

Template Week 5 – Operating Systems

Student number:

Assignment 5.1: Unix-like

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

Unix is a more specific, a certified brand by The Open Group which requires payment, unix-like systems are generated from unix in terms of functionality, often it gets via open-source implementations e.g. Linux or BSD roots in macOS.

- 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** is often considered the father of UNIX, having designed and implemented the original operating system at Bell Labs in 1969. His work established the fundamental philosophy of UNIX—simple, modular tools acting on streams of data—which remains the standard for operating systems today. Beyond UNIX, Thompson made massive contributions to computer science by inventing the B programming language (the direct predecessor to C), co-creating the UTF-8 character encoding which is the dominant standard for the World Wide Web, and later co-developing the Go programming language at Google.

- **Dennis Ritchie** was a computer scientist at Bell Labs who worked closely with Thompson and is best known as the creator of the C programming language. In the early 1970s, he rewrote the UNIX kernel in C, a move that made the operating system "portable," meaning it could be easily moved to different types of hardware; this was a revolutionary concept that allowed UNIX to spread rapidly. C became the most influential programming language in history, serving as the basis for C++, Java, Python, and the kernels of all modern operating systems including Windows, macOS, and Linux.

- **Bill Joy** was a graduate student at UC Berkeley who played a pivotal role in the development of the Berkeley Software Distribution (BSD) version of UNIX, which introduced essential features like virtual memory and the TCP/IP stack that serves as the backbone of the modern internet. He created widely used tools such as the vi text editor and the C shell (csh) before co-founding Sun Microsystems. At Sun, he was instrumental in the development of the Java programming language, the SPARC microprocessor, and the Network File System (NFS), bridging the gap between academic UNIX research and commercial enterprise computing.

- **Richard Stallman** is the founder of the Free Software movement and the GNU Project, which he launched in 1983 with the goal of creating a completely free, UNIX-like operating system. Although he did not write the kernel that eventually became famous (Linux), he wrote the essential user-space tools and compilers—such as the GNU Compiler Collection (GCC) and GNU Emacs—without which the Linux kernel would not have been a functional operating system. He also created the General Public License (GPL), a legal framework called "copyleft" that ensures

software remains free for users to study, modify, and distribute, fundamentally changing the software industry.

- **Linus Torvalds** is a Finnish software engineer who, in 1991, created the Linux kernel to act as a free alternative to MINIX for his personal computer. By combining his kernel with the GNU tools created by Stallman's team, he facilitated the birth of the GNU/Linux operating system, which now powers the vast majority of the internet's servers, supercomputers, and all Android devices. In addition to Linux, Torvalds developed Git, the distributed version control system that has become the global standard for software collaboration and code management.

- c) What is the philosophy of the GNU movement?

Initiate champions user freedom in computing, ensuring users can run, study, modify, and distribute software, emphasizing that software should be a communal resource, not proprietary

- d) Does Ubuntu as a Linux operating system conform to the philosophy of the GNU movement? Please explain your answer.

Actually, not but yes in some parts. It is not because, ubuntu chooses pragmatism over philosophy. It prioritizes "it just works" and ease use. Ubuntu includes or encourages proprietary software for the sake of convenience, which is not Free software foundation. Even though most of the software in Ubuntu's "Main" and "Universe" repositories is free and open source, allowing users to study, share, and modify the code. Therefore, while it is a major contributor to the open-source world, the Free Software Foundation does not endorse Ubuntu as a strictly free operating system.

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

- f) Find out, which operating system family belongs to Android, iOS and ChromeOS?
Both Android and ChromeOS belong to the Linux family. iOS belongs to the Unix family, specifically the BSD (Berkeley Software Distribution) branch.

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>

The timeline traces the origins of supercomputing from the pioneering CDC 6600 in 1964 and the iconic Cray-1 in 1976, which established the standard for high-performance vector processing. It highlights the industry's massive shift in the 1990s toward parallel processing architectures, exemplified by Intel's Paragon and the chess-playing IBM Deep Blue. Finally, it covers the modern era of petaflop-scale computing, featuring record-breaking machines like Japan's Earth Simulator, IBM's Roadrunner, and China's Tianhe systems.

- 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?

It built by connecting hundreds or thousands of consumer-grade PlayStation 3 consoles together over a network. It use for radar image processing, pattern recognition, artificial intelligence, academic research that stimulate black hole collisions dan study cryptography.

- 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?

The specific operating system running on this cluster is Oracle Linux for ARM. The developers chose to network boot this OS from a central server rather than using the default Raspbian (now Raspberry Pi OS) to avoid managing over a thousand individual SD cards.

- 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, the Oracle Raspberry Pi cluster does not appear on the Top 500 list because Raspberry Pis are low-power devices that, even when combined in the thousands, only reach performance in the TeraFLOPS range. To qualify for the Top 500, a system typically requires performance in the PetaFLOPS range, which is orders of magnitude faster than what this cluster can achieve.

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

AMD Zen 2 (x86 based- 64) CPU architecture

What operating systems run on these consoles?


PS5 uses freeBSD/Unix-like, and Xbox Series X uses customised version of Windows


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

Both using PC-like architecture so and PC-like ecosystem for development ease.

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.

