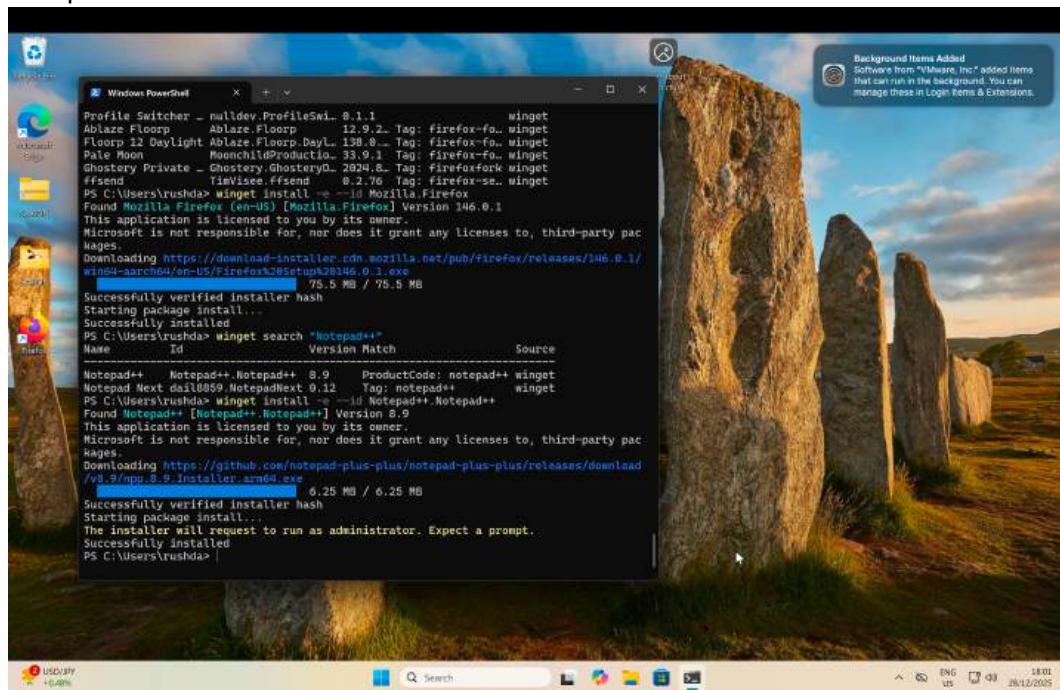
Install Software

Relevant screenshots that the following software is installed with winget:

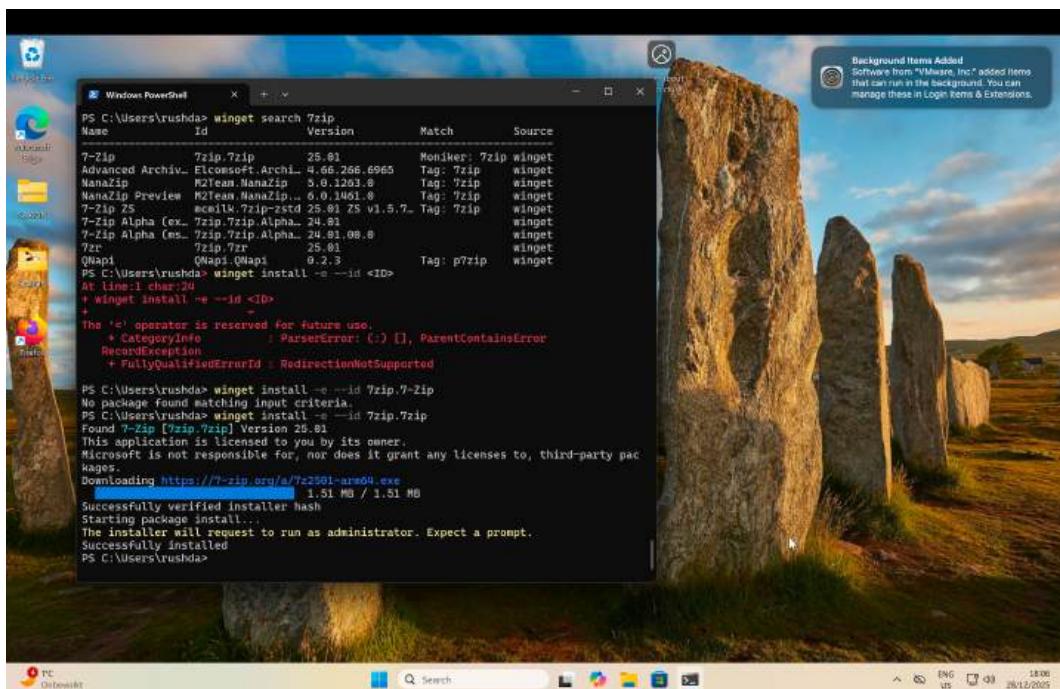
- WinSCP



- Notepad++



- 7zip



Assignment 5.4: Working with Linux

Relevant screenshots + motivation

This screenshot shows the text file testfile.txt that I created in my home folder using the Ubuntu file manager.

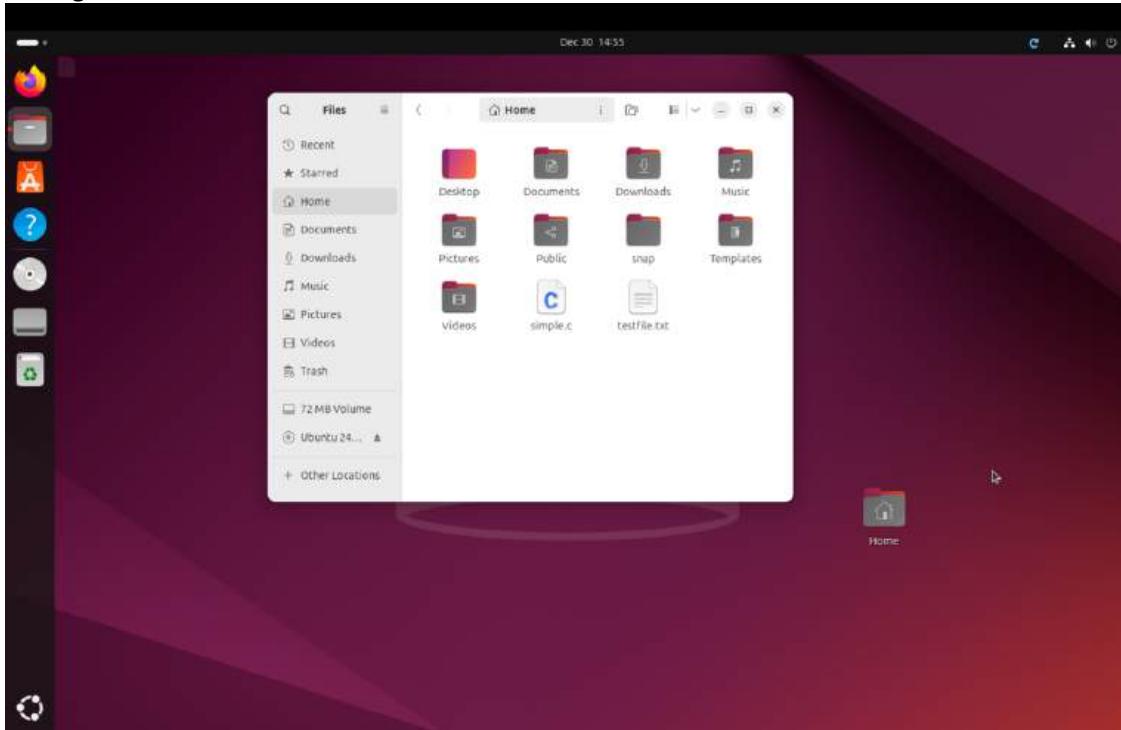


Figure 5.4-1 – Home folder with new text file

I copied testfile.txt from Home to the Documents folder using right-click Copy/Paste.

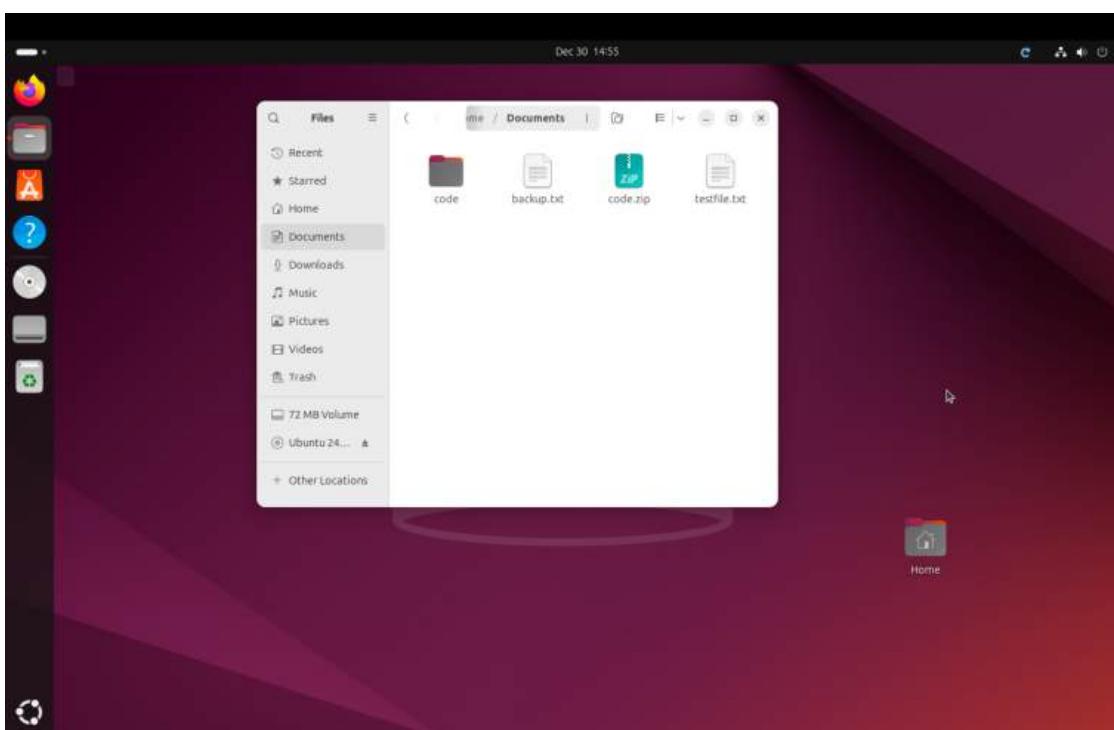
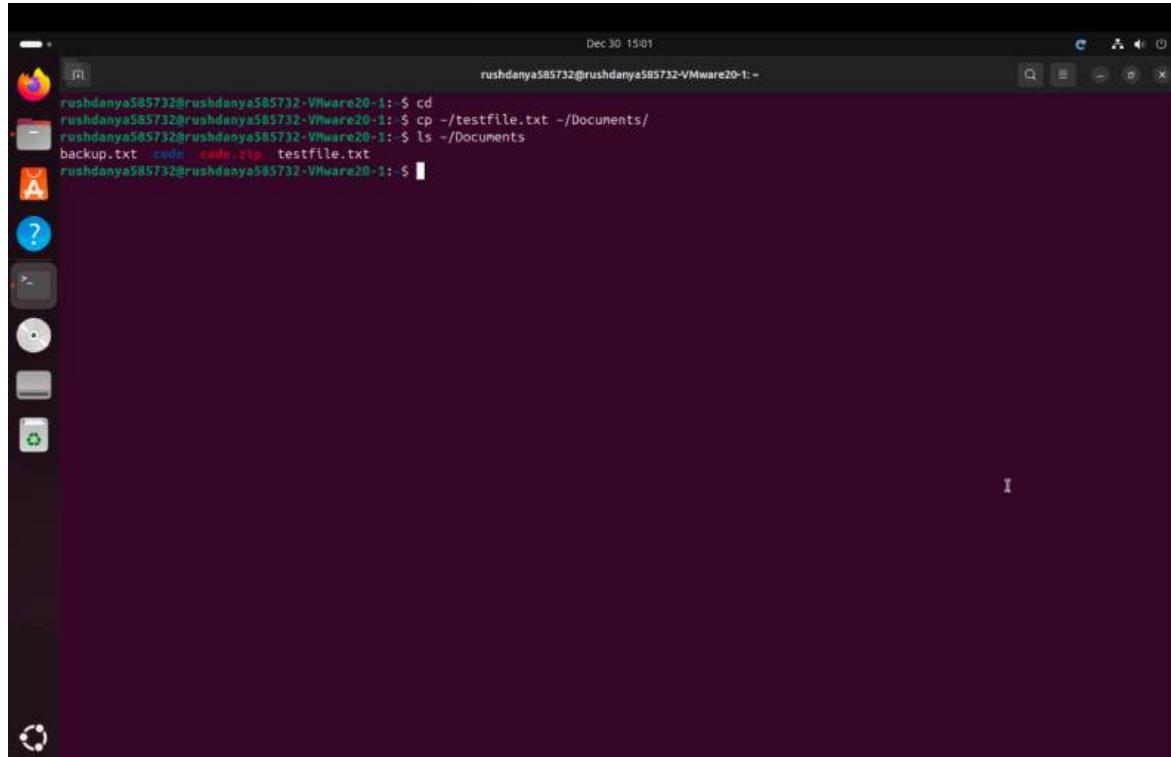


Figure 5.4-2 – testfile.txt folder after GUI copy

This screenshot shows the same copy operation on the command line. I used cp ~/testfile.txt ~/Documents/ and ls ~/Documents to check that the file is present. This shows that file operations can be done both via GUI and terminal.



```
Dec 30 15:01
rushdanya585732@rushdanya585732-Vmware20-1:~ cd
rushdanya585732@rushdanya585732-Vmware20-1:~ $ cp ~/testfile.txt ~/Documents/
rushdanya585732@rushdanya585732-Vmware20-1:~ $ ls ~/Documents
backup.txt code code.zip testfile.txt
rushdanya585732@rushdanya585732-Vmware20-1:~
```

Figure 5.4-3 – Terminal copy of lab5.txt to Documents

Here I navigated to the /etc directory using the file manager (Other Locations → Computer → etc). This folder contains system-wide configuration files.

