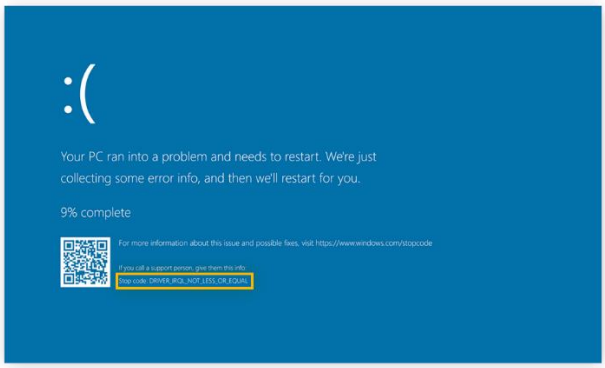
Question 1

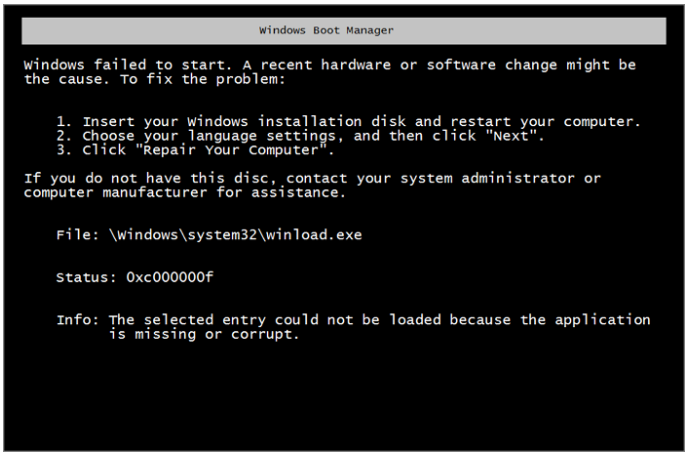
BSOD - is a critical OS fault occurring in Windows systems when some form of unrecoverable error occurs, resulting in a system crash. At this point, the screen goes blue, and a message appears with information about the error [1]. The purpose of this error is to stop the system from getting damaged further; it forces a device to kill all the current running processes and restart [1].



Troubleshoot tools –

- Restart the device – it may be a one-time issue.
- Use event viewer to understand what went wrong.
- Scan and repair disk by using check disk - type “chkdsk /f” in command prompt launched in administrator mode [1].
- Use system file checker – type “sfc /scannow” in command prompt launched in administrator mode. [1]
- Check for hardware issues – check newly installed hardware and ensure installed hardware is connected properly.

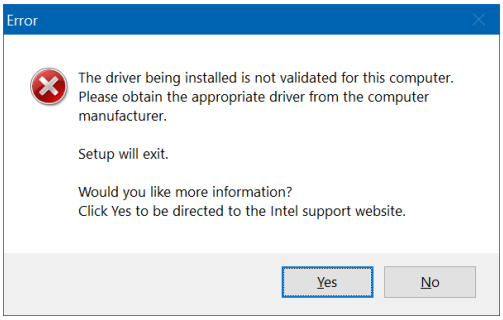
Boot error - is a startup error that appears on a device when the system fails to load the boot files. Typically, when the windows operating system for example is booted up, it would display the loading and startup screen [2]. This error may lead to the displaying of error messages, system crashes, or the computer getting stuck during the boot process. There are many causes for this issue such as hardware failures, file corruption, misconfigurations or software issues [2].



Troubleshoot tools –

- Boot the system in safe mode to understand and resolve issues.
- Enter the BIOS to change the boot order [3].
- Use tools like Bootrec to repair the system's Master Boot Record.
- On windows, use windows startup repair tool [3].

