Grade 12 A/L ICT

Lesson 5: Computer Operating System

- 5.1 Introduction to Operating Systems: Need, Functions and Classification
- 5.2 Files, Directories and Storage Allocation
- 5.3 Process Management: States, PCB, Schedulers and Waiting Time
- 5.4 Memory Management, Paging, Device Drivers and Spooling

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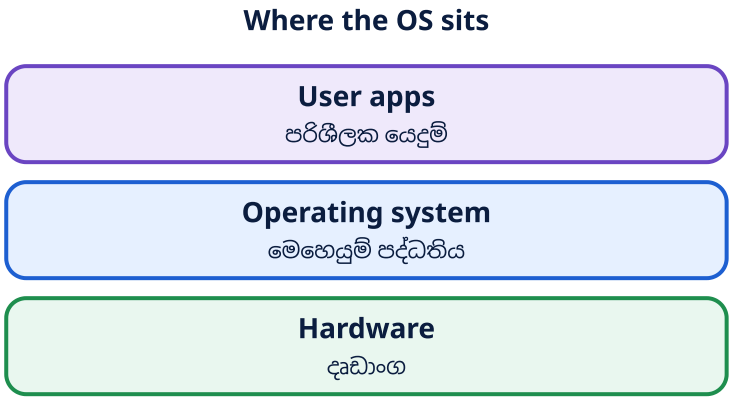
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5.1 Introduction to Operating Systems: Need, Functions and Classification

Syllabus 5.1. An **operating system (OS)** is the system software that sits between you and the hardware. It provides interfaces, manages processes and resources, and protects the machine. In this part you learn **what an OS is**, a short **history**, its **main functions**, and how we **classify** OS types (single-user, multi-user, multi-tasking, multi-threading, real-time and time-sharing).

1. What is an operating system?

Without an OS you would talk to the CPU in machine code for every file, screen update and key press. The OS is the **manager**: it hides messy hardware details and gives you a safe, useful view – windows, folders, printers and apps.



The OS sits between apps and hardware

💡 Common examples: **Windows**, **macOS**, **Linux**, **Android**, **iOS**, and school lab systems based on Ubuntu or Windows.

2. A short evolution of the OS

- Early machines (1950s): **no OS** – operators loaded one job at a time by hand.
- Batch systems: jobs collected on punched cards and run in a **batch** with little interaction.
- Multi-programming: several jobs stay in memory so the CPU is **rarely idle** while one waits for I/O.
- Time-sharing: many users share the CPU in short **time slices** so each feels interactive.
- Personal and mobile OS: GUI desktops, then smartphones with always-on multitasking.

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3. Main functions of an OS

Interfaces
CLI (commands) and GUI (windows, icons, menus) so people and programs can use the machine.

Process management
Creates, schedules, switches and ends processes (you study this in 5.3).

Resource management
Shares CPU, memory, disks and devices fairly and safely among programs.

Security and protection
Accounts, passwords, permissions and isolation so one program cannot wreck another.

The OS also gives useful **abstractions**: **files** (named streams of bytes), **directories/folders** (named collections of files), and **data** organised for programs. You do not care which disk sector holds your essay – you open a path like `/home/amma/essay.docx`.

🧱 **Worked example: Name the four main OS functions and one abstraction each for "files" and "directories".**
Functions: interfaces, process management, resource management, security/protection.
Abstractions: a **file** is a named byte stream; a **directory** is a named folder of files.

4. Classification of operating systems

Type	Idea	Example flavour	
Single user – single task	One person, one program at a time.	Early MS-DOS style.	
Single user – multi task	One person, many programs at once.	D	ඒ
Multi user – multi task	Many people, many programs, shared machine.	L	L
Multi-threading	One process has several threads of control.	B	ඩ
Real time	Must meet strict deadlines (cars, robots, medical).	R	ඓ
Time sharing	CPU switched in short slices among users/jobs.	C	ඝ

🧱 **Worked example: Is Android on a phone "single user – multi task" or "multi user – multi task"? Explain briefly.**
Mostly **single user – multi task**: one human owner, but many apps run together. (Under the hood Linux can support more users, but the phone UI is single-user.)

💡 **Multi-programming** keeps several jobs in memory to raise CPU use. **Time-sharing** emphasises interactive sharing with short slices. They often appear together on modern OS.

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🚀 **Beyond the syllabus (2026 update)** *Not required for the exam – read for interest.* In 2026, cloud "OS" layers (Linux containers, Kubernetes nodes, Android/iOS) still rest on the same ideas: isolate processes, share CPU and memory, and protect users. Chromebooks and school thin clients often stream a full desktop from a server – that is multi-user time-sharing in a modern jacket.

Key Words

Operating system – System software that manages hardware and provides services to users and apps.

Interface – How you talk to the OS – CLI or GUI.

CLI – Command-line interface – typed commands.

GUI – Graphical user interface – windows, icons, menus, pointer.

Process management – Creating, scheduling and ending running programs.

Resource management – Sharing CPU, memory, disk and devices among programs.

Security and protection – Keeping users and programs from harming each other or the system.

File abstraction – A named stream of bytes managed by the OS.