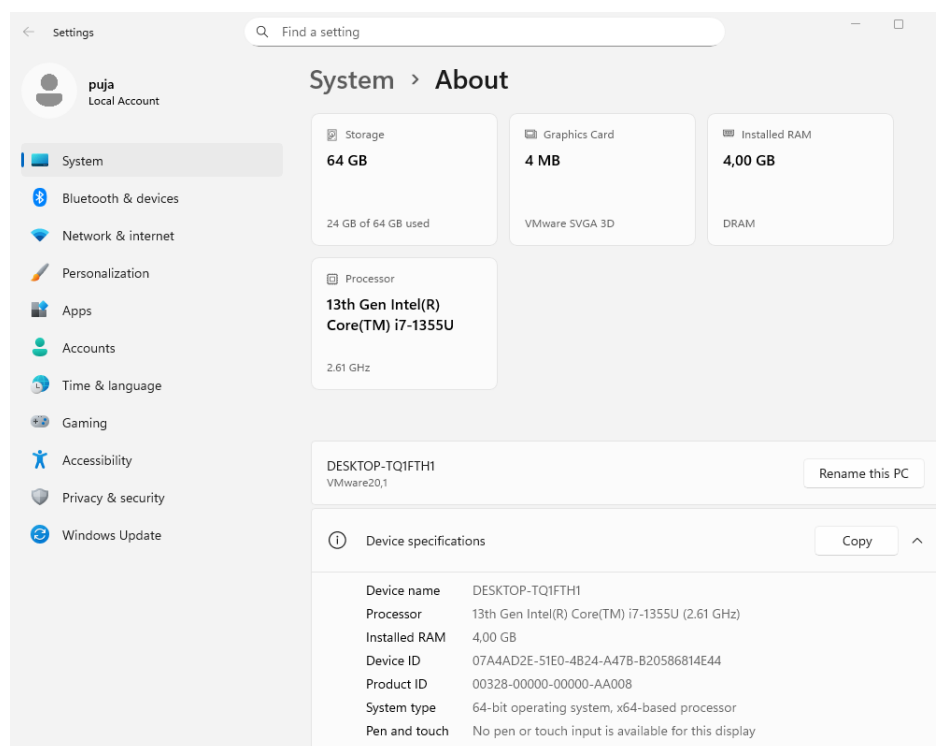
b) The file explorer can be opened with  + E, Which key combination could you also use?

 + X

 + R, then type “explorer”

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

 + Fn + P



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.

Ctrl + Shift + Esc

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

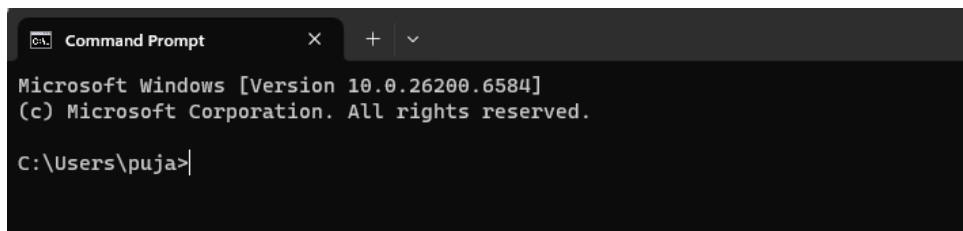
screen that you don't show over the projector, while the PowerPoint presentation is displayed on the projector, or the second screen. Which key combination should you use for this?

Win + 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?

Win + 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.



```
Microsoft Windows [Version 10.0.26200.6584]
(c) Microsoft Corporation. All rights reserved.

C:\Users\puja>
```

Working in the File Explorer

Relevant screenshots **copy** command:

```
PS C:\SAXION> copy Plug.png HBOICT/YEAR1/QUARTILE1/IF
PS C:\SAXION> copy Plug.png .././IF
PS C:\SAXION> copy Wave.png .././IP
PS C:\SAXION> copy Wave.png HBOICT/YEAR1/QUARTILE1/IP
PS C:\SAXION> copy Wave.png HBOICT/YEAR1/QUARTILE1/Synergy
PS C:\SAXION> copy Tumble.png HBOICT/YEAR1/QUARTILE1/Synergy
PS C:\SAXION>
```

Relevant screenshots **tree** command:

```
C:\SAXION>tree
Folder PATH listing
Volume serial number is 1CE9-A4D4
C:..
├── HBOICT
│   ├── YEAR1
│   │   ├── QUARTILE1
│   │   │   ├── IF
│   │   │   ├── IP
│   │   │   └── Synergy
│   │   ├── QUARTILE2
│   │   │   ├── Database
│   │   │   ├── IT Fundamental
│   │   │   └── Project IT in The Game
│   │   ├── QUARTILE3
│   │   └── QUARTILE4
│   ├── YEAR2
│   ├── YEAR3
│   └── YEAR4
C:\SAXION>echo %username%
puja
```