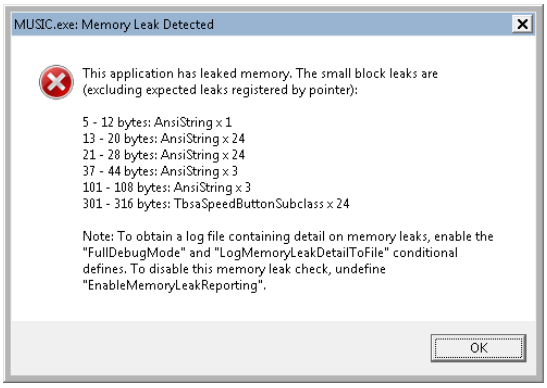
Improper drivers / driver corruption - may occur for users when their drivers are outdated, incompatible, or corrupted during installation. The software programs that allow the OS to communicate with hardware devices are known as drivers [4]. When the drivers of a system are faulty it may lead to the malfunctioning of the devices, system crashes, and system instability as the OS will no longer be able to communicate effectively with the hardware [4].



Troubleshoot tools -

- Reinstall drivers from the official website of the hardware manufacturer [4].
- Use device manager to update, roll back or uninstall drivers [4].
- Boot the system in safe mode to understand which drivers are corrupted.
- Use the system file checker – type "sfc /scannow" in command prompt in administrator mode to repair all corrupted system files, including drivers [1].

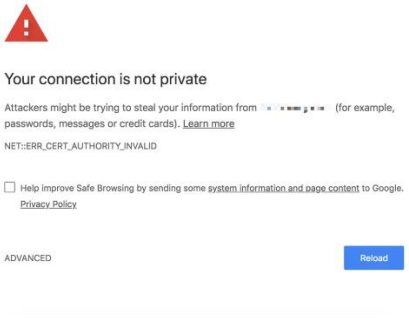
Memory leaks - occurs when memory is allocated but not deallocated upon completion of the process, eventually leading to the system running out of memory. Memory leaks can happen when the program being executed cannot call the needed memory deallocation functions [5]. This fault may also happen if the internal components of an OS do not manage memory correctly because of bugs in the code of the operating system, issues with system drivers, or improper handling of resources.



Troubleshoot tools –

- Use inbuilt OS performance monitors or third-party tools such as Valgrind to track device memory usage and identify leaks and irregular memory usage patterns [5].
- Close applications, restart the device [5].
- Update the OS and install the latest system patches.

Security vulnerabilities – refer to any defects that might be leveraged by assailants to conduct unauthorized access, disrupt operations, or take a toll on system integrity. These are consequences of design flaws in the OS, coding errors, and/or configuration issues [6]. There are many different types of security vulnerabilities, including buffer overflow, privilege escalation, code injection, denial of service, unpatched software, race conditions, cross site scripting, session hijacking, zero-day exploits [6].



Troubleshoot tools –

- Regularly update and patch the OS [6].
- Conduct full device scans.
- Implement access controls.
- Using Intrusion detection systems and intrusion prevention systems (IDS/IPS) [6].
- Installing antivirus software such as Norton or McAffee.
- Set up a firewall (On windows, can be done with windows defender) [6].

Question 2

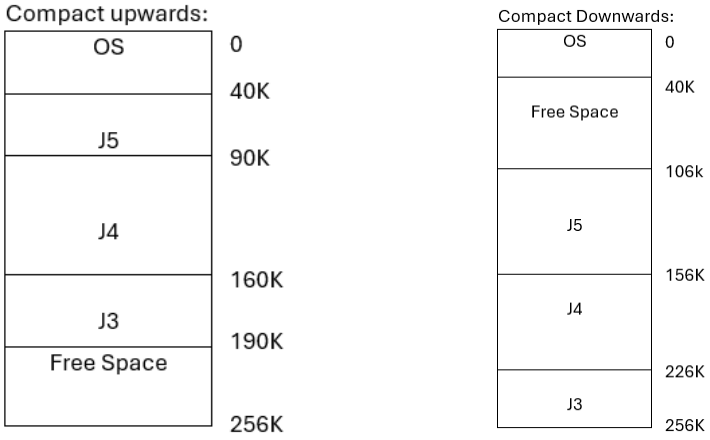
Real Time Operating System is an OS that has been designed with the primary goal of processing data and executing tasks within a defined time limit [7]. Contrary to other types of operating systems, RTOS offers timely and reliable responses by assuring to meet strict time constraints [7].