Directory – A named folder that organises files (and other directories).

Multi-programming – Keeping several jobs in memory so the CPU stays busy.

Time sharing – Giving each user/job a short turn on the CPU.

Real-time OS – An OS that must answer within a fixed deadline.

Sample Q&A

1. Define an operating system.

> **Answer:** System software that manages computer hardware and provides a convenient, safe interface for users and application programs.

2. List four main functions of an OS.

> **Answer:** Providing interfaces; process management; resource management; security and protection.

3. What abstractions does an OS give for stored data?

> **Answer:** Files (named byte streams) and directories/folders that organise them.

4. Distinguish multi-programming and time-sharing.

> **Answer:** Multi-programming keeps several jobs in memory to reduce CPU idle time; time-sharing switches the CPU in short slices for interactive sharing.

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5. What is a real-time OS used for?

> **Answer:** Systems that must meet strict timing deadlines, such as vehicle controllers, robots and medical devices.

6. Give one example of single-user multi-task and one of multi-user multi-task.

> **Answer:** Single-user multi-task: a home Windows PC. Multi-user multi-task: a Linux school server with many logins.

MCQ

1. An operating system is best described as

A. the CPU chip itself
B. only a word processor
C. system software that manages hardware and serves apps/users
D. a printer cable
E. a single application game

2. Which is an OS function?

A. smelting iron
B. drawing paper maps only
C. tax collection
D. writing novels for the user
E. process management

3. GUI means

A. Graphical User Interface
B. Gateway User Internet
C. Graphics Under Integer
D. General USB Input
E. Global Unit Index

4. A file, to the OS, is mainly

A. a password only
B. a network cable
C. always a picture
D. a named stream of bytes
E. the CPU cache

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5. Time-sharing emphasises

A. turning the machine off
B. one job until it ends with no switching
C. short CPU slices for interactive users
D. only printing
E. disk formatting only

6. A real-time OS must

A. never use memory
B. meet strict timing deadlines
C. support only one font
D. avoid all files
E. run only on paper

7. Single user – single task means

A. one person, one program at a time
B. only real-time control
C. no users
D. only networking
E. many people, many programs

8. Multi-threading means

A. formatting a disk
B. many CPUs with no OS
C. one process has several threads of control
D. no processes at all
E. only one bit of RAM

9. Which sits between apps and hardware?

A. the monitor cable
B. only the keyboard
C. a blank CD
D. the chair
E. the operating system

10. Resource management includes sharing the

A. school timetables on paper
B. CPU, memory, disk and devices
C. only the wallpaper
D. only the font size
E. weather only

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11. Batch systems historically

A. had no CPU
B. gave each user a smartphone GUI
C. printed nothing
D. were only used in cars
E. ran collected jobs with little interaction

12. Security and protection help to

A. remove all passwords
B. make the screen brighter only
C. increase font size only
D. stop programs/users harming each other or the system
E. disable the disk

13. Which term means: “System software that manages hardware and provides services to users and apps”?

A. Time sharing
B. Resource management
C. File abstraction
D. Operating system
E. CLI

14. Which term means: “How you talk to the OS – CLI or GUI”?

A. Interface
B. Security and protection
C. Directory
D. GUI
E. Real-time OS

15. Which term means: “Command-line interface – typed commands”?

A. CLI
B. Multi-programming
C. Process management
D. File abstraction
E. Operating system

16. Which term means: “Graphical user interface – windows, icons, menus, pointer”?

A. Interface
B. Time sharing
C. Directory
D. Resource management
E. GUI

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17. Which term means: “Creating, scheduling and ending running programs”?

A. CLI
B. Process management
C. Real-time OS
D. Multi-programming
E. Security and protection

18. Which term means: “Sharing CPU, memory, disk and devices among programs”?

A. GUI
B. Time sharing
C. Resource management
D. File abstraction
E. Operating system

19. Which term means: “Keeping users and programs from harming each other or the system”?

A. Real-time OS
B. Security and protection
C. Interface
D. Directory
E. Process management

20. Which term means: “A named stream of bytes managed by the OS”?

A. Multi-programming
B. CLI
C. Resource management
D. File abstraction
E. Operating system

Structured Questions

1. Define an OS and state why a computer needs one. *(2 marks)*

> System software managing hardware / serving apps (1); without it users would handle every device detail and sharing would be unsafe/hard (2).

2. List the four main OS functions with one sentence each. *(4 marks)*

> Interfaces (1); process management (1); resource management (1); security/protection (1).

3. Explain file and directory abstractions. *(3 marks)*

> File = named byte stream (1); directory = named container of files/dirs (1); hide physical sectors (1).

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4. Compare single-user multi-task and multi-user multi-task OS. *(3 marks)*

> Single: one login, many apps (1); multi-user: many logins share machine (1); example each (1).

5. Distinguish multi-programming and time-sharing; mention real-time OS briefly. *(3 marks)*

> Multi-programming: several jobs in memory / CPU busy (1); time-sharing: short interactive slices (1); real-time: strict deadlines (1).