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

```
Administrator: Command Prompt
Microsoft Windows [Version 10.0.26200.7462]
(c) Microsoft Corporation. All rights reserved.

C:\Windows\System32>cd \

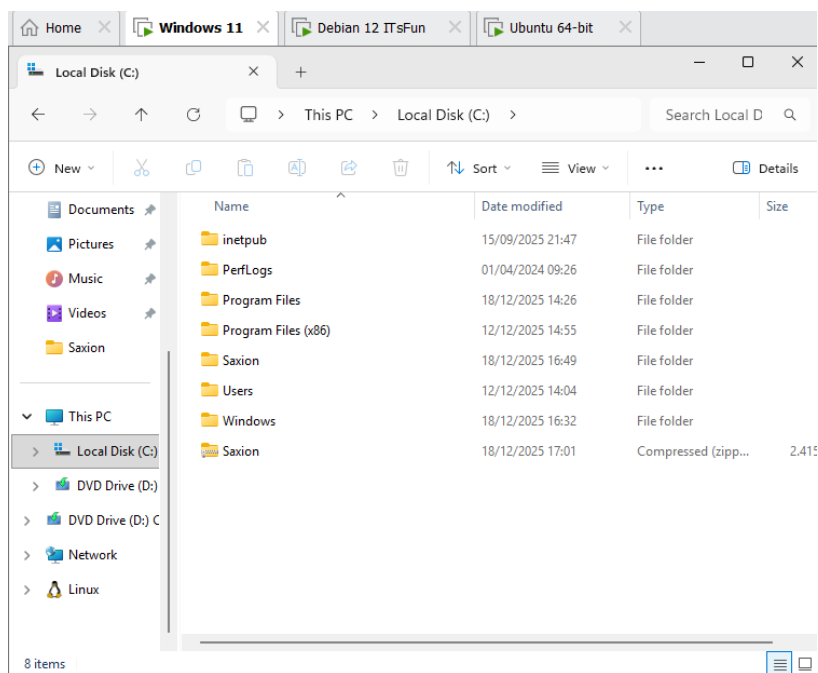
C:\>tar -a -c -f Saxion.zip Saxion

C:\>dir *.zip
Volume in drive C has no label.
Volume Serial Number is 1CE9-A4D4

Directory of C:\

18/12/2025  17:01                2.472.308 Saxion.zip
             1 File(s)                2.472.308 bytes
             0 Dir(s) 41.233.399.808 bytes free

C:\>
```



Terminating Processes

Relevant Screenshots Task Manager Window:

Apps (4)						
<div> <div>🕒</div> <div>🔍</div> <div>👤</div> </div>	>	🖨️ Calculator (2)		0%	20,8 MB	0 MB/s 0 Mbps
	>	🖥️ Task Manager		0%	44,3 MB	0 MB/s 0 Mbps
	>	🖨️ Windows Command Processor		0%	0,7 MB	0 MB/s 0 Mbps
	>	📁 Windows Explorer		0%	96,6 MB	0 MB/s 0 Mbps

Install Software

Relevant screenshots that the following software is installed with winget:

- WinSCP

```
C:\>winget search WinSCP
Name      Id              Version Match      Source
-----
WinSCP     WinSCP.WinSCP    6.5.5              winget
WinSCP RC  WinSCP.WinSCP.RC 5.18.5- Tag: winscp winget

C:\>winget install -e --id WinSCP.WinSCP
Found WinSCP [WinSCP.WinSCP] Version 6.5.5
This application is licensed to you by its owner.
Microsoft is not responsible for, nor does it grant any licenses to, third-party packages
Downloading https://sourceforge.net/projects/winscp/files/WinSCP/6.5.5/WinSCP-6.5.5-Setup.exe/download
11.6 MB / 11.6 MB
Successfully verified installer hash
Starting package install...
Successfully installed

C:\>echo %username%
puja

C:\>
```

- Notepad++

```
C:\>echo %username%
puja

C:\>winget search Notepad++
Name      Id              Version Match      Source
-----
Notepad++ Notepad++.Notepad++ 8.8.9      ProductCode: notepad++ winget
Notepad Next dail8859.NotepadNext 0.12      Tag: notepad++ winget

C:\>winget install -e --id Notepad++.Notepad++
Found Notepad++ [Notepad++.Notepad++] Version 8.8.9
This application is licensed to you by its owner.
Microsoft is not responsible for, nor does it grant any licenses to, third-party packages
Downloading https://github.com/notepad-plus-plus/notepad-plus-plus/releases/download/npp.8.8.9/Installer.x64.exe
6.54 MB / 6.54 MB
Successfully verified installer hash
Starting package install...
Successfully installed

C:\>
```

- 7zip

```
C:\>winget install -e --id 7zip.7zip
Found 7-Zip [7zip.7zip] Version 25.01
This application is licensed to you by its owner.
Microsoft is not responsible for, nor does it grant any licenses to, thi
Downloading https://7-zip.org/a/7z2501-x64.exe
1.56 MB / 1.56 MB
Successfully verified installer hash
Starting package install...
Successfully installed

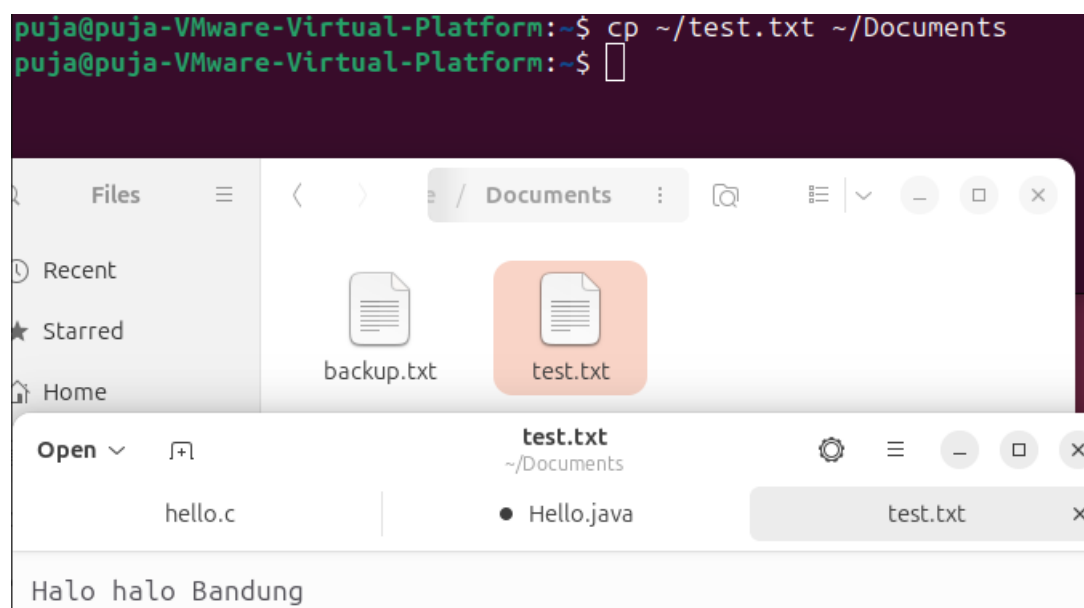
C:\>echo %username%
puja

C:\>
```