RTOSs are useful when there is a need to maintain timings and reliability, such as:

- Medical Devices such as pacemakers requires quick and reliable responses since any delay or inaccuracy in such systems could threaten the life of a patient.
- Industrial automation: The robotic systems in industries require perfect timings for sensitive tasks such as assembling.
- Air traffic control systems: These systems have to process information in real time to locate the aircraft, `direct flight paths, and calculate distances between planes for safety.

Question 3

Let's consider two memory compaction approaches; upward compaction and downward compaction and compare the data movement between the two [8].



According to the Figures drawn above, compacting memory upwards requires less data movement than compacting memory downwards. Memory relocation allows the OS to move a process easily, it allows a process to get larger with time (can be relocated to a different block that can fit it), it improves memory utilization by reducing fragmentation, it also gives more flexibility to a process as it can be loaded into any part of memory, irrespective of its' original location.

Question 4

Given below is example of expected gantt charts and calculation table for Shortest job first

Shortest Job First –

	P2	P3	P4	P1	P5
0 1	29	31	41	52	68

Process	Turnaround time	Waiting Time	Completion Time
P1	(52 - 2) = 50	(50 - 11) = 39	52
P2	(29 - 1) = 28	(28 - 28) = 0	29
P3	(31 - 3) = 28	(28 - 2) = 26	31
P4	(41 - 4) = 37	(37 - 10) = 27	41
P5	(68 - 5) = 63	(63 - 16) = 47	68

Given below is example of expected gantt charts and calculation table for Shortest remaining time

Shortest Remaining Time –

	P2	P1	P3	P1	P4	P5	P2
0 1	2	3	5	15	25	41	68

Process	Turnaround time	Waiting Time	Completion Time
P1	(15 - 2) = 13	(13 - 11) = 2	15
P2	(68 - 1) = 67	(67 - 28) = 39	68
P3	(5 - 3) = 2	(2 - 2) = 0	5
P4	(25 - 4) = 21	(21 - 10) = 11	25
P5	(41 - 5) = 36	(36 - 16) = 20	41

Given below is example of expected gantt charts and calculation table for round robin

Round Robin –

	P2	P1	P3	P4	P5	P2	P1	P4	P5	P2	P1	P4	P5	P2	P5	P2	P2	P2
0 1	5	9	11	15	19	23	27	31	35	39	42	44	48	52	56	60	64	68

Process	Turnaround time	Waiting Time	Completion Time
P1	(42 - 2) = 40	(40 - 11) = 29	42
P2	(68 - 1) = 67	(67 - 28) = 39	68
P3	(11 - 3) = 8	(8 - 2) = 6	11
P4	(44 - 4) = 40	(40 - 10) = 30	44
P5	(56 - 5) = 51	(51 - 16) = 35	56

P1 has a priority level of 3 which means it could be a medium priority background task like scheduled data processing. P2 has a priority level of 1, which in this case means it is not very important so it could be a non-time-sensitive task like a virus scan. P3 has a priority level of 4 so it could be a high priority task such as system monitoring. P4 has a level 2 priority, it is a time sensitive yet unurgent task such as media buffering. P5 has a level 5 priority making it a very important task, probably a real-time system task such as handling user input.

Question 5

A deadlock occurs in a computer system when two or more processes compete for the same non-sharable resources, leading to a standstill [8]. Deadlocks can be a very serious issue in real time systems where timely responsiveness is crucial, this is because deadlocks will greatly increase the response time for the completion of processes [8].

In a deadlock:

- Entire system is affected [8].
    - Halts the processing of many jobs.
- Resources will become locked [8].
    - Jobs will start to execute but never finish.
    - Computing resources wasted.
- Throughput will fall [8].
- CPU utilization will fall [8].
- System may crash in prolonged situations.