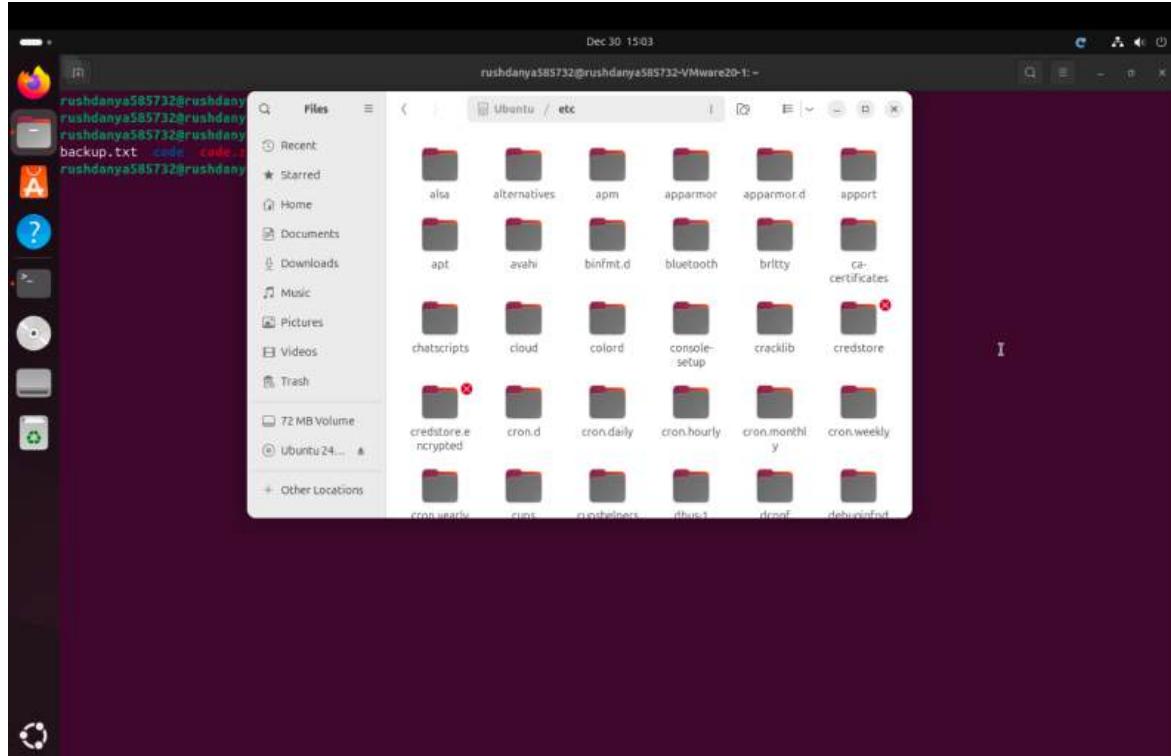
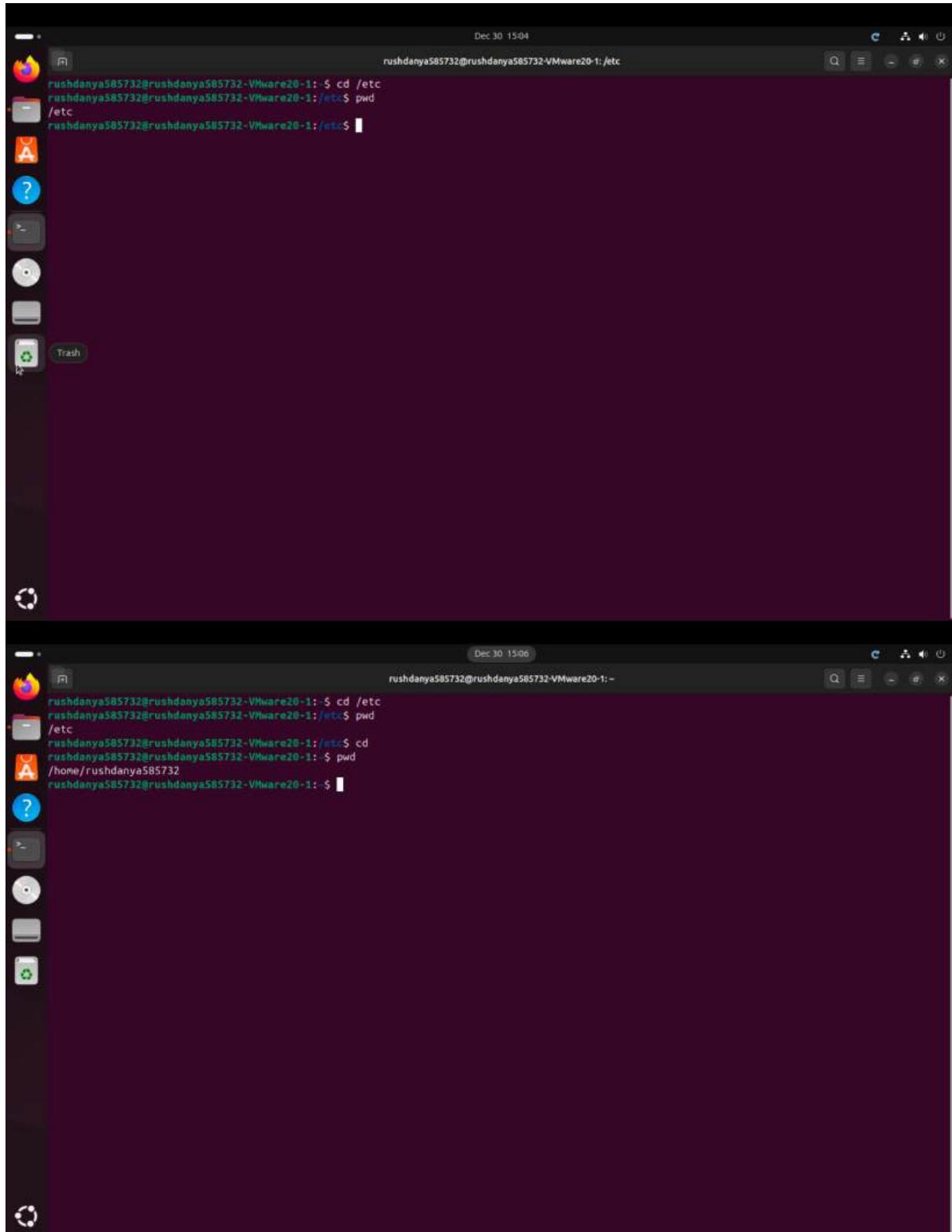


Figure 5.4-4 – /etc opened in the file manager

With cd /etc , pwd and cd plus pwd I showed how to move between system and home directories from the command line.



The image consists of two vertically stacked screenshots of a Linux desktop environment, likely Elementary OS, showing a terminal window and a desktop interface.

Screenshot 1 (Top): The terminal window shows the user navigating to the /etc directory. The session starts at the root prompt (rushdanya585732@rushdanya585732-VMware20-1:~) and runs the command `cd /etc`. The output shows the current working directory has changed to /etc. The desktop interface includes a dock with icons for Dash, Home, Applications, and Trash, and a panel with system status indicators.

```
Dec 30 15:04
rushdanya585732@rushdanya585732-VMware20-1:~$ cd /etc
rushdanya585732@rushdanya585732-VMware20-1:/etc$ pwd
/etc
rushdanya585732@rushdanya585732-VMware20-1:/etc$
```

Screenshot 2 (Bottom): The terminal window shows the user navigating back to their home directory. The session starts at the /etc directory prompt and runs the command `cd ..`. The output shows the current working directory has changed to /home/rushdanya585732. The desktop interface is identical to the first screenshot.

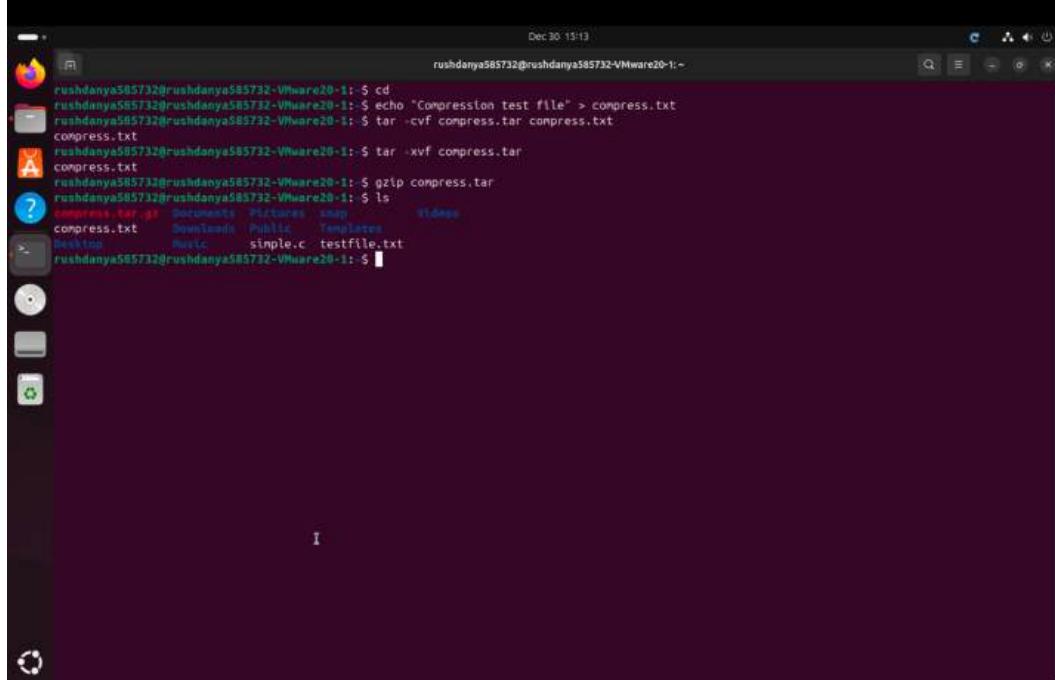
```
Dec 30 15:06
rushdanya585732@rushdanya585732-VMware20-1:~/etc$ cd ..
rushdanya585732@rushdanya585732-VMware20-1:/etc$ pwd
/etc
rushdanya585732@rushdanya585732-VMware20-1:/etc$ cd ..
rushdanya585732@rushdanya585732-VMware20-1:/home/rushdanya585732$ pwd
/home/rushdanya585732
rushdanya585732@rushdanya585732-VMware20-1:$
```

Figure 5.4-5,6 – Navigating to /etc and back to home in the terminal

Linux has a single root directory / and everything is under it, while Windows uses separate drive letters like C:\, D:\, etc. Linux also treats file names as case-sensitive.

/etc contains system-wide configuration files for the operating system and services.

In this screenshot I created a tar archive of testfile.txt using tar -cvf compress.tar compress.txt and then compressed it with gzip compress.tar, which produced compress.tar.gz.

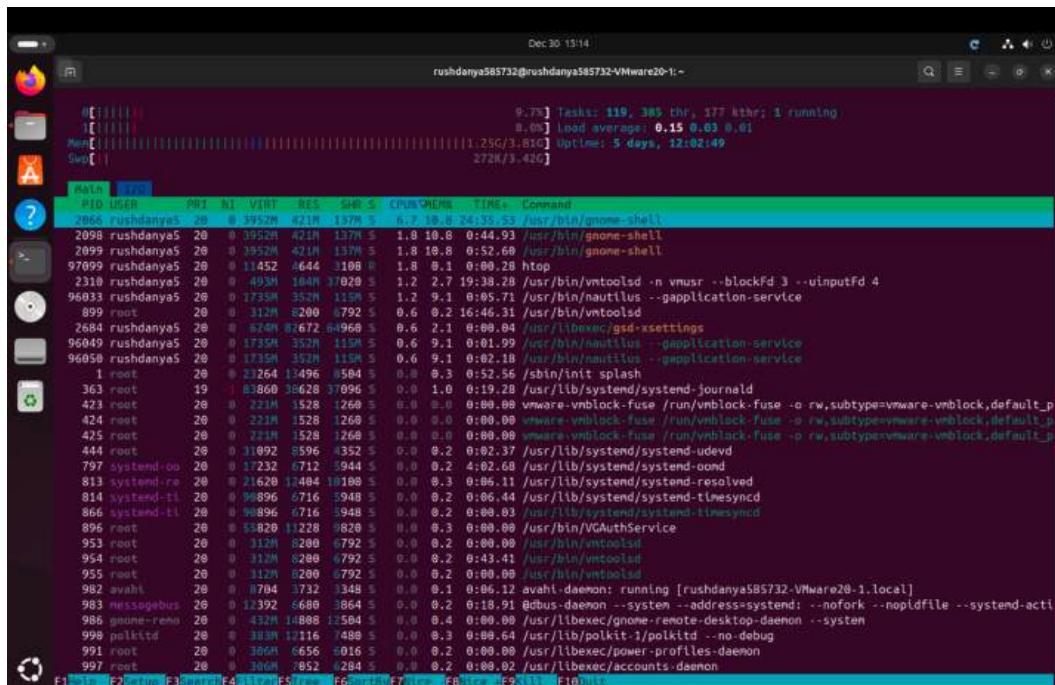


The terminal window shows the following command sequence:

```
rushdanya585732@rushdanya585732-Vmware20-1:~$ cd  
rushdanya585732@rushdanya585732-Vmware20-1:~$ echo "Compression test file" > compress.txt  
rushdanya585732@rushdanya585732-Vmware20-1:~$ tar -cvf compress.tar compress.txt  
compress.txt  
rushdanya585732@rushdanya585732-Vmware20-1:~$ tar -xvf compress.tar  
rushdanya585732@rushdanya585732-Vmware20-1:~$ gzip compress.tar  
rushdanya585732@rushdanya585732-Vmware20-1:~$ ls  
compress.txt.gz  Documents  Pictures  shop  Videos  
Desktop  Downloads  Public  Templates  
Desktop  Public  simple.c  testfile.txt  
rushdanya585732@rushdanya585732-Vmware20-1:~$
```

Figure 5.4-6 – Creating and compressing a tar archive

htop is an interactive process viewer that shows real-time CPU, memory and swap usage and lists all running processes. It lets you scroll, sort and kill processes.



The htop window displays the following system information at the top:

```
9.7% Tasks: 119, 385 thr, 177 kthr; 1 running  
8.0% Load average: 0.15 0.03 0.01  
Mem: 1.25G/3.81G [Uptime: 5 days, 12:02:49]  
272K/3.42G]
```

The main table lists processes with columns: PID, USER, NI, VIRT, RES, SHR, S, CHUNCKERS, EINE+, and Command. Some processes are highlighted in green, such as the gnome-shell process.