Assignment 5.4: Working with Linux

Relevant screenshots + motivation

Copying files



Navigating the file structure

- Significant difference between Linux and Windows is the naming of the different storage devices, and each drive has its own root. While Linux uses single hierarchical tree starting at Root (/), doesn't use letters.
- Directory `/etc` directory used for system whole configuration files, its like settings for Linx system.


```
puja@puja-VMware-Virtual-Platform: ~  
puja@puja-VMware-Virtual-Platform:/etc$ pwd  
/etc  
puja@puja-VMware-Virtual-Platform:/etc$ cd ~  
puja@puja-VMware-Virtual-Platform:~$
```

Compress Files

```
puja@puja-VMware-Virtual-Platform: ~  
tar: Exiting with failure status due to previous errors  
puja@puja-VMware-Virtual-Platform:~$ tar -cvf test.tar test.txt  
test.txt  
puja@puja-VMware-Virtual-Platform:~$ tar -xvf test.tar  
test.txt  
puja@puja-VMware-Virtual-Platform:~$ tar -czvf test.tar.gz test.txt  
test.txt  
puja@puja-VMware-Virtual-Platform:~$ ls -lh  
total 60K  
drwxr-xr-x 2 puja puja 4.0K Oct  2 22:57 Desktop  
drwxr-xr-x 2 puja puja 4.0K Dec 18 21:24 Documents  
drwxr-xr-x 3 puja puja 4.0K Dec 11 12:02 Downloads  
drwxr-xr-x 2 puja puja 4.0K Oct  2 22:57 Music  
drwxr-xr-x 3 puja puja 4.0K Dec 18 21:26 Pictures  
drwxr-xr-x 2 puja puja 4.0K Oct  2 22:57 Public  
drwx----- 5 puja puja 4.0K Oct  3 00:57 snap  
drwxr-xr-x 2 puja puja 4.0K Oct  2 22:57 Templates  
-rw-rw-r-- 1 puja puja 10K Dec 18 22:20 test.tar  
-rw-rw-r-- 1 puja puja 139 Dec 18 22:21 test.tar.gz  
-rw-rw-r-- 1 puja puja 18 Dec 18 21:21 test.txt  
drwxr-xr-x 2 puja puja 4.0K Oct  2 22:57 Videos  
drwxrwxr-x 2 puja puja 4.0K Dec 18 15:06 website  
puja@puja-VMware-Virtual-Platform:~$ ^C  
puja@puja-VMware-Virtual-Platform:~$
```

View Processes

htop command is an interactive command-line tool for Linux that provide a real-time system processes and resource usage of CPU, memory, swap usage giving an instant health check. The visual is sortable by column

Install Software

```
      .-/+00ssssso+/-.
    `:+ssssssssssssssssss+:`
  -+ssssssssssssssssssyyssss+-
 .osssssssssssssssssdMMMMyssssso.
 /ssssssssssshdmmNNmmyNMMMMhssssss/
 +ssssssssshmydMMMMMMMMddddyssssss+
 /ssssssssshNMMMyhhyyyhmNMMMNhssssss/
 .ssssssssdMMMNhssssssssshNMMMdssssss.
 +ssssshhhyNMMNyssssssssssyNMMMyssssss+
 ossyNMMMNyMMhssssssssssshmmhssssssso
 ossyNMMMNyMMhssssssssssshmmhssssssso
 +ssssshhhyNMMNyssssssssssyNMMMyssssss+
 .ssssssssdMMMNhssssssssshNMMMdssssss.
 /ssssssssshNMMMyhhyyyhdNMMMNhssssss/
 +ssssssssdmydMMMMMMMMddddyssssss+
 /ssssssssshdmmNNNmyNMMMMhssssss/
 .osssssssssssssssssdMMMMyssssso.
  -+ssssssssssssssssssyyyssss+-
    `:+ssssssssssssssssss+:`
      .-/+00ssssso+/-.

puja@puja-VMware-Virtua
-----
OS: Ubuntu 24.04.3 LTS
Host: VMware Virtual PL
Kernel: 6.14.0-37-gener
Uptime: 1 hour, 56 mins
Packages: 1652 (dpkg),
Shell: bash 5.2.21
Resolution: 756x897
DE: GNOME 46.0
WM: Mutter
WM Theme: Adwaita
Theme: Yaru [GTK2/3]
Icons: Yaru [GTK2/3]
Terminal: gnome-termina
CPU: 13th Gen Intel i7-
GPU: 00:0f.0 VMware SVG
Memory: 1801MiB / 3867M
```

Neofetch is a tool to show system configurations and specifications.