There are four main strategies to handling deadlocks: prevention, avoidance, detection, and recovery. Deadlocks can only happen when four key conditions are met: mutual exclusion, resource holding, no preemption, and circular wait [8]. The prevention strategy of deadlocks includes eliminating one of the four conditions so that a deadlock will not occur [8].

Each condition can be prevented as shown below [8]:

- Mutual exclusion –bypassed by I/O devices that use spooling.
- Resource holding - bypassed by having jobs request all the necessary resources at the time of creation.
- No preemption - bypassed if the OS allows the deallocation of resources from jobs if the job states can be saved and restored
- Circular waits - prevented if the OS prevents a circular formation by using a hierarchical ordering scheme

If the condition cannot be removed, the second strategy comes into play, which is avoidance. Deadlocks can be avoided if the system knows the order of requests connected to each active process ahead of time [8]. This is possible if:

- Resource allocation is regulated similar to Dijkstra's Bankers Algorithm [8].
- The OS does not satisfy jobs that are in an "unsafe" job state [8].
- Jobs with less resources needed are prioritized [8].

- Jobs that need more resources than available are not processed and blocked until resources are freed [8].

To detect whether a deadlock has/will happen, the OS can make use of directed resource graphs and algorithms to look for any circular cycles. If a cycle is identified, the OS must start the recovery process [8]. Recovery includes solving a deadlock situation and returning the system to normal. This can be done by either of the following methods [8]:

- Terminating every active job
- Terminating all the jobs involved in the deadlock
- Identifying and terminating the jobs involved in deadlock one at a time.
- Preempt the resources of a non-deadlocked job and allocate it to deadlocked processes.
- Stop new jobs from entering the systems to free up resources for deadlocked processes [8].

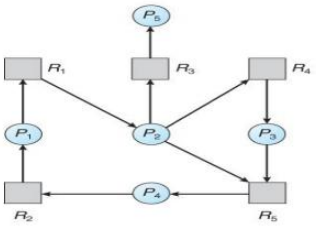


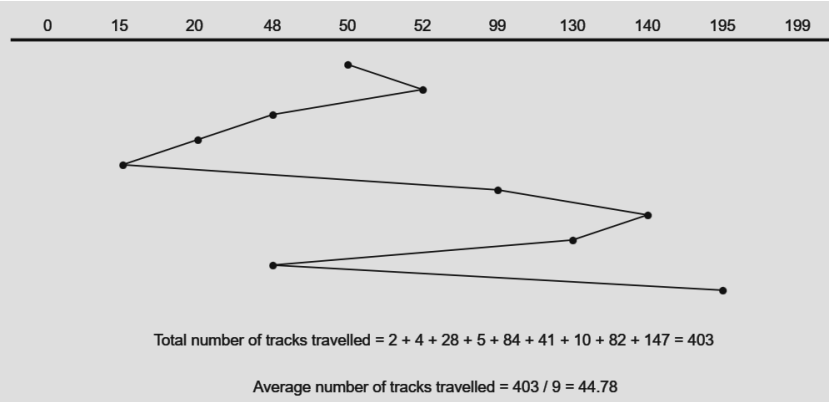
Figure 2: Resource allocation graph

In figure 2 above, there is a deadlock. The deadlocked processes are P1, P2, P3, and P4. All these processes are requesting resources that have already been allocated to other processes, forming a cycle and thus they will never be able to finish. P5 is not a deadlocked process yet as it does not need any other resource to finish executing.