PID	USER	NI	VIRT	RES	SHR	S	CHUNCKERS	EINE+	Command
2865	rushdanya5	20	0 3952M	421M	137M	S	6.7 19.8	24:35.53	/usr/bin/gnome-shell
2098	rushdanya5	20	0 3952M	421M	137M	S	1.8 10.8	0:44.93	/usr/bin/gnome-shell
2099	rushdanya5	20	0 3952M	421M	137M	S	1.8 10.8	0:52.68	/usr/bin/gnome-shell
97099	rushdanya5	20	0 11452	#644	1008	R	1.8 0.1	0:00.28	htop
2310	rushdanya5	20	0 493M	164M	31820	S	1.2 2.7	19:38.28	/usr/bin/vmtoolsd -n vmsr --blockFd 3 --uninputFd 4
96033	rushdanya5	20	0 1735M	352M	115M	S	1.2 9.1	0:05.71	/usr/bin/vmtoolsd --gapplication-service
899	root	20	0 312M	200	1792	S	0.6 0.2	16:46.31	/usr/bin/vmtoolsd
2684	rushdanya5	20	0 624M	81672	61968	S	0.5 2.1	0:00.84	/usr/libexec/gsd-xsettings
96049	rushdanya5	20	0 3735M	352M	115M	S	0.6 9.1	0:01.99	/usr/bin/nautilus -gapplication-service
96050	rushdanya5	20	0 1735M	352M	115M	S	0.6 9.1	0:02.18	/usr/bin/nautilus -gapplication-service
1	root	20	0 2024	12496	5804	S	0.0 0.3	0:52.56	/sbin/init splash
363	root	19	0 868	38628	37096	S	0.0 1.0	0:19.28	/usr/lib/systemd/systemd-journald
423	root	20	0 221M	1528	2668	S	0.0 0.0	0:00.00	vmware-vmblock-fuse /run/vmblock-fuse -o rw,subtype=vmware-vmblock,default_p
424	root	20	0 221M	1528	2668	S	0.0 0.0	0:00.00	vmware-vmblock-fuse /run/vmblock-fuse -o rw,subtype=vmware-vmblock,default_p
425	root	20	0 221M	1528	2668	S	0.0 0.0	0:00.00	vmware-vmblock-fuse /run/vmblock-fuse -o rw,subtype=vmware-vmblock,default_p
444	root	20	0 1192	8596	3352	S	0.0 0.2	0:02.37	/usr/lib/systemd/systemd-udevd
797	systemd-oo	20	0 17232	6712	5944	S	0.0 0.2	4:02.68	/usr/lib/systemd/systemd-oomd
813	systemd-re	20	0 21628	12484	10188	S	0.0 0.3	9:08.11	/usr/lib/systemd/systemd-resolved
814	systemd-tl	20	0 9896	6716	5948	S	0.0 0.2	0:06.44	/usr/lib/systemd/systemd-timesyncd
866	systemd-tl	20	0 9896	6716	5948	S	0.0 0.2	0:00.83	/usr/lib/systemd/systemd-timesyncd
896	root	20	0 5820	13228	8820	S	0.0 0.3	0:00.00	/usr/bin/vmtoolsd
953	root	20	0 312M	6200	6792	S	0.0 0.2	0:00.00	/usr/bin/vmtoolsd
954	root	20	0 312M	6200	6792	S	0.0 0.2	0:43.41	/usr/bin/vmtoolsd
955	root	20	0 312M	6200	6792	S	0.0 0.2	0:00.00	/usr/bin/vmtoolsd
982	avahi	20	0 704	1732	1348	S	0.0 0.1	0:06.12	avahi-daemon: running [rushdanya585732-Vmware20-1.local]
983	messagebus	20	0 1392	6680	1864	S	0.0 0.2	0:18.91	ibus-daemon --running [rushdanya585732-Vmware20-1.local]
986	gnome-remo	20	0 432M	18808	15804	S	0.0 0.4	0:00.00	/usr/libexec/gnome-remote-desktop-daemon --system
990	polkitd	20	0 333M	12116	1488	S	0.0 0.3	0:00.64	/usr/lib/polkit-1/polkitd --no-debug
991	root	20	0 306M	6656	2016	S	0.0 0.2	0:00.00	/usr/libexec/power-profiles-daemon
997	root	20	0 306M	7852	284	S	0.0 0.2	0:00.02	/usr/libexec/accounts-daemon

Figure 5.4-7 – htop process viewer running

Here I used the Ubuntu Software Center to search for and install the Sublime Text editor. This demonstrates how to install applications using the graphical package manager.

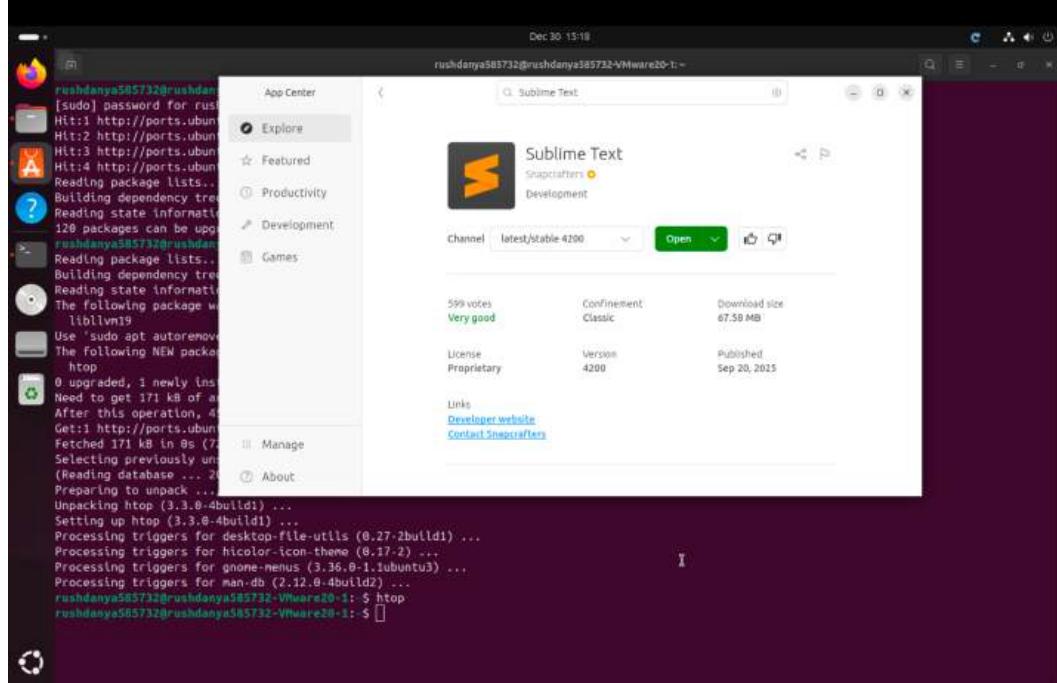


Figure 5.4-8 – Sublime Text installed via Ubuntu Software

In this terminal screenshot I installed neofetch with sudo apt install neofetch and ran it. neofetch prints system information (OS version, kernel, CPU, RAM, etc.) together with an ASCII logo. This shows that I can install packages from the command line and verify that they work.

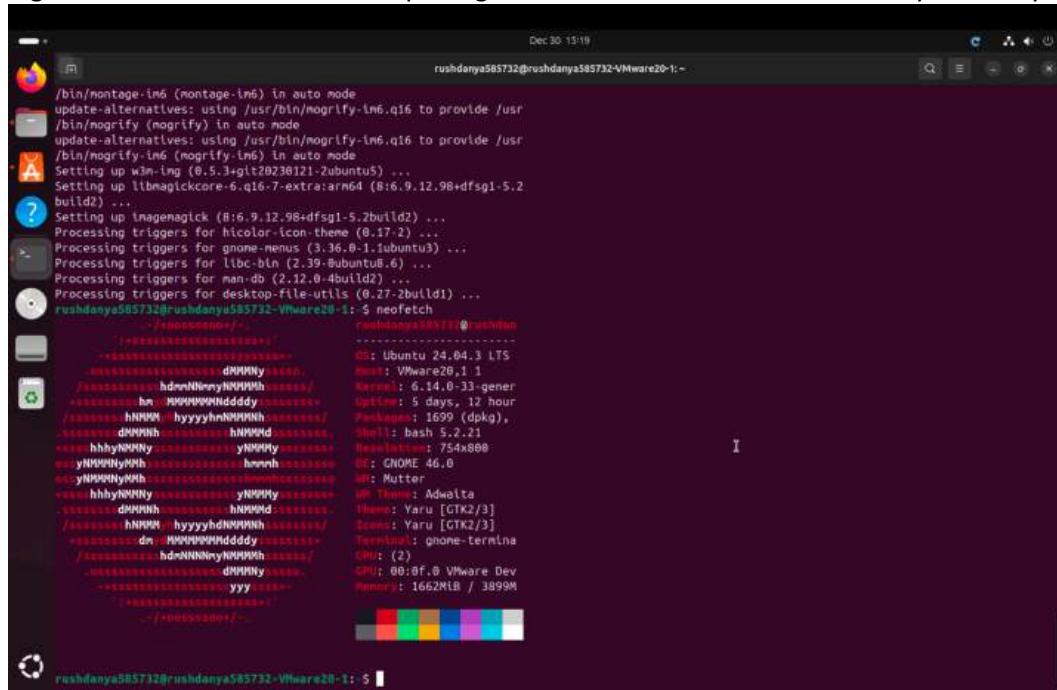


Figure 5.4-9 – neofetch output in the terminal

Assignment 5.5: Users and permissions on Linux

Relevant screenshots + motivation

cat file: prints the whole contents of a file to the terminal.

wc file: shows how many lines, words and bytes a file has.

wc -m file: shows how many characters a file has.

less file: opens the file in a viewer so you can scroll; q closes it.

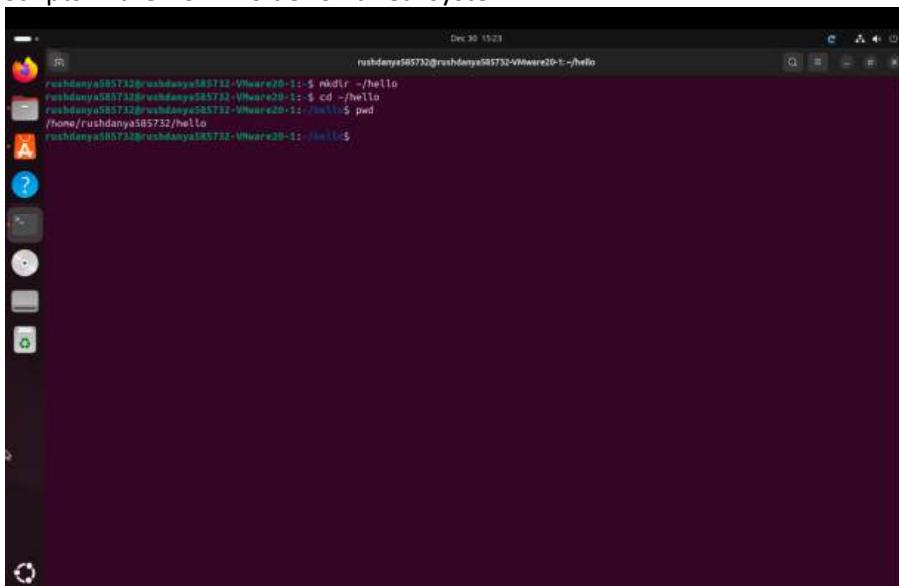
head file: shows the first part of a file (by default the first 10 lines).

tail file: shows the last part of a file (by default the last 10 lines).

grep “text” file: searches the file and prints the lines that contain the given text.

grep -n “text” file: same as above, but also shows line numbers.

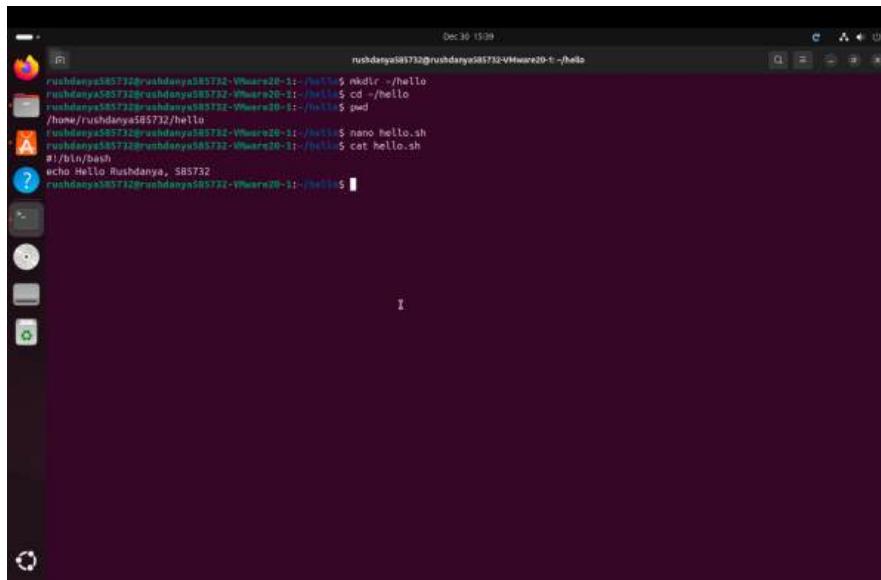
In this figure I create a new directory called hello in my home folder with mkdir ~/hello and move into it with cd ~/hello. This prepares a separate place for the shell script, just like you would organise scripts in their own folder on a real system.



```
Dec 30 15:23
rushdanya585732@rushdanya585732-VirtualBox:~$ mkdir ~/hello
rushdanya585732@rushdanya585732-VirtualBox:~$ cd ~/hello
rushdanya585732@rushdanya585732-VirtualBox:~/hello$ pwd
/home/rushdanya585732/hello
rushdanya585732@rushdanya585732-VirtualBox:~/hello$
```

Figure 5.5-1 – Creating the ~/hello directory

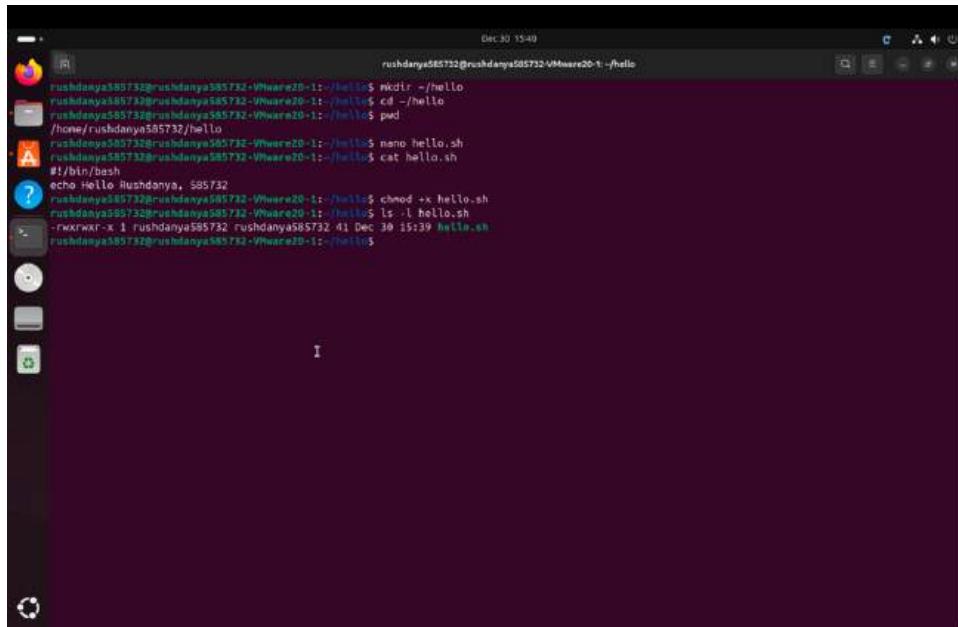
The hello.sh file contains the required bash shebang and an echo command with my name and student number.



```
Dec 30 15:39
rushdanya585732@rushdanya585732-VirtualBox:~$ mkdir -p /Hello
rushdanya585732@rushdanya585732-VirtualBox:~$ cd -/Hello
rushdanya585732@rushdanya585732-VirtualBox:~/Hello$ pwd
/home/rushdanya585732/Hello
rushdanya585732@rushdanya585732-VirtualBox:~/Hello$ nano hello.sh
rushdanya585732@rushdanya585732-VirtualBox:~/Hello$ cat hello.sh
#!/bin/bash
echo Hello Rushdanya, 585732
rushdanya585732@rushdanya585732-VirtualBox:~/Hello$
```