Assignment 5.5: Users and permissions on Linux

Relevant screenshots + motivation

```
puja@sari:~$ chmod +x ~/hello/hello.sh
puja@sari:~$ cd ~/hello
puja@sari:~/hello$ ./hello.sh
Hello Puja, 577029!
puja@sari:~/hello$ chmod 744 hello.sh
puja@sari:~/hello$ ls -l hello.sh
-rwxr--r-- 1 puja puja 42 Dec 18 23:24 hello.sh
puja@sari:~/hello$
```

Assignment 5.6: View the contents of files

Relevant screenshots + motivation

```

puja@sari:~/hello$ cd ~
puja@sari:~$ wget https://www.gutenberg.org/files/1661/1661-0.txt -O sherlock.txt
--2025-12-18 23:54:06-- https://www.gutenberg.org/files/1661/1661-0.txt
Resolving www.gutenberg.org (www.gutenberg.org)... 152.19.134.47, 2610:28:3090:3000:0: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%[=====]
2025-12-18 23:54:10 (207 KB/s) - 'sherlock.txt' saved [607504/607504]

puja@sari:~$ wc sherlock.txt
 12306 107562 607504 sherlock.txt
puja@sari:~$ 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
puja@sari:~$ 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
puja@sari:~$ head -n 590 sherlock.txt | tail -n 20
anything else of interest.

"I then lounged down the street and found, as I expected, that there
was a mews in a lane which runs down by one wall of the garden. I lent
the ostlers a hand in rubbing down their horses, and received in
exchange twopence, a glass of half-and-half, two fills of shag tobacco,
and as much information as I could desire about Miss Adler, to say
nothing of half a dozen other people in the neighbourhood in whom I was
not in the least interested, but whose biographies I was compelled to
listen to."

"And what of Irene Adler?" I asked.

"Oh, she has turned all the men's heads down in that part. She is the
daintiest thing under a bonnet on this planet. So say the
Serpentine-mews, to a man. She lives quietly, sings at concerts, drives
out at five every day, and returns at seven sharp for dinner. Seldom
goes out at other times, except when she sings. Has only one male
visitor, but a good deal of him. He is dark, handsome, and dashing,
never calls less than once a day, and often twice. He is a Mr. Godfrey
puja@sari:~$ _

```

wget is efficient I away that transparent, durable, flexible and free approach that depends entirely on open-source community. It allows us to automated download, website mirroring, download resumption, bandwidth limiting that to avoid saturating the connection.

Assignment 5.7: Digital forensics

Relevant screenshots + motivation

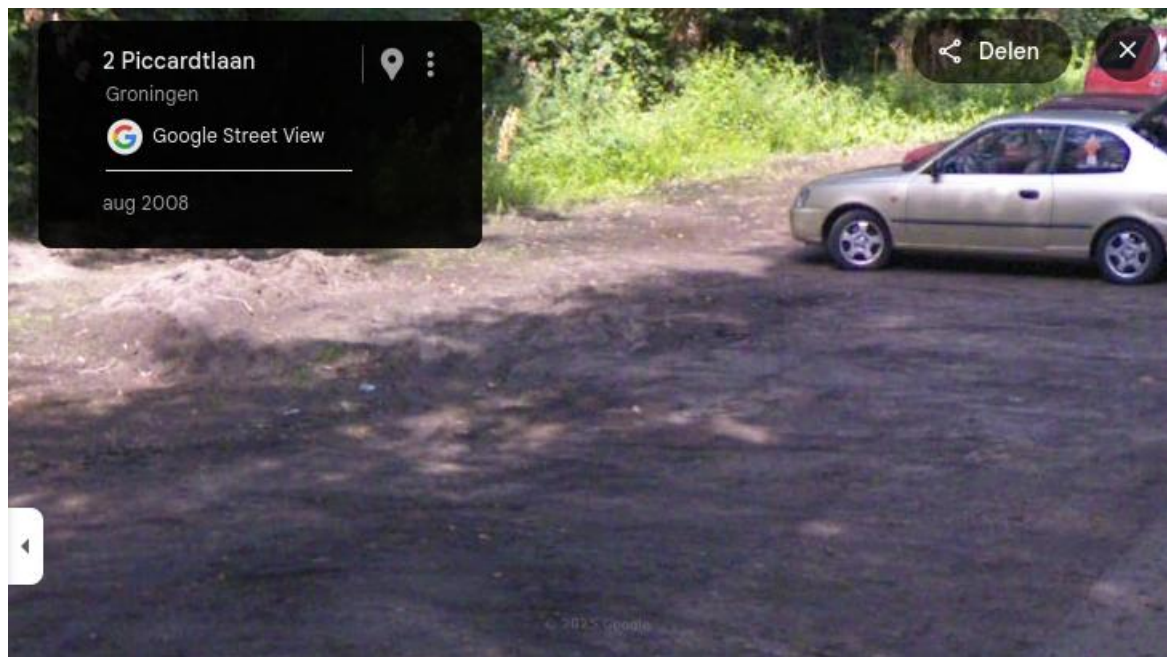
EXIF tools is to check document the metadata of a file. Below is the metada extracted from a photo using exif tool command.

```

puja@puja-VMware-Virtual-Platform: ~
File Size : 2.4 MB
File Modification Date/Time : 2025:12:19 00:17:31+01:00
File Access Date/Time : 2025:12:19 01:23:34+01:00
File Inode Change Date/Time : 2025:12:19 01:23:04+01:00
File Permissions : -rw-----
File Type : JPEG
File Type Extension : jpg
MIME Type : image/jpeg
JFIF Version : 1.01
Exif Byte Order : Big-endian (Motorola, MM)
Make : motorola
Camera Model Name : moto g(6) play
X Resolution : 72
Y Resolution : 72
Resolution Unit : inches
Software : aljeter-user 9 PPPS29.55-35-18-7 6a0d0 rele
Modify Date : 2020:11:07 15:08:57
Y Cb Cr Positioning : Centered
Exposure Time : 1/33
F Number : 2.0
Exposure Program : Program AE
ISO : 64
Exif Version : 0220
Date/Time Original : 2020:11:07 15:08:57
Create Date : 2020:11:07 15:08:57
Components Configuration : Y, Cb, Cr, -
Shutter Speed Value : 1/33
Aperture Value : 2.0
Brightness Value : -1
Exposure Compensation : 0
Max Aperture Value : 2.0
Metering Mode : Center-weighted average
Flash : Auto, Did not fire
Focal Length : 3.5 mm
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 : 2.2.0.0
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 Date Stamp : 2020:11:07
Compression : JPEG (old-style)
Thumbnail Offset : 2862
Thumbnail Length : 59453
Image Width : 4160
Image Height : 3120
Encoding Process : Baseline DCT, Huffman coding
Bits Per Sample : 8
Color Components : 3
Y Cb Cr Sub Sampling : YCbCr4:2:0 (2 2)
Aperture : 2.0
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' 12.90" E
Focal Length : 3.5 mm
GPS Position : 53 deg 11' 39.68" N, 6 deg 32' 12.90" E
Light Value : 7.7
puja@puja-VMware-Virtual-Platform: $