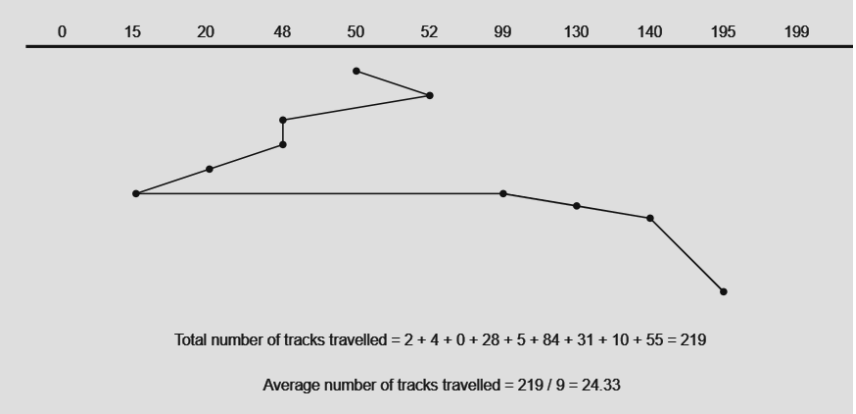
Question 6

Given bellow are the example of graphs and the calculation of seek strategies

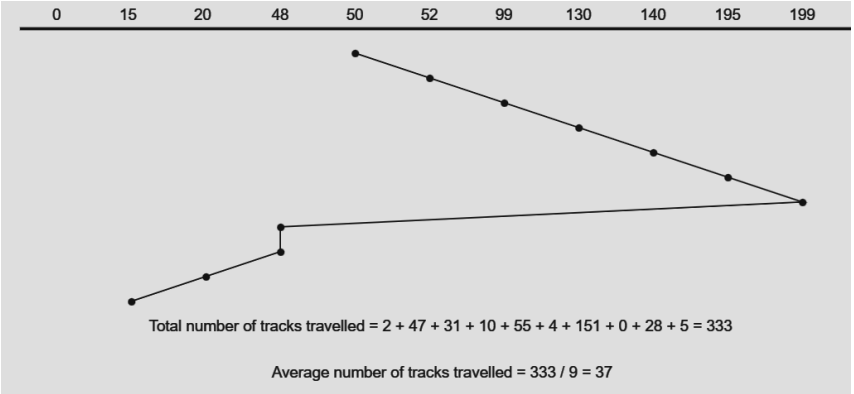
FCFS –



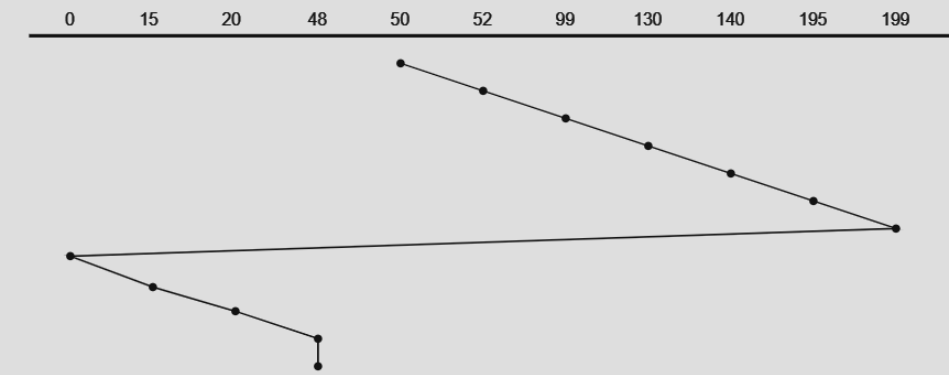
SSTF –



SCAN –



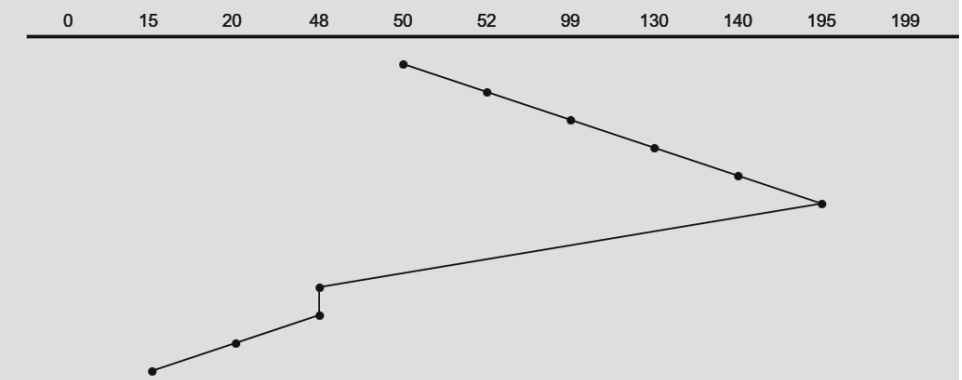
C-SCAN –



Total number of tracks travelled = 2 + 47 + 31 + 10 + 55 + 4 + 199 + 15 + 5 + 28 + 0 = 396