Figure 5.5-2 – Editing hello.sh with the script contents

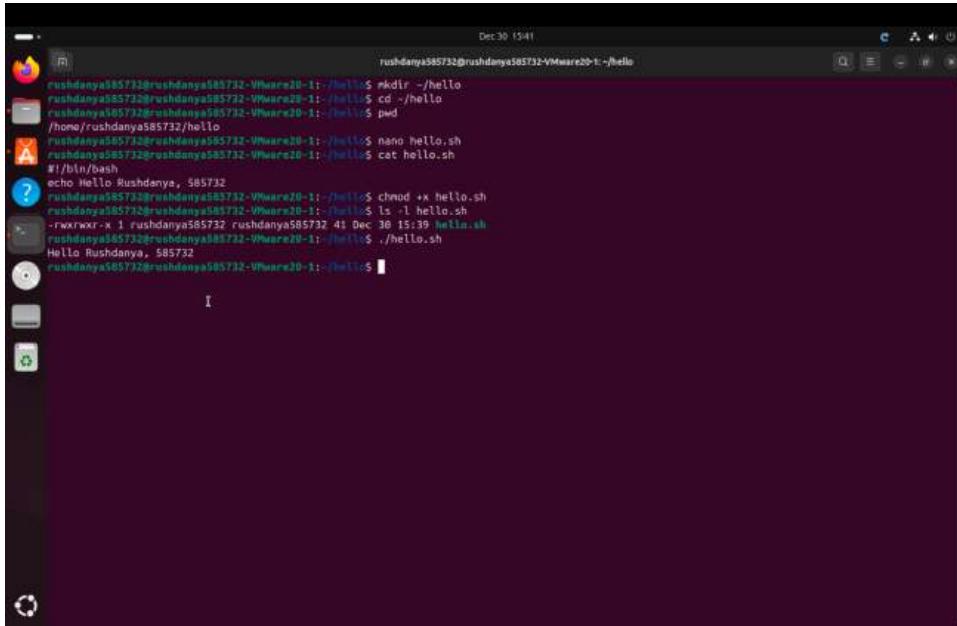
After running chmod +x hello.sh, ls -l shows that the file has execute permission (rwxr-xr-x).



```
Dec 30 15:40
rushdanya585732@rushdanya585732-VirtualBox:~$ mkdir -p /Hello
rushdanya585732@rushdanya585732-VirtualBox:~$ cd -/Hello
rushdanya585732@rushdanya585732-VirtualBox:~/Hello$ pwd
/home/rushdanya585732/Hello
rushdanya585732@rushdanya585732-VirtualBox:~/Hello$ nano hello.sh
rushdanya585732@rushdanya585732-VirtualBox:~/Hello$ cat hello.sh
#!/bin/bash
echo Hello Rushdanya, 585732
rushdanya585732@rushdanya585732-VirtualBox:~/Hello$ chmod +x hello.sh
rushdanya585732@rushdanya585732-VirtualBox:~/Hello$ ls -l hello.sh
-rwxrwxr-x 1 rushdanya585732 rushdanya585732 41 Dec 30 15:39 hello.sh
rushdanya585732@rushdanya585732-VirtualBox:~/Hello$
```

Figure 5.5-3 – Making hello.sh executable

Executing ./hello.sh prints the personalised “Hello ...” message, proving the script runs correctly.

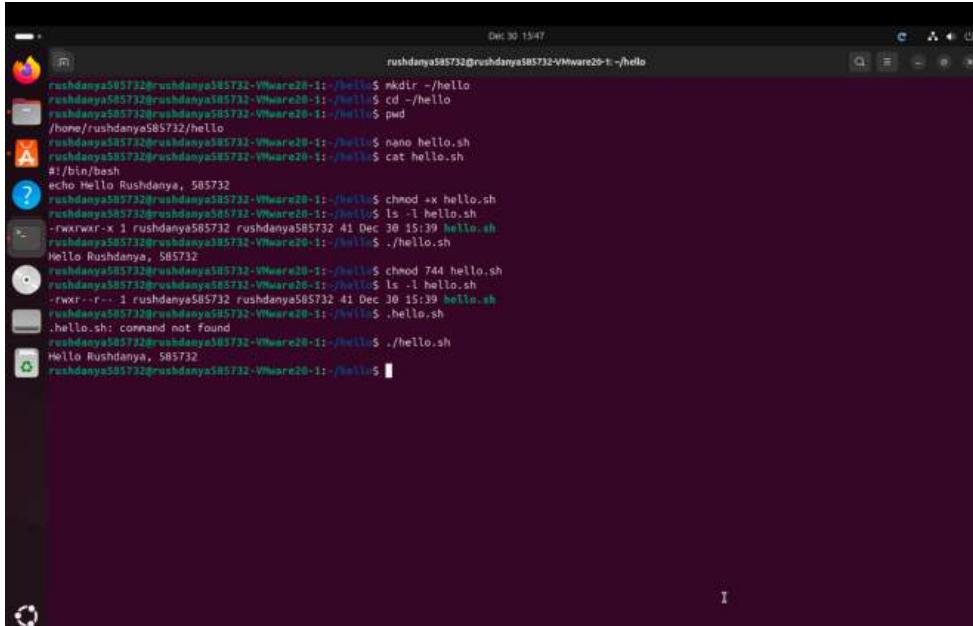


The screenshot shows a terminal window with a dark background and light-colored text. The terminal title is "rushdanya585732@rushdanya585732-VMware20-1: ~/hello". The user has navigated to the directory ~./hello and run the command nano hello.sh to edit the file. After saving, they run chmod +x hello.sh to make it executable. They then use ls -l to show the file permissions, which are set to -rwxrwxr-x. Finally, they run the script with ./hello.sh, and the output "Hello Rushdanya, 585732" is displayed.

```
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ mkdir -p hello
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ cd -p hello
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ pwd
/home/rushdanya585732/hello
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ nano hello.sh
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ cat hello.sh
#!/bin/bash
echo Hello Rushdanya, $585732
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ chmod +x hello.sh
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ ls -l hello.sh
-rwxrwxr-x 1 rushdanya585732 rushdanya585732 41 Dec 30 15:39 hello.sh
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ ./hello.sh
Hello Rushdanya, 585732
rushdanya585732@rushdanya585732-VMware20-1:~/hello$
```

Figure 5.5-4 – Running the script with ./hello.sh

With chmod 744 hello.sh, only the owner can execute the script while others only have read access (rwxr--r--).



This screenshot shows the same terminal session as Figure 5.5-4, but with different file permissions. After running chmod 744 hello.sh, the file now has permissions -rwxr--r--. When the user runs ./hello.sh, they receive an error message stating "hello.sh: command not found".

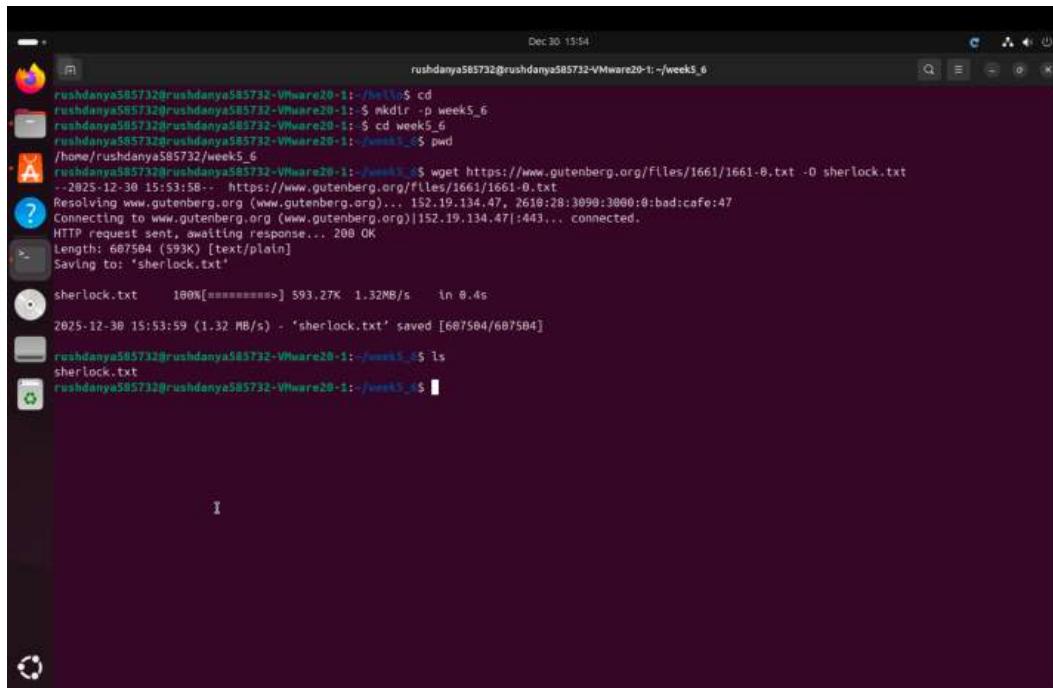
```
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ chmod 744 hello.sh
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ ls -l hello.sh
-rwxr--r-- 1 rushdanya585732 rushdanya585732 41 Dec 30 15:39 hello.sh
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ ./hello.sh
hello.sh: command not found
rushdanya585732@rushdanya585732-VMware20-1:~/hello$ ./hello.sh
Hello Rushdanya, 585732
rushdanya585732@rushdanya585732-VMware20-1:~/hello$
```

Figure 5.5-5 – Restricting execute permission to the owner only

Assignment 5.6: View the contents of files

Relevant screenshots + motivation

I created the week5_6 folder and downloaded the Sherlock Holmes book as sherlock.txt using wget.



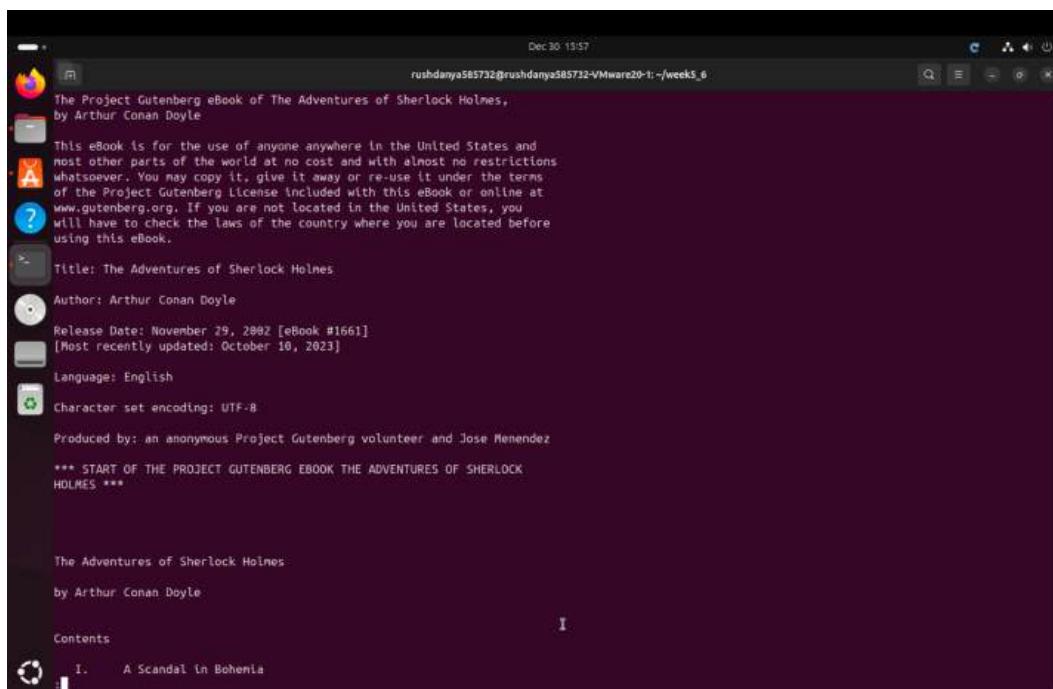
```
rushdanya585732@rushdanya585732-Vmware20-1:~/week5_6$ cd
rushdanya585732@rushdanya585732-Vmware20-1:~$ mkdir -p week5_6
rushdanya585732@rushdanya585732-Vmware20-1:~$ cd week5_6
rushdanya585732@rushdanya585732-Vmware20-1:~/week5_6$ pwd
/home/rushdanya585732/week5_6
rushdanya585732@rushdanya585732-Vmware20-1:~/week5_6$ wget https://www.gutenberg.org/files/1661/1661-0.txt -O sherlock.txt
--2025-12-30 15:53:58-- https://www.gutenberg.org/files/1661/1661-0.txt
Resolving www.gutenberg.org (www.gutenberg.org)... 152.19.134.47, 2610:28:3099:3000:0:bad:cafe:47
Connecting to www.gutenberg.org (www.gutenberg.org)|152.19.134.47|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 607504 (593K) [text/plain]
Saving to: 'sherlock.txt'

sherlock.txt      100%[=====] 593.27K  1.32MB/s   in 0.4s
2025-12-30 15:53:59 (1.32 MB/s) - 'sherlock.txt' saved [607504/607504]

rushdanya585732@rushdanya585732-Vmware20-1:~/week5_6$ ls
sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1:~/week5_6$
```

Figure 5.6-1 – Downloading the Sherlock Holmes text file

Using head/cat | head I displayed the first lines of the Sherlock Holmes text file



```
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by Arthur Conan Doyle

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[Most recently updated: October 10, 2023]
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Produced by: an anonymous Project Gutenberg volunteer and Jose Menendez

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HOLMES ***

The Adventures of Sherlock Holmes
by Arthur Conan Doyle
Contents
I.
    1. A Scandal in Bohemia
```

Figure 5.6-2 – Viewing the beginning of sherlock.txt

The wc and wc -m commands show how many lines, words and characters the file contains. The file has 12306 lines, 107562 words and 593731 characters.

```

rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6
rushdanya585732@rushdanya585732-Vmware20-1: ~$ cd
rushdanya585732@rushdanya585732-Vmware20-1: ~$ mkdir -p week5_6
rushdanya585732@rushdanya585732-Vmware20-1: ~$ cd week5_6
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ pwd
/home/rushdanya585732/week5_6
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ wget https://www.gutenberg.org/files/1661/1661-0.txt -O sherlock.txt
--2025-12-30 15:53:58-- https://www.gutenberg.org/files/1661/1661-0.txt
Resolving www.gutenberg.org (www.gutenberg.org)... 152.19.134.47, 2610:28:3099:3000:0:bad:cafe:47
Connecting to www.gutenberg.org (www.gutenberg.org)|152.19.134.47|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 607504 (593K) [text/plain]
Saving to: 'sherlock.txt'

sherlock.txt    100%[=====] 593.27K  1.32MB/s   in 0.4s
2025-12-30 15:53:59 (1.32 MB/s) - 'sherlock.txt' saved [607504/607504]

rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ ls
sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ cat sherlock.txt | head
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rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ less sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ less sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ wc sherlock.txt
12306 107562 607504 sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ wc -m sherlock.txt
593731 sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$
```