```

From above result, we could see the device is Motorola G6 Play



```
puja@puja-VMware-Virtual-Platform:~$ exiftool oldcar > metadata_oldcar.txt
puja@puja-VMware-Virtual-Platform:~$ exiftool -CreateDate -GPSPosition oldcar
Create Date           : 2020:11:07 15:08:57
GPS Position          : 53 deg 11' 39.68" N, 6 deg 32' 12.90" E
puja@puja-VMware-Virtual-Platform:~$
```

This photo was taken in Groningen, The Netherlands

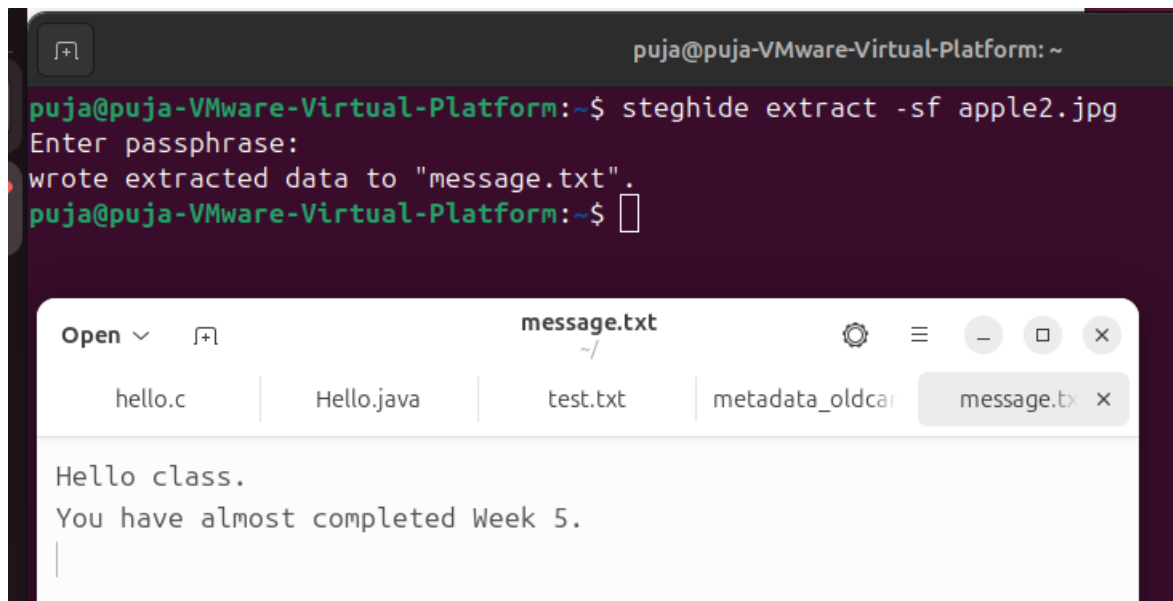
Filename extension

```
puja@puja-VMware-Virtual-Platform: ~
puja@puja-VMware-Virtual-Platform:~$ man base64
puja@puja-VMware-Virtual-Platform:~$ base64 -d email-base64.txt > email.gif
puja@puja-VMware-Virtual-Platform:~$ file email.gif
email.gif: GIF image data, version 89a, 108 x 52
puja@puja-VMware-Virtual-Platform:~$
```

Assignment 5.8: Steganography

Relevant screenshots + motivation

Accidently saved the picture on png, turns out its not supported by steghide then I realised the picture must be on jpeg.



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.