Average number of tracks travelled = 396 / 9 = 44

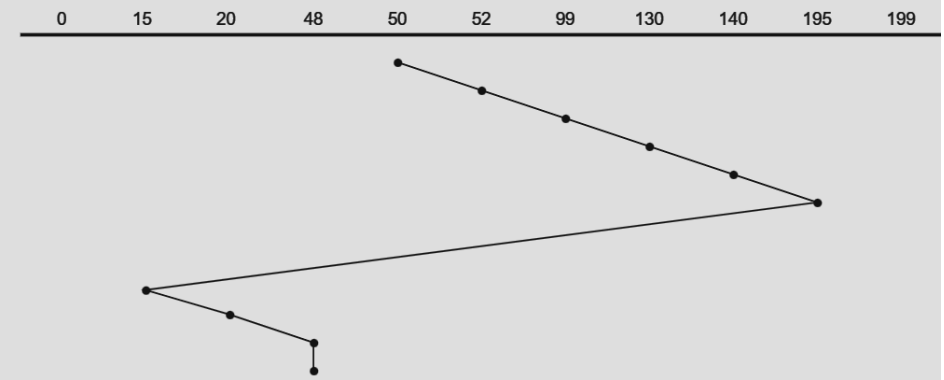
LOOK –



Total number of tracks travelled = 2 + 47 + 31 + 10 + 55 + 147 + 0 + 28 + 5 = 325

Average number of tracks travelled = 325 / 9 = 36.11

C-LOOK –



Total number of tracks travelled = 2 + 47 + 31 + 10 + 55 + 180 + 5 + 28 + 0 = 358

Average number of tracks travelled = 358 / 9 = 39.78

The fastest strategy is SSTF. In SSTF, the number of tracks travelled is the least. However, it is complicated and time taking to use this seek strategy. Overall, the best strategy to use is SCAN, it offers fast seek times and is not too complicated and does not take too much time.

Question 7

The most frequently used file systems in contemporary operating systems are NTFS and FAT32.

NTFS is an acronym for New Technology File System. It is a popular file system that was developed by Microsoft in July 1993. The NTFS architecture makes use of a Master File Table which acts as a central database that can track every file, directory, and metadata [9]. It allows the usage of file level permissions through access control lists and ensures data security through the encrypting file system. It proved to perform better than its predecessor, offering a state-of-the-art logging system that comes with multiuser access control and access control lists [9]. Files and directories can be compressed in NTFS to make better use of storage space. NTFS uses a software called RAID to enhance the disk management capabilities, this is possible due to NTFS's dynamic disk support [9].

A few features of NTFS include [9]:

- Data recovery (journalism)
- Multi-streaming
- Fault tolerance
- UNICODE names
- Dynamic disk support
- Sparse file support
- Transaction support

Advantages	Limitations
Highly secure	Not extensively supported
Performs well even when partition sizes are large	Performance gets worse when partition sizes are too small
Less vulnerable to fragmentation	Space overhead
Offers faster processing than FAT32	Incompatible with many OSs
Offers more stability than FAT32	File naming conventions are strict
Disc issues are fixed automatically	
Can support large files	

FAT32 is an acronym for file allocation table, it is an upgraded model of FAT16 and can store data in 32-bit chunks. It overcomes the limitations of its predecessor that was designed with the goal of being able to support larger media [10]. FAT32 was the file system that was used in older Windows machines and was made for floppy drives. The FAT32 architecture is very simple, it makes use of a file allocation table that helps map each file to disk clusters [10]. It is not as advanced as NTFS, but it has its' own benefits.