Figure 5.6-3 – Counting lines, words and characters with wc

grep -n "kingdom" sherlock.txt lists every line containing “kingdom” together with its line number. The word ‘kingdom’ occurs on lines 490 and 1124.

```

rushdanya585732@rushdanya585732-Vmware20-1: ~$ mkdir -p week5_6
rushdanya585732@rushdanya585732-Vmware20-1: ~$ cd week5_6
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ pwd
/home/rushdanya585732/week5_6
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ wget https://www.gutenberg.org/files/1661/1661-0.txt -O sherlock.txt
--2025-12-30 15:53:58-- https://www.gutenberg.org/files/1661/1661-0.txt
Resolving www.gutenberg.org (www.gutenberg.org)... 152.19.134.47, 2610:28:3099:3000:0:bad:cafe:47
Connecting to www.gutenberg.org (www.gutenberg.org)|152.19.134.47|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 607504 (593K) [text/plain]
Saving to: 'sherlock.txt'

sherlock.txt    100%[=====] 593.27K  1.32MB/s   in 0.4s
2025-12-30 15:53:59 (1.32 MB/s) - 'sherlock.txt' saved [607504/607504]

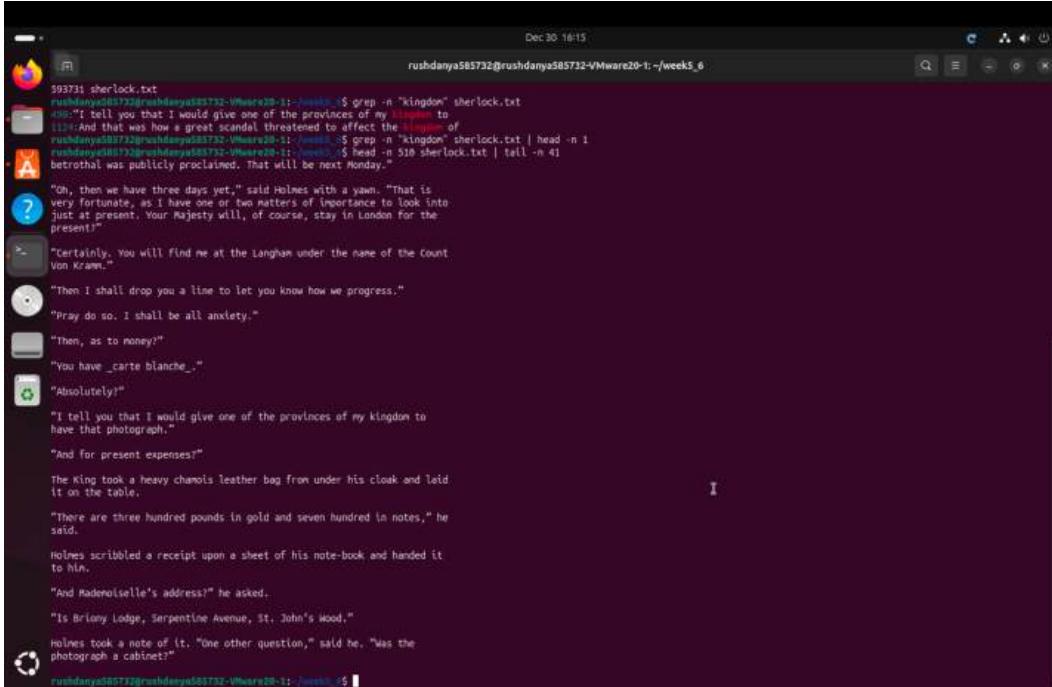
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ ls
sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ cat sherlock.txt | head
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by Arthur Conan Doyle

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rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ less sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ less sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ wc sherlock.txt
12306 107562 607504 sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ wc -m sherlock.txt
593731 sherlock.txt
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$ grep -n "kingdom" sherlock.txt
490:"I tell you that I would give one of the provinces of my kingdom to
1124:And that was how a great scandal threatened to affect the kingdom of
rushdanya585732@rushdanya585732-Vmware20-1: ~/week5_6$
```

Figure 5.6-4 – Finding all lines that contain the word “kingdom”

Combining head -n ... | tail -n 41 displays 20 lines before and after the first line that contains "kingdom".

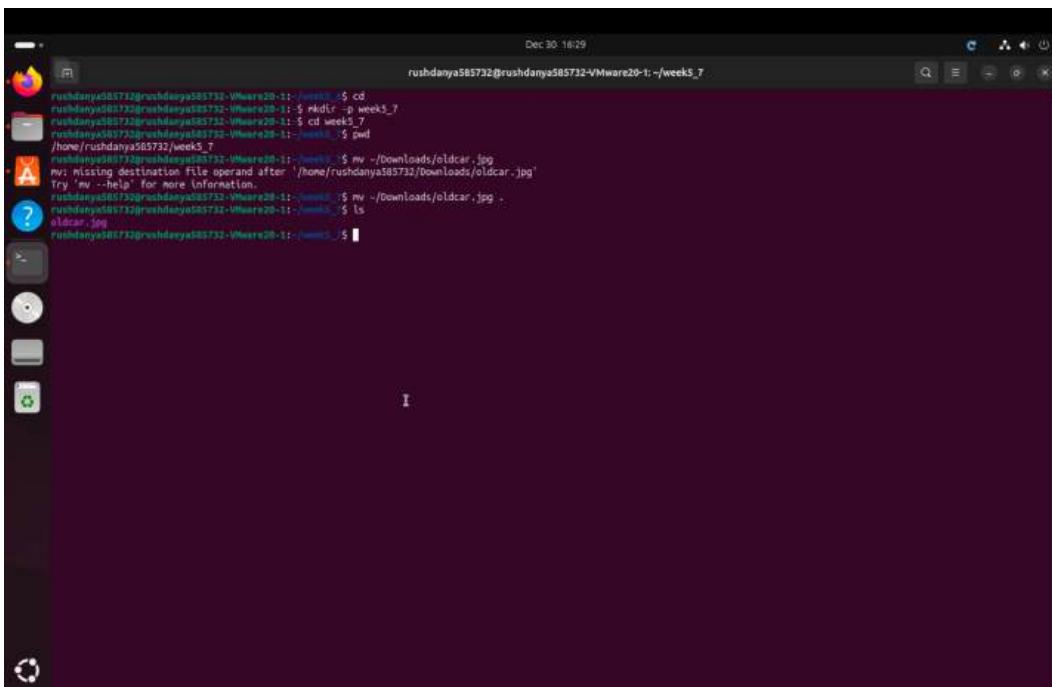


```
Dec 30 16:15
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_6
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_6$ grep -n "Kingdom" sherlock.txt
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_6$ grep -n "Kingdom" sherlock.txt | head -n 1
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_6$ head -n 50 sherlock.txt | tail -n 41
A betrothal was publicly proclaimed. That will be next Monday."
B "Oh, then we have three days yet," said Holmes with a yawn. "That is
C very fortunate, as I have one or two matters of importance to look into
D D at present. Your majesty will, of course, stay in London for the
E E present?"
F "Certainly. You will find me at the Langham under the name of the Count
G G Von Kramm."
H "Then I shall drop you a line to let you know how we progress."
I "Pray do so. I shall be all anxiety."
J "Then, as to money?"
K "You have carte blanche."
L "Absolutely!"
M "I tell you that I would give one of the provinces of my kingdom to
N N have that photograph."
O "And for present expenses?"
P The King took a heavy chamois leather bag from under his cloak and laid
Q Q it on the table.
R "There are three hundred pounds in gold and seven hundred in notes," he
S S said.
T Holmes scribbled a receipt upon a sheet of his note-book and handed it
U U to him.
V "And Mademoiselle's address?" he asked.
W "16 Briony Lodge, Serpentine Avenue, St. John's Wood."
X Holmes took a note of it. "One other question," said he. "Was the
Y Y photograph a cabinet?"
Z
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_6$
```

Figure 5.6-5 – Showing context around the first “kingdom” occurrence

Assignment 5.7: Digital forensics

Relevant screenshots + motivation



```
Dec 30 16:29
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_7
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_7$ cd
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_7$ mkdir -p week5_7
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_7$ cd week5_7
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_7$ pwd
/home/rushdanya585732/week5_7
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_7$ mv ~/Downloads/oldcar.jpg .
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_7$ mv ~/Downloads/oldcar.jpg oldcar.jpg
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_7$ mv ./oldcar.jpg .
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_7$ ls
oldcar.jpg
rushdanya585732@rushdanya585732-VirtualBox:~/.week5_7$
```

Figure 5.7-1 – Downloading oldcar.jpg

exiftool oldcar.jpg reveals camera information, including Make: motorola and Camera Model Name: moto g(6) play.

```

rushdanya585732@rushdanya585732-VirtualBox:~/week5_7$ exiftool oldcar.jpg
File: oldcar.jpg
ExtTool Version Number : 12.76
File Type : JPEG
File Size : 2.4 MB
File Modification Date/Time : 2021:12:28 16:26:45+01:00
File Access Date/Time : 2021:12:28 16:26:45+01:00
File Create Date/Time : 2021:12:28 16:25:12+01:00
File Permissions : -rwxr--r--
File Type Extension : jpg
Image Type : Image/jpeg
Image Version : 1.00
Image Width : 4160
Image Height : 3120
Image Resolution Unit : inches
Software : albert-user-9 PPP529.55-35-18-7 6add8 release-keys
Modify Date : 2020:11:07 15:00:17
V Cb Cr Positioning : Centered
Exposure Time : 1/33
F Number : 2.8
Exposure Program : Program AE
ISO : 44
EXIF Version : 0228
DateTimeOriginal : 2020:11:07 15:00:17
Create Date : 2020:11:07 15:00:17
Components Configuration : Y, Cb, Cr+
Shutter Speed Value : 1/33
Aperture Value : 2.0
Exposure Compensation : 0
Max Aperture Value : 2.0
Metering Mode : Center-weighted average
Flash : Auto, Did not fire
Focal Length : 3.3 mm
Build Number : PPP529.55-35-18-7
Sensor : BACK,mot,s3k318
Manufacture Date : 140ct2018
Flashpix Version : 0100
Color Space : sRGB
Exif Image Width : 4160
Exif Image Height : 3120
Interoperability Index : R9E - DCF basic file (sRGB)
Interoperability Version : R9E
Scene Type : Directly photographed
Custom Rendered : Normal
Exposure Mode : Auto
White Balance : Auto
Digital Zoom Ratio : 1
Image Capture Type : Standard
Contrast : Normal

```



```

rushdanya585732@rushdanya585732-VirtualBox:~/week5_7$ exiftool oldcar.jpg
Brightness Value : -1
Exposure Compensation : 0
Max Aperture Value : 2.0
Metering Mode : Center-weighted average
Flash : Auto, Did not fire
Focal Length : 3.3 mm
Build Number : PPP529.55-35-18-7
Sensor : BACK,mot,s3k318
Manufacture Date : 140ct2018
Flashpix Version : 0100
Color Space : sRGB
Exif Image Width : 4160
Exif Image Height : 3120
Interoperability Index : R9E - DCF basic file (sRGB)
Interoperability Version : R9E
Scene Type : Directly photographed
Custom Rendered : Normal
Exposure Mode : Auto
White Balance : Auto
Digital Zoom Ratio : 1
Image Capture Type : Standard
Contrast : Normal
Saturation : Low
Sharpness : Soft
GPS Version ID : 0.0.0-0
GPS Latitude Ref : East
GPS Altitude Ref : Above Sea Level
GPS Time Stamp : 14:00:57
GPS Img Dir : 000
GPS Antenna : ASCII
GPS Date Stamp : 2020:11:07
Compression : JPEG (old-style)
Thumbnail Offset : 2862
Thumbnail Length : 3888
Image Width : 4160
Image Height : 3120
Encoding Process : Baseline DCT, Huffman coding
Bits Per Sample : 8
Color Components : 3
V Cb Cr Sub Sampling : YCbCr4:2:0 (2:1)
Aperture : 2.8
Image Size : 4160x3120
Resolution : 15.0
Shutter Speed : 1/33
Thumbnail Image : [Binary data SHA15 bytes, use -b option to extract]
GPS Altitude : 42 m Above Sea Level
GPS Date/Time : 2020:11:07 14:00:57Z
GPS Latitude : 35 deg 11' 39.68" N
GPS Longitude : 6 deg 32' 12.99" E
GPS Altitude : 42 m
GPS Position : 35 deg 11' 39.68" N, 6 deg 32' 12.99" E
Light Value : 7.7

```

Figure 5.7-2,3 – EXIF metadata of oldcar.jpg

I analysed the photo file with the command exiftool oldcar.jpg on my Ubuntu VM.

The EXIF data shows that the picture was taken with a **Motorola moto g(6) play** smartphone.

The GPS information in the file gives the coordinates **53°19'39.68"N, 6°32'12.90"E** at an altitude of **42 m**.

I entered these coordinates into Google Maps and checked the surroundings with Street View.

The coordinates point to a **rural area in the Netherlands, in the province of Groningen, near the village of Harnem in the municipality of Eemsdelta**.

I removed the .jpg extension from the filename using mv oldcar.jpg oldcar.

```
Dec 30 17:17: rushdanya585732@rushdanya585732:~/VMware20-1: ~/week5_7
```

EXIF Tag	Value
Exif Version	02.3.0
Flashpix Version	0100
Color Space	sRGB
Exif Image Width	4168
Exif Image Height	3120
Interoperability Index	R98 - DCF basic file (sRGB)
Interoperability Version	0100
Scene Type	Directly photographed
Custom Rendered	Normal
Exposure Mode	Auto
White Balance	Auto
Digital Zoom Ratio	1
Scene Capture Type	Standard
Contrast	Normal
Saturation	Low
Sharpness	Soft
GPS Version ID	2.3.8.0
GPS Latitude Ref	North
GPS Longitude Ref	East
GPS Altitude Ref	Above Sea level
GPS Time Stamp	14:00:57
GPS Map Datum	WGS-84
GPS Processing Method	ASCII
GPS Date Stamp	2020:11:07
Compression	JPEG (old-style)
Thumbnail Offset	2862
Thumbnail Length	59453
Image Width	4168
Image Height	3120
Encoding Process	Baseline DCT, Huffman coding
Bit Depth	8
Color Components	3
YCbCr Sub Sampling	YCbCr4:2:0 (2 2)
Aperture	2.0
Image Size	4168x3120
Megapixels	13.0
Shutter Speed	1/33
Thumbnail Image	(Binary data 59453 bytes, use -b option to extract)
GPS Altitude	42 m Above Sea Level
GPS Date/Time	2020:11:07 14:00:57Z
GPS Latitude	53 deg 19' 39.68" N
GPS Longitude	6 deg 32' 12.90" E
Focal Length	3.0 mm
GPS Position	53 deg 19' 39.68" N, 6 deg 32' 12.90" E
Light Value	7.7

```
rushdanya585732@rushdanya585732:~/VMware20-1: ~/week5_7$ mv oldcar.jpg oldcar
rushdanya585732@rushdanya585732:~/VMware20-1: ~/week5_7$ ls
oldcar
rushdanya585732@rushdanya585732:~/VMware20-1: ~/week5_7$
```

Figure 5.7-4 – Renaming oldcar.jpg to oldcar

After removing the .jpg extension, Ubuntu still recognises the file oldcar as JPEG image data. So yes, Ubuntu still considers it to be a JPG file, because it determines the type from the file's contents, not from the extension.

```

Dec 30 17:17
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7

Build Number : PPPS29.55-35-10-7
Sensor       : BACK.mot.skl10
Manufacture Date : 140ct2018
Flashpix Version : 0100
Color Space   : sRGB
Exif Image Width : 4160
Exif Image Height : 3120
Interoperability Index : 998 - DCF basic file (sRGB)
Interoperability Version : 0100
Scene Type    : Directly photographed
Custom Rendered : Normal
Exposure Mode : Auto
White Balance  : Auto
Digital Zoom Ratio : 1
Scene Capture Type : Standard
Contrast      : Normal
Saturation    : Low
Sharpness     : Soft
GPS Version ID : 2.2.0.6
GPS Latitude Ref : North
GPS Longitude Ref : East
GPS Altitude Ref : Above Sea Level
GPS Time Stamp : 14:08:57
GPS Map Datum : WGS-84
GPS Processing Method : ASCII
GPS Data Stamp : 2020:11:07:15:08:57
Compression   : JPEG (old-style)
Thumbnail Offset : 2082
Thumbnail Length : 59453
Image Width   : 4160
Image Height  : 3120
Encoding Process : Baseline DCT, Huffman coding
Bits Per Sample : 8
Color Components : 3
YCbCr Sub Sampling : YCbCr4:2:0 (2 2)
Aperture      : 2.8
Image Size    : 4160x3120
Megapixels    : 13.0
Shutter Speed : 1/33
Thumbnail Image : (Binary data 59453 bytes, use -b option to extract)
GPS Altitude  : 42 m Above Sea Level
GPS Date/Time : 2020:11:07 14:08:57Z
GPS Latitude  : 53 deg 11' 39.68" N
GPS Longitude : 6 deg 32' 12.98" E
Focal length   : 3.5 mm
GPS Position  : 53 deg 11' 39.68" N, 6 deg 32' 12.98" E
Light Value    : 7.7
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ mv oldcar.jpg oldcar
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ ls
oldcar
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ file oldcar
oldcar: JPEG image data, JFIF standard 1.01, aspect ratio, density 1xi, segment length 16, Exif Standard: [TIFF image data, big-endian, direntries=10, manufacturer=motorola, model=mota g(6) play, xresolution=100, yresolution=100, resolutionunit=2, software=aljeter-user 9 PPPS29.55-35-10-7 6a0d0 release-keys, datetime=2020:11:07 15:08:57, GPS-Data], baseline, precision 8, 4160x3120, components 3
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$
```

Figure 5.7-5 – file oldcar still reporting JPEG image data

I created email-base64.txt and pasted the long BASE64-encoded text from the assignment into it.