Debian servers setup

```
puja@sari:~$ 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 noprefixroute
        valid_lft forever preferred_lft forever
2: ens33: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default
    link/ether 00:0c:29:d4:49:0d brd ff:ff:ff:ff:ff:ff
    altname enp2s1
    inet 192.168.116.129/24 brd 192.168.116.255 scope global dynamic ens33
        valid_lft 1781sec preferred_lft 1781sec
    inet6 fe80::20c:29ff:fed4:490d/64 scope link
        valid_lft forever preferred_lft forever
```

Disk capture

```
ubuntu@ubuntu: ~  
ubuntu@ubuntu:~$ lsblk  
NAME        MAJ:MIN RM   SIZE RO TYPE MOUNTPOINTS  
loop0         7:0    0    1.7G  1 loop /rofs  
loop1         7:1    0 523.3M  1 loop  
loop2         7:2    0 925.9M  1 loop  
loop3         7:3    0     4K  1 loop /snap/bare/5  
loop4         7:4    0   73.9M  1 loop /snap/core22/2045  
loop5         7:5    0 245.1M  1 loop /snap/firefox/6565  
loop6         7:6    0   91.7M  1 loop /snap/gtk-common-themes/1535  
loop7         7:7    0   11.1M  1 loop /snap/firmware-updater/167  
loop8         7:8    0    516M  1 loop /snap/gnome-42-2204/202  
loop9         7:9    0   10.8M  1 loop /snap/snap-store/1270  
loop10        7:10   0    49.3M  1 loop /snap/snapd/24792  
loop11        7:11   0    576K  1 loop /snap/snapd-desktop-integration/315  
loop12        7:12   0    210M  1 loop /snap/thunderbird/769  
loop13        7:13   0   112.6M  1 loop /snap/ubuntu-desktop-bootstrap/413  
sr0          11:0    1    5.9G  0 rom  /cdrom  
nvme0n1      259:0    0    64G   0 disk  
ubuntu@ubuntu:~$
```

Image Storage

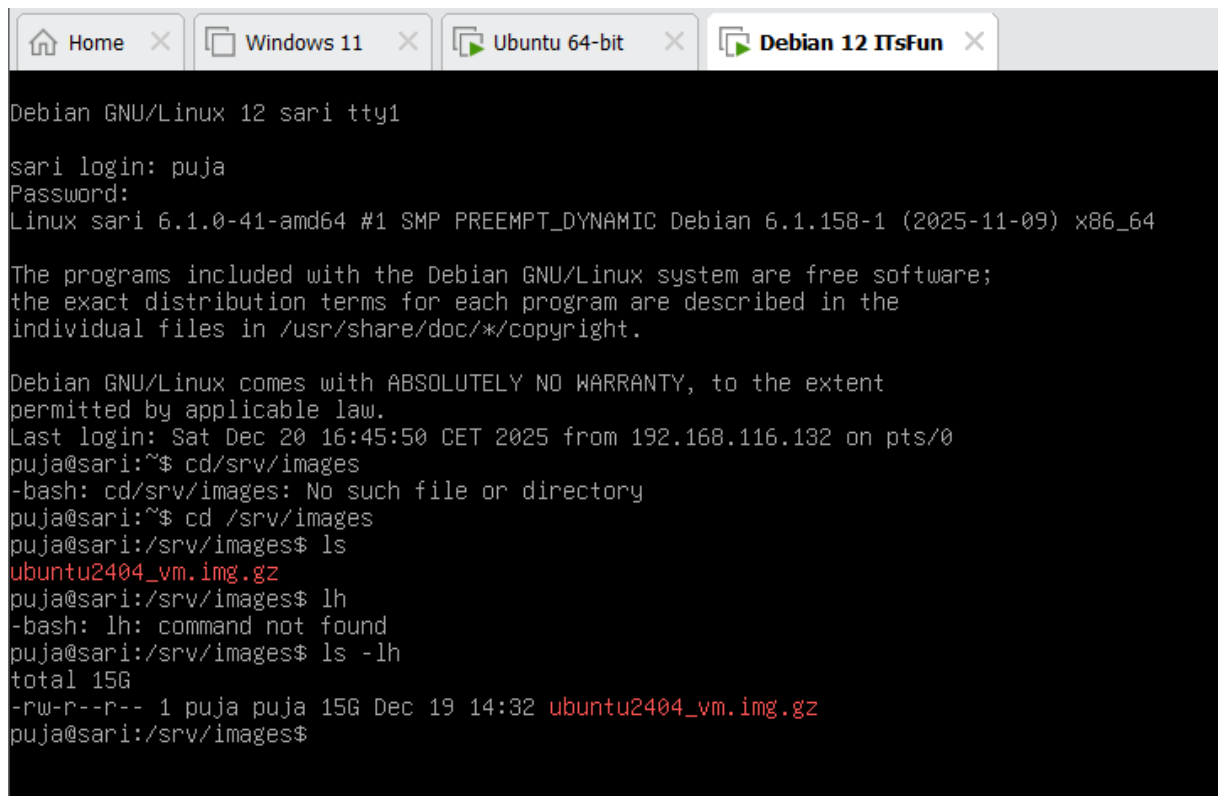
```
ubuntu@ubuntu:~$ lsblk  
NAME        MAJ:MIN RM   SIZE RO TYPE MOUNTPOINTS  
loop0         7:0    0    1.7G  1 loop /rofs  
loop1         7:1    0 523.3M  1 loop  
loop2         7:2    0 925.9M  1 loop  
loop3         7:3    0   10.8M  1 loop /snap/snap-store/1270  
loop4         7:4    0   73.9M  1 loop /snap/core22/2045  
loop5         7:5    0 245.1M  1 loop /snap/firefox/6565  
loop6         7:6    0     4K  1 loop /snap/bare/5  
loop7         7:7    0   11.1M  1 loop /snap/firmware-updater/167  
loop8         7:8    0    210M  1 loop /snap/thunderbird/769  
loop9         7:9    0    516M  1 loop /snap/gnome-42-2204/202  
loop10        7:10   0   91.7M  1 loop /snap/gtk-common-themes/1535  
loop11        7:11   0    576K  1 loop /snap/snapd-desktop-integration/315  
loop12        7:12   0    49.3M  1 loop /snap/snapd/24792  
loop13        7:13   0   112.6M  1 loop /snap/ubuntu-desktop-bootstrap/413  
sr0          11:0    1    5.9G  0 rom  /cdrom  
nvme0n1      259:0    0    64G   0 disk  
nvme0n1p1    259:1    0     1M   0 part  
nvme0n1p2    259:2    0    64G   0 part  
ubuntu@ubuntu:~$ sudo dd if=/dev/nvme0n1 bs=4M status=progress | gzip | ssh puja@  
cu2404_vm.img.gz  
The authenticity of host '192.168.116.129 (192.168.116.129)' can't be established  
ED25519 key fingerprint is SHA256:QAWTXNREY4BpFF8phsd14iScw/WS01fNLHL/DiXcFYM.  
This key is not known by any other names.  
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes  
Warning: Permanently added '192.168.116.129' (ED25519) to the list of known hosts  
puja@192.168.116.129's password:  
54463037440 bytes (54 GB, 51 GiB) copied, 985 s, 55.3 MB/s
```