Advantages	Disadvantages

Works well with small partitions	Performs poorly with larger partitions
Compatible with many operating systems	Not very secure due to the lack of encryption
Can be used to make disc partitions up to 2TB	Very vulnerable to fragmentation
Uses less disc space for larger partitions	

Question 8

Voice user interfaces (VUIs) are a type of user interface that a user interacts with using speech commands. A few examples of VUIs in systems include Siri, Google Assistant, Alexa, and Bixby [11]. There are many benefits of using a VUI over traditional user interfaces but there are also many challenges that prevent it from being implemented on a wider scale. VUIs provide users with a hands and eyes free method of interacting with their systems. It is very convenient to use as a tool when multitasking, for example, if a user is doing some other tasks like cooking and needs something done on their phone such as finding out the next part of the recipe. Due to the lack of physical interaction, VUIs prove to be very accessible and convenient to use for all people including those with disabilities such as having no limbs [12]. As expected, a VUI must have the ability to clearly communicate with users, both understanding what the user is saying and providing a clear and appropriate response [12]. To properly communicate with a user, a VUI must be able to make use of context awareness. It must be able to use information it has of the user's history and preferences to provide appropriate answers [13]. VUIs are very complicated to build and implement due to the many challenges that come with it. It is a challenge to make the VUI understand different accents, dialects and unclear language. It must also be able to understand the tone of the user. Another limitation of VUIs is their reliability. They do not perform consistently in noisy environments and can misinterpret commands [12].

Question 9

Below are the examples of expected screen shots for linux commands

1.)

```
ubuntu@ubuntu:~$ cd Desktop
ubuntu@ubuntu:~/Desktop$ ls -l
total 16
-rw-rw-r-- 1 ubuntu ubuntu 9702 Sep 22 12:10 Hello.odt
-rwxr-xr-x 1 ubuntu ubuntu  421 Sep 22 11:54 ubuntu-desktop-bootstrap_ubuntu-desktop-bootstrap.desktop
ubuntu@ubuntu:~/Desktop$ chmod 711 Hello.odt
ubuntu@ubuntu:~/Desktop$ ls -l
total 16
-rwx--x--x 1 ubuntu ubuntu 9702 Sep 22 12:10 Hello.odt
-rwxr-xr-x 1 ubuntu ubuntu  421 Sep 22 11:54 ubuntu-desktop-bootstrap_ubuntu-desktop-bootstrap.desktop
```

2.)

```
ubuntu@ubuntu:~/Desktop$ ls -al
total 20
drwxr-xr-x  2 ubuntu ubuntu  100 Sep 22 12:11  .
drwxr-x--- 17 ubuntu ubuntu  420 Sep 22 11:56  ..
-rwx--x--x  1 ubuntu ubuntu 9702 Sep 22 12:10  Hello.odt
-rw-rw-r--  1 ubuntu ubuntu   74 Sep 22 12:10 '.~lock.Untitled 1.odt#'
-rwxr-xr-x  1 ubuntu ubuntu  421 Sep 22 11:54  ubuntu-desktop-bootstrap_ubuntu-desktop-bootstrap.desktop
```

3.)

```
ubuntu@ubuntu:~/Desktop$ mkdir bn104
ubuntu@ubuntu:~/Desktop$ cp assignment2.txt /bn104
cp: cannot create regular file '/bn104': Permission denied
ubuntu@ubuntu:~/Desktop$ cp assignment2.txt bn104/
ubuntu@ubuntu:~/Desktop$ cd bn104
ubuntu@ubuntu:~/Desktop/bn104$ ls -l
total 4
-rw-rw-r-- 1 ubuntu ubuntu 16 Sep 22 12:19 assignment2.txt
```

4.)

```
ubuntu@ubuntu:~/Desktop$ less report.txt
```

```
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```

```
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This is page 2 of the document

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    • BlahBlahBlah
```

5.)

```
ubuntu@ubuntu:~/Desktop$ grep "issue" file1.txt
There is no issues with the current program, I hope you rethink your decision about this. I repeat there is no issue with this
 program.
```

Question 10

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