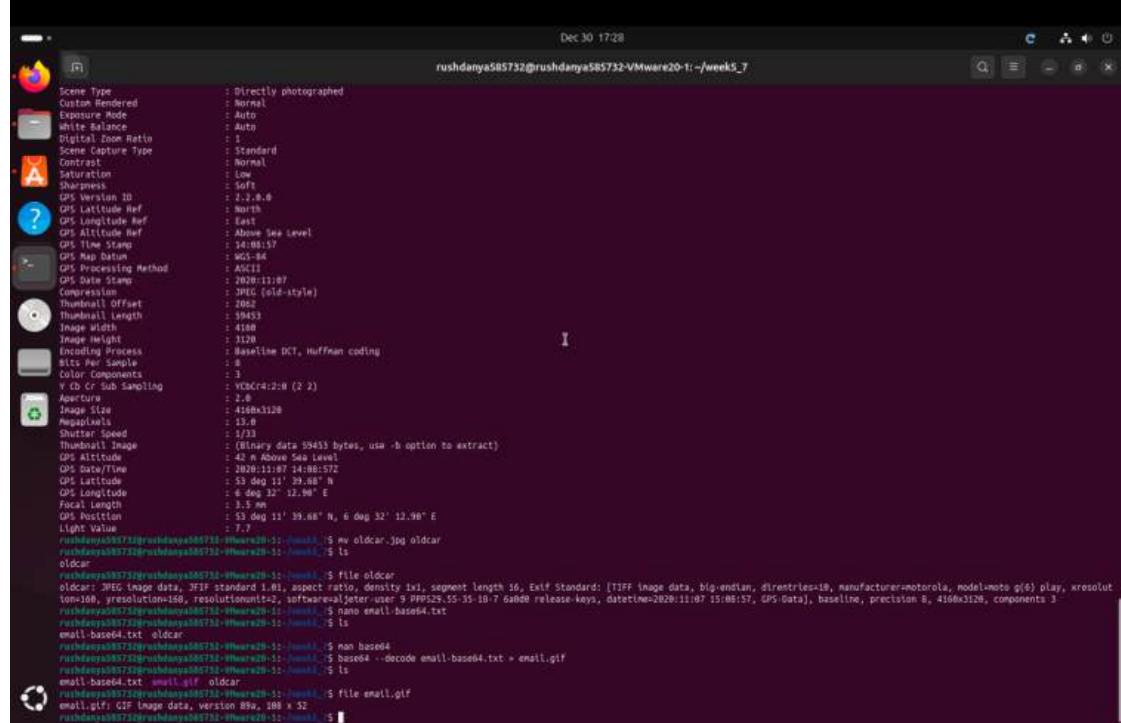
```

Dec 30 17:28
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7

Build Number : PPPS29.55-35-10-7
Interoperability Version : 0100
Scene Type    : Directly photographed
Custom Rendered : Normal
Exposure Mode : Auto
White Balance  : Auto
Digital Zoom Ratio : 1
Scene Capture Type : Standard
Contrast      : Normal
Saturation    : Low
Sharpness     : Soft
GPS Version ID : 2.2.0.6
GPS Latitude Ref : North
GPS Longitude Ref : East
GPS Altitude Ref : Above Sea Level
GPS Time Stamp : 14:08:57
GPS Map Datum : WGS-84
GPS Processing Method : ASCII
GPS Data Stamp : 2020:11:07:14:08:57Z
Compression   : JPEG (old-style)
Thumbnail Offset : 2082
Thumbnail Length : 59453
Image Width   : 4160
Image Height  : 3120
Encoding Process : Baseline DCT, Huffman coding
Bits Per Sample : 8
Color Components : 3
YCbCr Sub Sampling : YCbCr4:2:0 (2 2)
Aperture      : 2.8
Image Size    : 4160x3120
Megapixels    : 13.0
Shutter Speed : 1/33
Thumbnail Image : (Binary data 59453 bytes, use -b option to extract)
GPS Altitude  : 42 m Above Sea Level
GPS Date/Time : 2020:11:07 14:08:57Z
GPS Latitude  : 53 deg 11' 39.68" N
GPS Longitude : 6 deg 32' 12.98" E
Focal length   : 3.5 mm
GPS Position  : 53 deg 11' 39.68" N, 6 deg 32' 12.98" E
Light Value    : 7.7
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ mv oldcar.jpg oldcar
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ ls
oldcar
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ file oldcar
oldcar: JPEG image data, JFIF standard 1.01, aspect ratio, density 1xi, segment length 16, Exif Standard: [TIFF image data, big-endian, direntries=10, manufacturer=motorola, model=mota g(6) play, xresolution=100, yresolution=100, resolutionunit=2, software=aljeter-user 9 PPPS29.55-35-10-7 6a0d0 release-keys, datetime=2020:11:07 15:08:57, GPS-Data], baseline, precision 8, 4160x3120, components 3
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ rm email-base64.txt
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ rm email-base64.gif
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ rm oldcar
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ ls
```

Figure 5.7-6 – Creating email-base64.txt

Using base64 --decode email-base64.txt > email.gif I reconstructed the original binary GIF file.



```
Dec 30 17:28
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7

Custom Type : Directly photographed
Custom Rendered : Normal
Exposure Mode : Auto
White Balance : Auto
Digital Zoom Ratio : 1
Scene Capture Type : Standard
Contrast : Normal
Saturation : Low
Sharpness : Soft
GPS Version ID : 2.2.8.6
GPS Latitude Ref : North
GPS Longitude Ref : East
GPS Altitude Ref : Above sea level
GPS Time Stamp : 2020:11:07 14:00:57
GPS Map Datum : WGS-84
GPS Processing Method : ASCII
GPS Date Stamp : 2020:11:07
Compression : JPEG (old-style)
Thumbnail Offset : 2082
Thumbnail Length : 59453
Image Width : 4160
Image Height : 3120
Encoding Process : Baseline DCT, Huffman coding
Bits Per Sample : 8
Color Components : 3
YCbCr Sub Sampling : YCbCr4:2:0 (2 2)
Aperture : 2.8
Image Size : 4160x3120
Megapixels : 13.8
Shutter Speed : 1/33
Thumbnail Image : (Binary data 59453 bytes, use -b option to extract)
GPS Altitude : 42 m Above sea level
GPS Date/Time : 2020:11:07 14:00:57
GPS Latitude : 53 deg 15' 39.88" N
GPS Longitude : 6 deg 32' 12.98" E
Focal length : 3.5 mm
GPS Position : 53 deg 15' 39.88" N, 6 deg 32' 12.98" E
Light Value : 7.7
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ mv oldcar.jpg oldcar
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ ls
oldcar
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ file oldcar
oldcar: JPEG image data, JFIF standard 1.01, aspect ratio, density 1x1, segment length 16, Exif Standard: [TIFF image data, big-endian, direntries=10, manufacturer=motorola, model=moto g(6) play, xresolution=108, yresolution=108, resolutionunit=2, software=aljeter-user 9 PPP529.55-35-10-7 6400 release-keys, datetime=2020:11:07 15:08:57, GPS-Data], baseline, precision 8, 4160x3120, components 3
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ nano email-base64.txt
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ base64 -d email-base64.txt > email.gif
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ ls
email-base64.txt  oldcar.gif  oldcar
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$ file email.gif
email.gif: GIF image data, version 89a, 108 x 32
rushdanya585732@rushdanya585732-VMware20-1:~/week5_7$
```

Figure 5.7-7 – Decoding the BASE64 string into email.gif

Opening email.gif in an image viewer shows the Saxion logo, confirming that the BASE64 text decoded correctly.

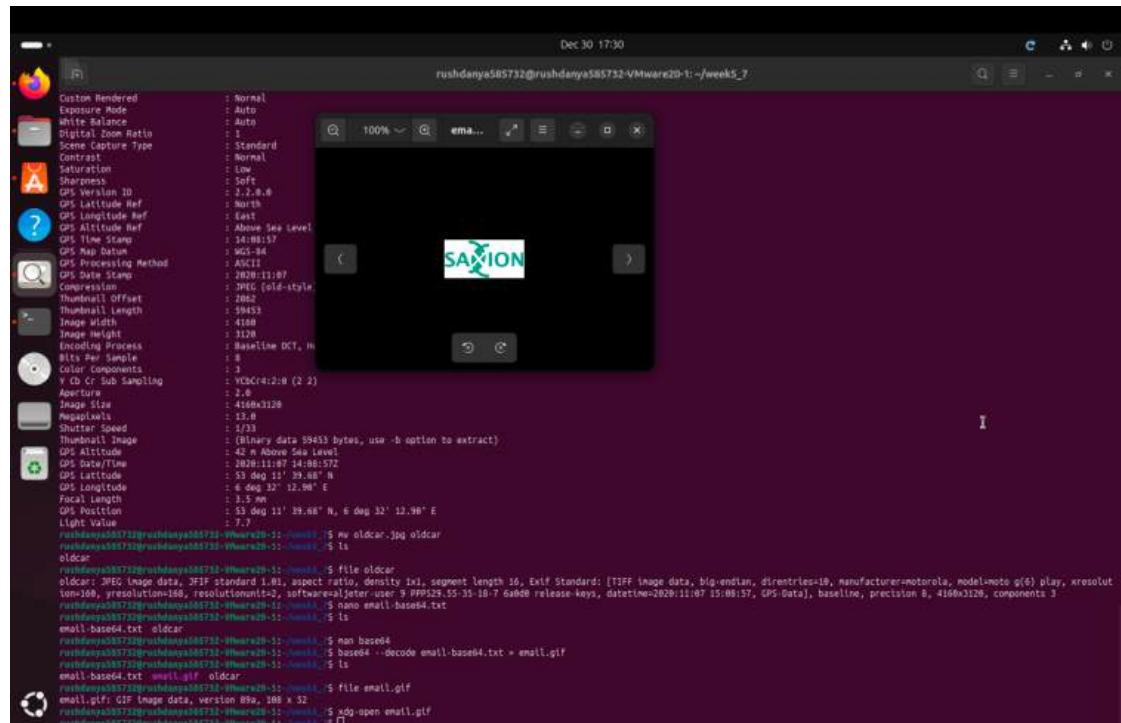


Figure 5.7-8 – Viewing email.gif (Saxion logo)

Assignment 5.8: Steganography

Relevant screenshots + motivation

This screenshot shows the downloaded apple2.jpg file, which contains hidden data in its least significant bits.

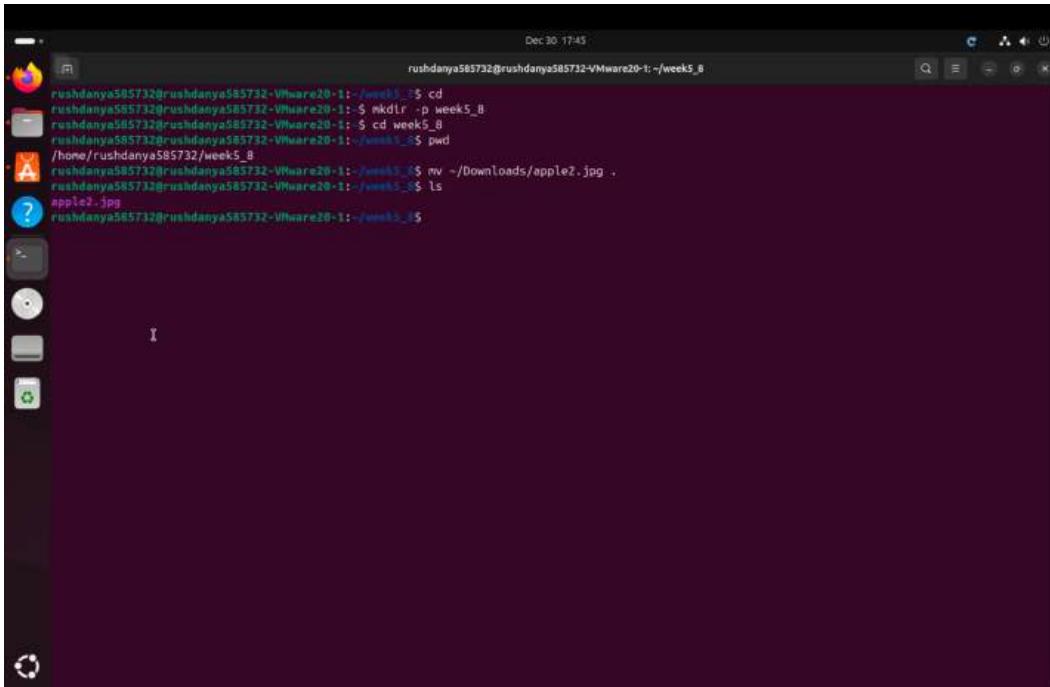


Figure 5.8-1 – apple2.jpg on the Ubuntu desktop

steghide --help confirms that the tool is installed and shows the extract option used to retrieve the hidden file.