Restore process

```
ubuntu@ubuntu: ~  
ubuntu@ubuntu:~$ ssh puja@192.168.116.129 "cat /srv/images/ubuntu2404_vm.img.gz"  
| gzip -d | sudo dd of=/dev/nvme0n1 bs=4M status=progress  
The authenticity of host '192.168.116.129 (192.168.116.129)' can't be established.  
ED25519 key fingerprint is SHA256:QAWTXNREY4BpFF8phsd14iScw/WS01fNLHL/DiXcFYM.  
This key is not known by any other names.  
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes  
Warning: Permanently added '192.168.116.129' (ED25519) to the list of known hosts.  
Connection closed by 192.168.116.129 port 22  
  
zip: stdin: unexpected end of file  
+0 records in  
+0 records out  
0 bytes copied, 212.319 s, 0.0 kB/s  
ubuntu@ubuntu:~$
```

- Proof that you can restore the back-up image into an empty VM.
Empty 2nd clean/client empty MV to restore

```
ubuntu@ubuntu: ~  
| gzip -d | sudo dd of=/dev/sda bs=4M status=progress  
^C0+0 records in  
0+0 records out  
0 bytes copied, 13.7333 s, 0.0 kB/s  
  
ubuntu@ubuntu:~$ lsblk  
NAME        MAJ:MIN RM  SIZE RO TYPE MOUNTPOINTS  
loop0        7:0      0   1.7G  1 loop /rofs  
loop1        7:1      0 523.3M  1 loop  
loop2        7:2      0 925.9M  1 loop  
loop3        7:3      0    4K   1 loop /snap/bare/5  
loop4        7:4      0  73.9M  1 loop /snap/core22/2045  
loop5        7:5      0 245.1M  1 loop /snap/firefox/6565  
loop6        7:6      0  91.7M  1 loop /snap/gtk-common-themes/1535  
loop7        7:7      0  11.1M  1 loop /snap/firmware-updater/167  
loop8        7:8      0   516M  1 loop /snap/gnome-42-2204/202  
loop9        7:9      0  49.3M  1 loop /snap/snapd/24792  
loop10       7:10     0   576K  1 loop /snap/snapd-desktop-integration/315  
loop11       7:11     0  10.8M  1 loop /snap/snap-store/1270  
loop12       7:12     0   210M  1 loop /snap/thunderbird/769  
loop13       7:13     0 112.6M  1 loop /snap/ubuntu-desktop-bootstrap/413  
sr0         11:0     1   5.9G  0 rom  /cdrom  
nvme0n1     259:0    0   64G   0 disk  
ubuntu@ubuntu:~$
```


A terminal window titled 'Debian 12 ITsFun' is shown. The user 'puja' has logged in. The terminal displays the Debian GNU/Linux 12 sari tty1 prompt. It shows the login process, including the password prompt and the system version: Linux sari 6.1.0-41-amd64 #1 SMP PREEMPT_DYNAMIC Debian 6.1.158-1 (2025-11-09) x86_64. The user is then prompted to read the Debian GNU/Linux system's free software license and warranty information. After reading, the user is prompted to log in. The user then enters the command 'cd /srv/images', which results in an error: '-bash: cd:/srv/images: No such file or directory'. The user then enters 'cd /srv/images', which is successful. The user then enters 'ls', which lists the file 'ubuntu2404_vm.img.gz'. The user then enters 'lh', which results in an error: '-bash: lh: command not found'. The user then enters 'ls -lh', which shows the file details: 'total 15G' and '-rw-r--r-- 1 puja puja 15G Dec 19 14:32 ubuntu2404_vm.img.gz'. The user then enters the prompt again.

```
Debian GNU/Linux 12 sari tty1

sari login: puja
Password:
Linux sari 6.1.0-41-amd64 #1 SMP PREEMPT_DYNAMIC Debian 6.1.158-1 (2025-11-09) x86_64

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.
Last login: Sat Dec 20 16:45:50 CET 2025 from 192.168.116.132 on pts/0
puja@sari:~$ cd/srv/images
-bash: cd:/srv/images: No such file or directory
puja@sari:~$ cd /srv/images
puja@sari:/srv/images$ ls
ubuntu2404_vm.img.gz
puja@sari:/srv/images$ lh
-bash: lh: command not found
puja@sari:/srv/images$ ls -lh
total 15G
-rw-r--r-- 1 puja puja 15G Dec 19 14:32 ubuntu2404_vm.img.gz
puja@sari:/srv/images$
```

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