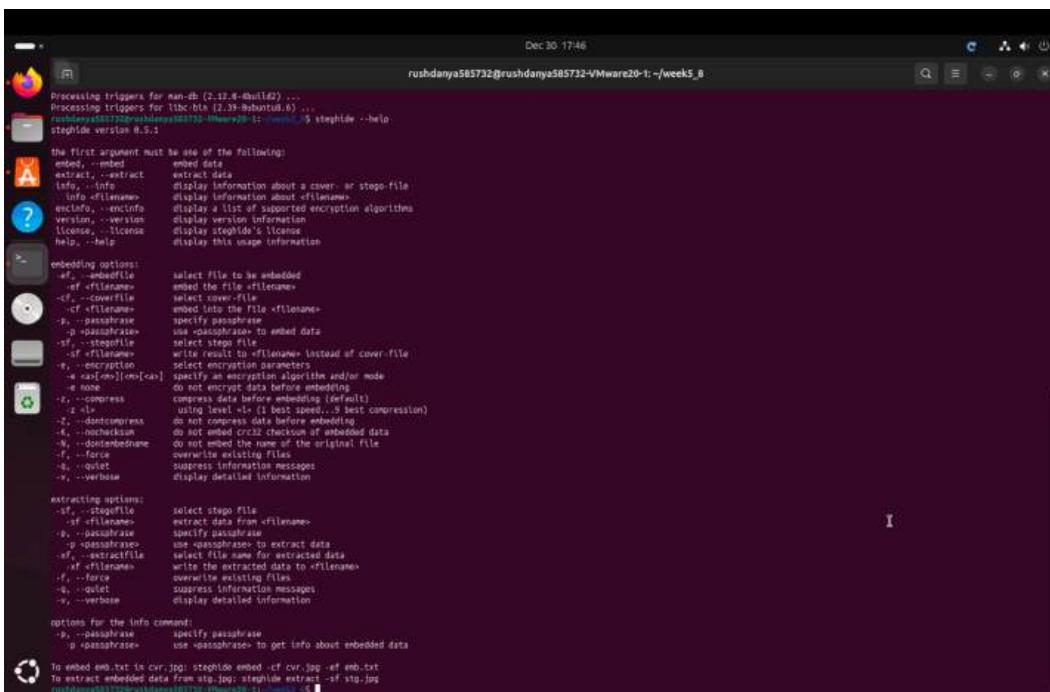


Figure 5.8-2 – Using steghide --help

With steghide extract -sf apple2.jpg and the passphrase apple2 I extracted the concealed text file to disk.

```

Dec 30 17:48
rushdanya585732@rushdanya585732:~/VMware20-1:/week5_8

steghide version 0.5.1

the first argument must be one of the following:
embed, -embed      embed data
extract, --extract extract data
info, --info       display information about a cover- or stego-file
info <filename>   display information about <filename>
encinfo, --encinfo display a list of supported encryption algorithms
version, --version  display version information
license, --license display steghide's license
help, --help        display this usage information

embedding options:
-eF, --embedfile  select file to be embedded
-eF <filename>    embed the file <filename>
-cF, --coverfile  select cover-file
-cF <filename>    embed into the file <filename>
-p, --passphrase  specify passphrase
-p <passphrase>  use <passphrase> to embed data
-sF, --stegofile  select stego file
-sF <filename>   write result to <filename> instead of cover-file
-a, --encryption  select encryption parameters
-a <algorithm>[+<mode>] specify an encryption algorithm and/or mode
-d, --decode       do not encrypt data before embedding
-z, --compress    compress data before embedding (default)
-z <n>            using level <n> (1 best speed... 9 best compression)
-Z, --dontcompress do not compress data before embedding
-A, --nochecksum  do not embed CRC32 checksum of embedded data
-W, --dontembedname do not embed the name of the original file
-f, --force        overwrite existing files
-q, --quiet        suppress information messages
-v, --verbose     display detailed information

extracting options:
-sF, --stegofile  select stego file
-sF <filename>   extract data from <filename>
-p, --passphrase  specify passphrase
-p <passphrase>  use <passphrase> to extract data
-o, --output       select file name for extracted data
-sx, --extractfile select file name for extracted data
-sx <filename>   write the extracted data to <filename>
-f, --force        overwrite existing files
-q, --quiet        suppress information messages
-v, --verbose     display detailed information

options for the info command:
-p, --passphrase  specify passphrase
-p <passphrase>  use <passphrase> to get info about embedded data

To embed emb.txt in cvr.jpg: steghide embed -rf cvr.jpg -ef emb.txt
To extract embedded data from stg.jpg: steghide extract -sf stg.jpg
rushdanya585732@rushdanya585732:~/VMware20-1:/week5_8$ steghide extract -sf apple2.jpg
Enter passphrase:
write extracted data to 'message.txt'.
rushdanya585732@rushdanya585732:~/VMware20-1:/week5_8$ ls
apple2.jpg  message.txt
rushdanya585732@rushdanya585732:~/VMware20-1:/week5_8$ cat message.txt
Hello class.
You have almost completed Week 5.

```

Figure 5.8-3 – Extracting the hidden file from apple2.jpg

Using cat (or a text editor) I show the message stored inside the hidden text file that was embedded in the image.

```

Dec 30 17:52
rushdanya585732@rushdanya585732:~/VMware20-1:/week5_8

steghide version 0.5.1

the first argument must be one of the following:
embed, -embed      embed data
extract, --extract extract data
info, --info       display information about a cover- or stego-file
info <filename>   display information about <filename>
encinfo, --encinfo display a list of supported encryption algorithms
version, --version  display version information
license, --license display steghide's license
help, --help        display this usage information

embedding options:
-eF, --embedfile  select file to be embedded
-eF <filename>    embed the file <filename>
-cF, --coverfile  select cover-file
-cF <filename>    embed into the file <filename>
-p, --passphrase  specify passphrase
-p <passphrase>  use <passphrase> to embed data
-sF, --stegofile  select stego file
-sF <filename>   write result to <filename> instead of cover-file
-a, --encryption  select encryption parameters
-a <algorithm>[+<mode>] specify an encryption algorithm and/or mode
-d, --decode       do not encrypt data before embedding
-z, --compress    compress data before embedding (default)
-z <n>            using level <n> (1 best speed... 9 best compression)
-Z, --dontcompress do not compress data before embedding
-A, --nochecksum  do not embed CRC32 checksum of embedded data
-W, --dontembedname do not embed the name of the original file
-f, --force        overwrite existing files
-q, --quiet        suppress information messages
-v, --verbose     display detailed information

extracting options:
-sF, --stegofile  select stego file
-sF <filename>   extract data from <filename>
-p, --passphrase  specify passphrase
-p <passphrase>  use <passphrase> to extract data
-o, --output       select file name for extracted data
-sx, --extractfile select file name for extracted data
-sx <filename>   write the extracted data to <filename>
-f, --force        overwrite existing files
-q, --quiet        suppress information messages
-v, --verbose     display detailed information

options for the info command:
-p, --passphrase  specify passphrase
-p <passphrase>  use <passphrase> to get info about embedded data

To embed emb.txt in cvr.jpg: steghide embed -rf cvr.jpg -ef emb.txt
To extract embedded data from stg.jpg: steghide extract -sf stg.jpg
rushdanya585732@rushdanya585732:~/VMware20-1:/week5_8$ steghide extract -sf apple2.jpg
Enter passphrase:
write extracted data to 'message.txt'.
rushdanya585732@rushdanya585732:~/VMware20-1:/week5_8$ ls
apple2.jpg  message.txt
rushdanya585732@rushdanya585732:~/VMware20-1:/week5_8$ cat message.txt
Hello class.
You have almost completed Week 5.

```

Figure 5.8-4 – Viewing the extracted secret text

Assignment 5.9: Capture disk images

Make relevant screenshots + motivation:

- Proof that the Debian 13 server stored a back-up image of the Ubuntu 24.04 Desktop VM.

On the Debian server I enabled ssh and created /srv/images as the storage location for disk image files.

The image consists of two vertically stacked screenshots of a Linux terminal window. Both screenshots show a terminal session with the user 'rushda585732' on a 'debian-imageserver' host, dated 'Jan 7 2:24 AM'.
The top screenshot shows the user running several commands to configure SSH:
```bashrushda585732@debian-imageserver:~\$ sudo apt update  
Hit:1 http://security.debian.org/debian-security trixie-security InRelease  
Hit:2 http://deb.debian.org/debian trixie InRelease  
Hit:3 http://deb.debian.org/debian trixie-updates InRelease  
All packages are up to date.  
rushda585732@debian-imageserver:~\$ sudo apt install openssh-server -y  
openssh-server is already the newest version (1:10.0p1-7).  
openssh-server set to manually installed.  
Summary:  
 Upgrading: 0, Installing: 0, Removing: 0, Not Upgrading: 0  
rushda585732@debian-imageserver:~\$ sudo systemctl enable --now ssh  
Synchronizing state of ssh.service with SysV service script with /usr/lib/systemd/systemd-sysv-install.  
Executing: /usr/lib/systemd/systemd-sysv-install enable ssh  
rushda585732@debian-imageserver:~\$```  
The bottom screenshot shows the user creating a directory for disk images:  
```bashrushda585732@debian-imageserver:~\$ sudo mkdir -p /srv/images  
rushda585732@debian-imageserver:~\$ sudo chown "\$USER":'\$USER' /srv/images
rushda585732@debian-imageserver:~\$ ls -ld /srv/images
drwxr-xr-x 2 rushda585732 rushda585732 4096 Jan 7 02:31 /srv/images
rushda585732@debian-imageserver:~\$```

Figure 5.9-1,2 – Debian image server with SSH and /srv/images configured

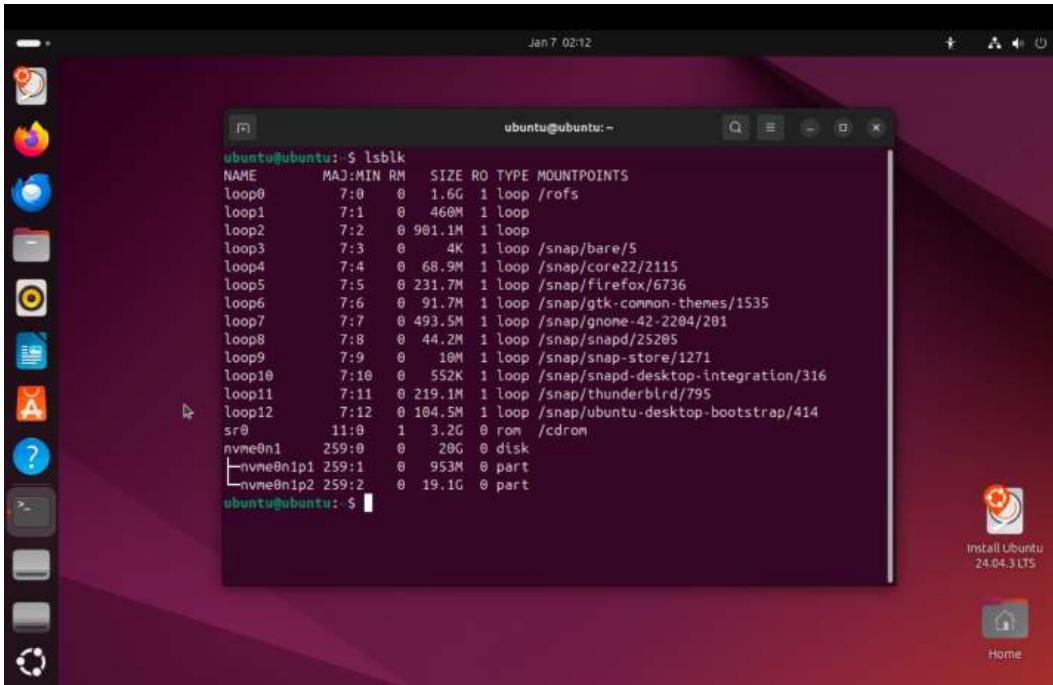
The ip a output shows the server's IP address, which I use in all ssh commands from the Ubuntu VMs.



```
rushda585732@debian-imageserver:~$ 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 loopback
            valid_lft forever preferred_lft forever
        inet6 ::1/128 scope host noprefixroute
            valid_lft forever preferred_lft forever
2: ens160: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default
    qlen 1000
        link/ether 00:0c:29:38:01:cc brd ff:ff:ff:ff:ff:ff
        altname enp2s0
        altname enx000c293801cc
        inet 192.168.229.138/24 brd 192.168.229.255 scope global dynamic noprefixroute
            valid_lft 998sec preferred_lft 998sec
            inet6 fe80::20c:29ff:fe38:01cc/64 scope link noprefixroute
                valid_lft forever preferred_lft forever
rushda585732@debian-imageserver:~$
```

Figure 5.9-3 – IP address of the Debian image server

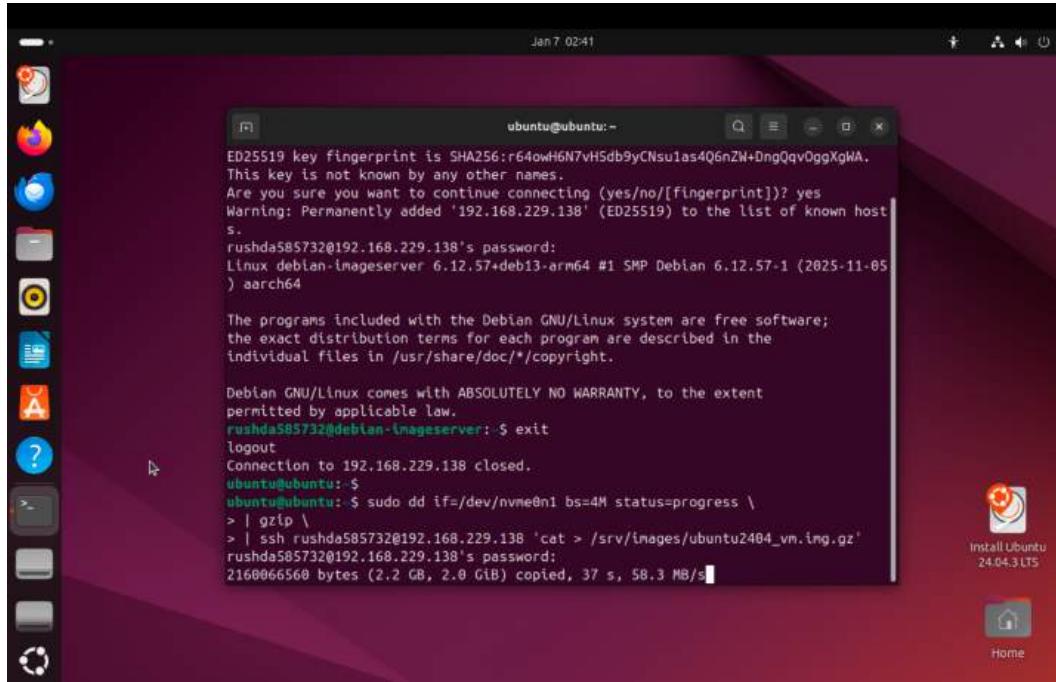
In the original Ubuntu VM booted as “Try Ubuntu”, lsblk identifies the full disk device (e.g. /dev/nvme0n1) to be captured.



```
ubuntu@ubuntu:~$ lsblk
NAME      MAJ:MIN RM  SIZE RO TYPE MOUNTPOINTS
loop0      7:0     0   1.6G  1 loop /rofs
loop1      7:1     0   460M  1 loop
loop2      7:2     0  901.1M  1 loop
loop3      7:3     0    4K  1 loop /snap/bare/5
loop4      7:4     0   68.9M  1 loop /snap/core22/2115
loop5      7:5     0  231.7M  1 loop /snap/firefox/6736
loop6      7:6     0   91.7M  1 loop /snap/gtk-common-themes/1535
loop7      7:7     0  493.5M  1 loop /snap/gnome-42-2204/201
loop8      7:8     0   44.2M  1 loop /snap/snapd/25205
loop9      7:9     0    10M  1 loop /snap/snap-store/1271
loop10     7:10    0    552K  1 loop /snap/snapd-desktop-integration/316
loop11     7:11    0  219.1M  1 loop /snap/thunderblr/795
loop12     7:12    0  104.5M  1 loop /snap/ubuntu-desktop-bootstr/414
sr0       11:0     1   3.2G  0 rom /cdrom
nvme0n1   259:0    0   20G  0 disk
└─nvme0n1p1 259:1    0   953M  0 part
└─nvme0n1p2 259:2    0   19.1G 0 part
ubuntu@ubuntu:~$
```

Figure 5.9-4 – Ubuntu client VM booted into Live session with disk lsblk

The command `sudo dd if=/dev/... bs=4M status=progress | gzip | ssh user@debian 'cat > /srv/images/ubuntu2404_vm.img.gz'` copies, compresses and streams the entire disk to the Debian server.



A screenshot of a Linux desktop environment showing a terminal window. The terminal window title is "ubuntu@ubuntu:~". The terminal content shows the following steps:

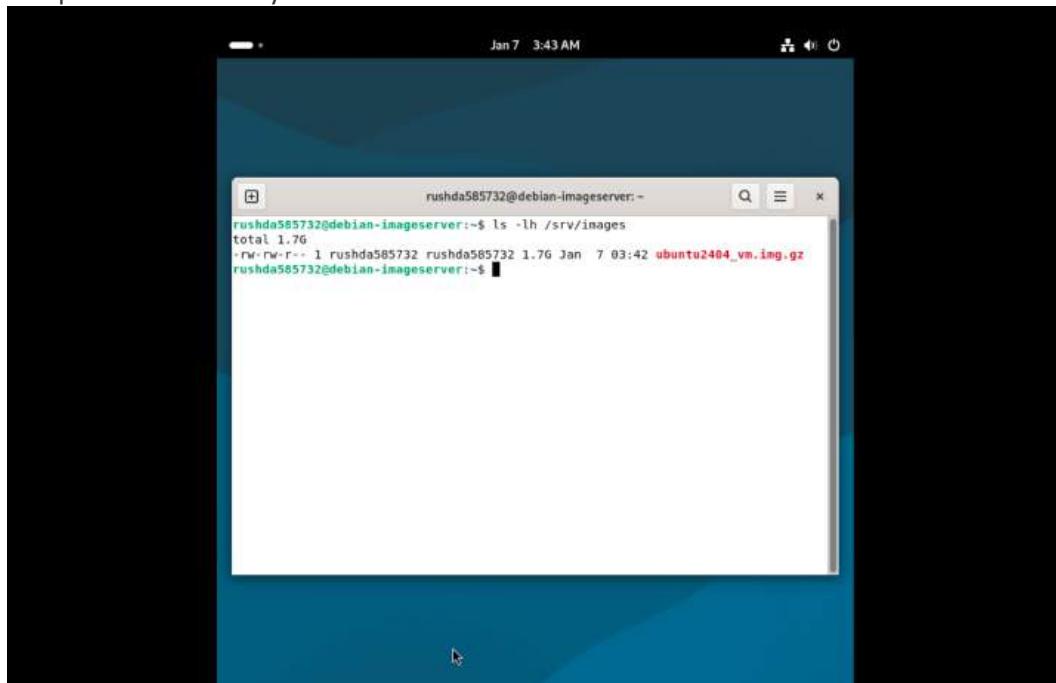
```
ED25519 key fingerprint is SHA256:r64owH6N7vH5db9yCnsu1as4Q6nZW+DngQqvOpgXgWA.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '192.168.229.138' (ED25519) to the list of known host
s.
rushda585732@192.168.229.138's password:
Linux debian-imageserver 6.12.57+deb13-arm64 #1 SMP Debian 6.12.57-1 (2025-11-05)
) aarch64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
rushda585732@debian-imageserver: $ exit
logout
Connection to 192.168.229.138 closed.
ubuntu@ubuntu: ~
ubuntu@ubuntu: $ sudo dd if=/dev/nvme0n1 bs=4M status=progress \
> | gzip \
> | ssh rushda585732@192.168.229.138 'cat > /srv/images/ubuntu2404_vm.img.gz'
rushda585732@192.168.229.138's password:
2160066560 bytes (2.2 GB, 2.0 GiB) copied, 37 s, 58.3 MB/s
```

Figure 5.9-5 – Capturing the Ubuntu disk to Debian with `dd | gzip | ssh`

`ls -lh /srv/images` on Debian shows the large `ubuntu2404_vm.img.gz` file, proving the capture completed successfully.



A screenshot of a Linux desktop environment showing a terminal window. The terminal window title is "rushda585732@debian-imageserver:~". The terminal content shows the following command and its output:

```
rushda585732@debian-imageserver:~$ ls -lh /srv/images
total 1.7G
-rw-rw-r-- 1 rushda585732 rushda585732 1.7G Jan  7 03:42 ubuntu2404_vm.img.gz
rushda585732@debian-imageserver:~$
```

Figure 5.9-6 – Image file stored on Debian

- Proof that you can restore the back-up image into an empty VM.

On the new empty VM in “Try Ubuntu” mode, lsblk shows the target disk (same size as the original) that will receive the restored image.

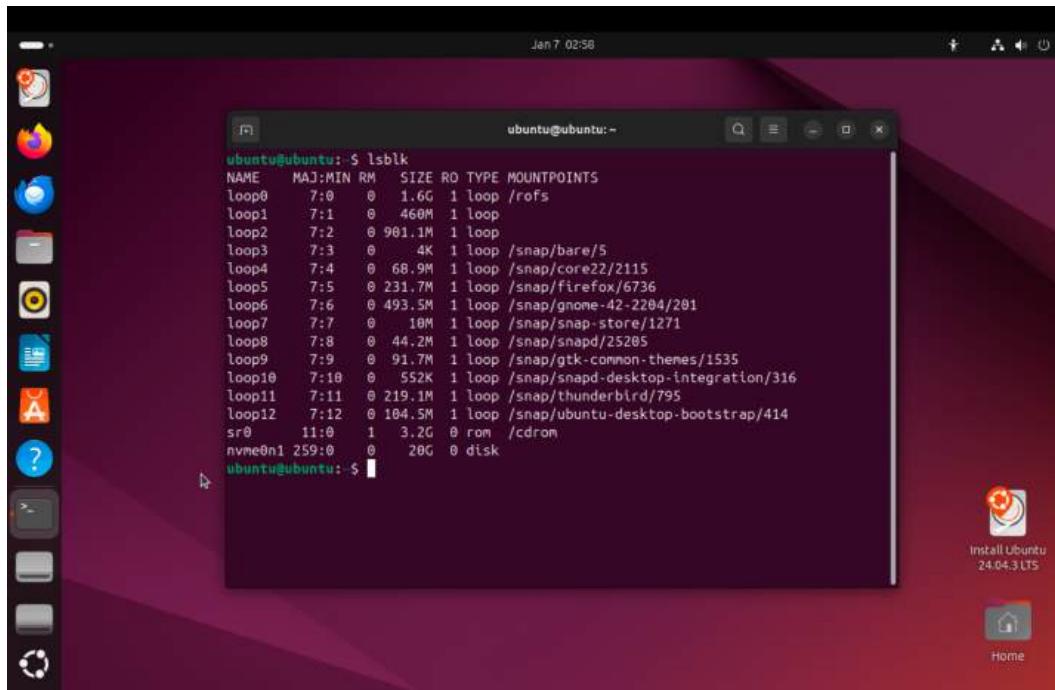
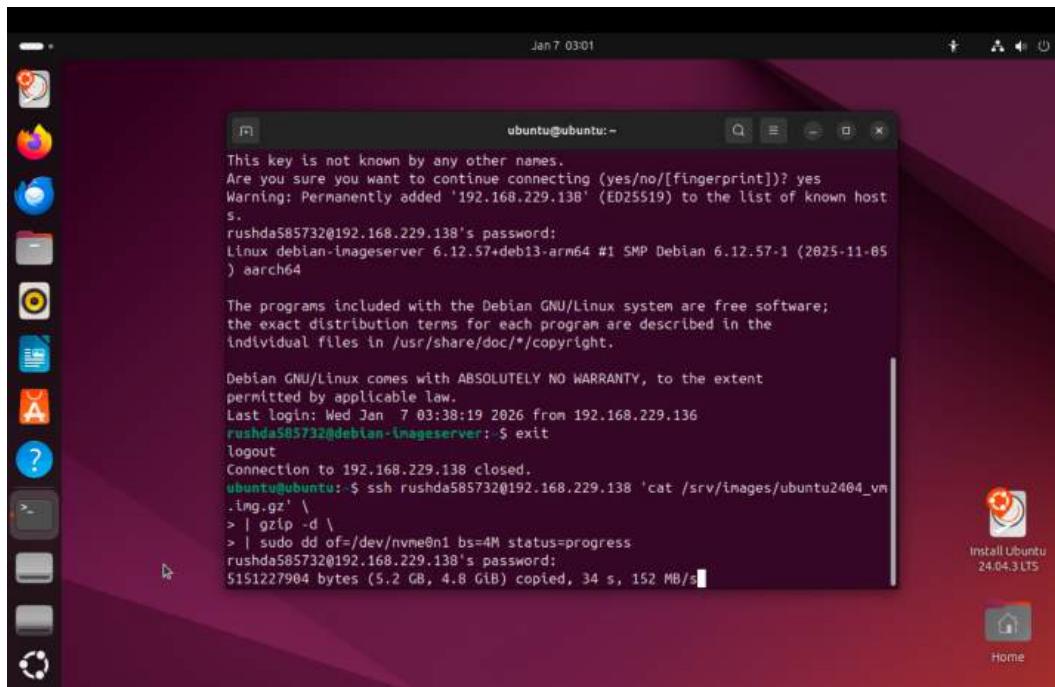


Figure 5.9-7 – Ubuntu-Restored VM Live session showing target disk with lsblk

The restore pipeline `ssh user@debian 'cat /srv/images/ubuntu2404_vm.img.gz' | gzip -d | sudo dd of=/dev/... bs=4M status=progress` writes the captured image back to the new VM's disk.



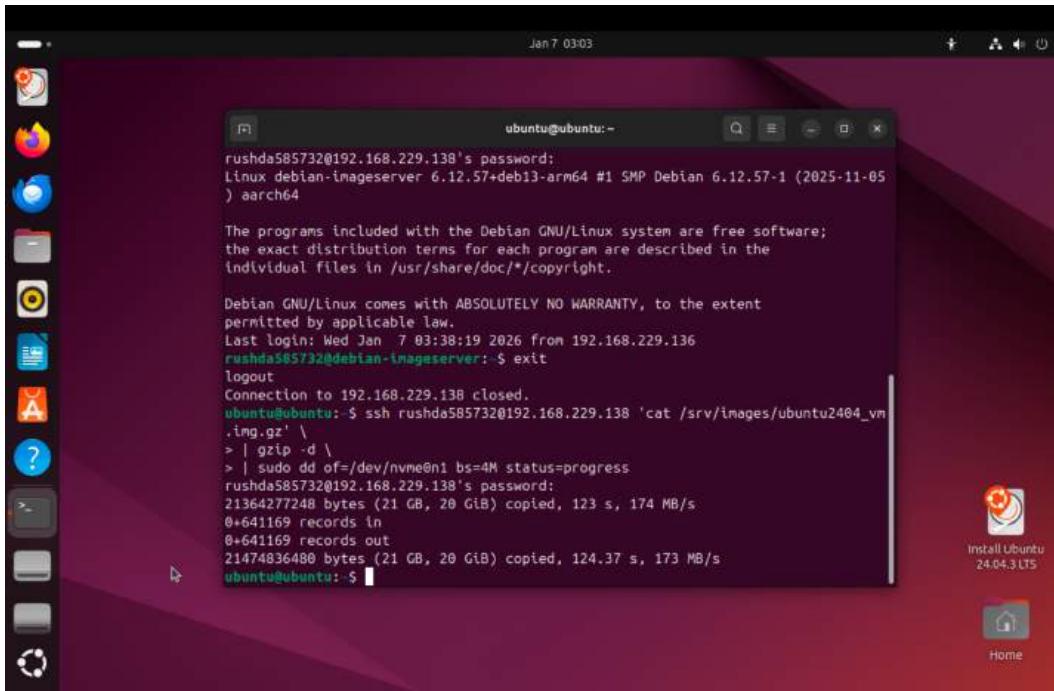


Figure 5.9-8, 9 – Restoring the image from Debian onto the new disk

On a new empty Ubuntu VM I booted into a live session and restored the captured image from the Debian server with:

```
ssh rushda585732@192.168.229.138 'cat /srv/images/ubuntu2404_vm.img.gz' | gzip -d | sudo dd  
of=/dev/nvme0n1 bs=4M status=progress.
```

After shutting down the live session, disconnecting the ISO and booting from the disk, the VM started normally with the restored Ubuntu system.

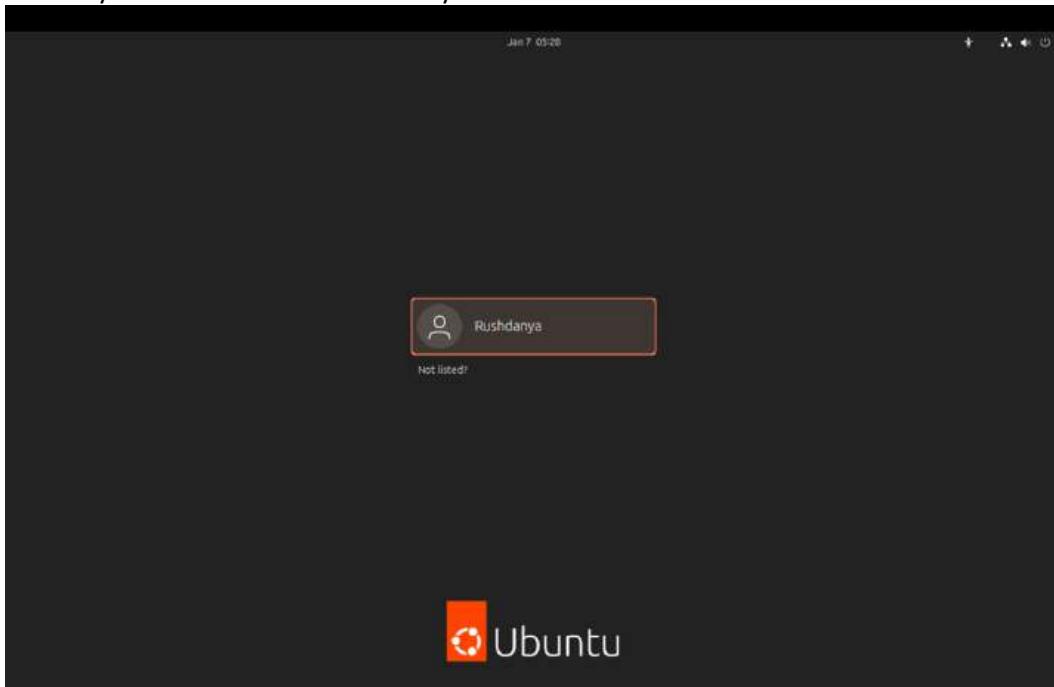


Figure 5.9-10 – Successfully booted restored Ubuntu VM