Summary

- An OS manages hardware and offers a safe interface to users and apps.
- Main functions: interfaces, processes, resources, security/protection.
- Abstractions include files and directories.
- OS types: single/multi user, multi-task, multi-thread, real-time, time-sharing.
- Evolution moved from no OS → batch → multi-programming → time-sharing → personal/mobile.

MCQ answer key – 5.1

1. **C** – OS = system software manager.
2. **E** – Process management is a core OS role.
3. **A** – Windows/icons/menus.
4. **D** – File abstraction.
5. **C** – Short turns on the CPU.
6. **B** – Deadlines matter.
7. **A** – Classic early PC/DOS style.
8. **C** – Threads inside a process.
9. **E** – OS layer.
10. **B** – Classic resources.
11. **E** – Punched-card batches.
12. **D** – Isolation and permissions.
13. **D** – Operating system – System software that manages hardware and provides services to users and apps.
14. **A** – Interface – How you talk to the OS – CLI or GUI.
15. **A** – CLI – Command-line interface – typed commands.
16. **E** – GUI – Graphical user interface – windows, icons, menus, pointer.
17. **B** – Process management – Creating, scheduling and ending running programs.
18. **C** – Resource management – Sharing CPU, memory, disk and devices among programs.
19. **B** – Security and protection – Keeping users and programs from harming each other or the system.
20. **D** – File abstraction – A named stream of bytes managed by the OS.

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5.2 Files, Directories and Storage Allocation

Syllabus 5.2. The OS organises your data as **files** and **directories**, using a **file system** (for example FAT-style). In this part you learn **file types**, the **hierarchy**, **security** (passwords and privileges), how space is given out with **contiguous, linked and indexed allocation**, why **defragmentation** helps, and why disks are **formatted**.

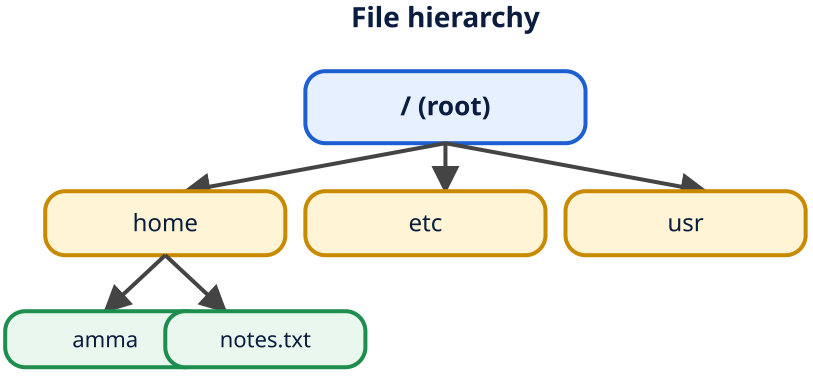
1. Files, types and attributes

A **file** is a named collection of related bytes. The **extension** (.exe, .jpg, .txt, .docx, .mp4) hints at the **type** so the OS and apps know how to open it. **Attributes** include name, size, type, location, creation/modification time, and access permissions.

> 💡 Extensions are conventions. Renaming `photo.jpg` to `photo.txt` does not turn pixels into text – it only changes the label the OS shows.

2. Directory hierarchy and file systems

Directories form a **tree** from a **root**. A path like `/home/amma/notes.txt` walks from root to the file. A **file system** (FAT, NTFS, ext4, APFS, …) is the on-disk layout of directories, files and free space. Older syllabuses often mention **FAT** as a classic example.



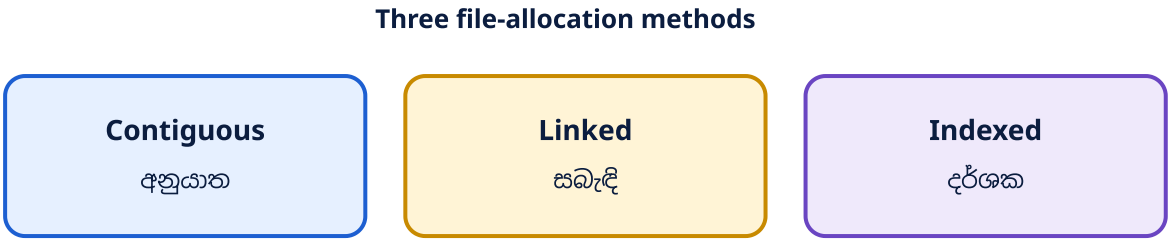
A tree of directories and files

3. File security

- **Passwords / accounts** control who can log in.
- **Access privileges** (read, write, execute; owner/group/others) limit what each user may do to a file.
- The OS **enforces** these rules on every open, read and write.

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4. Storage allocation methods



Contiguous, linked and indexed allocation

Contiguous
File occupies a run of neighbouring blocks. Fast sequential read; suffers **external fragmentation**.

Linked
Each block holds a pointer to the next. Easy to grow; slow random access.

Indexed
An **index block** lists pointers to all data blocks. Good for random access.

🧱 **Worked example: A disk has 10 blocks. Files A=2, B=3, C=1 blocks are stored contiguously from block 0. Where does each file live, and how many blocks stay free?**
A: blocks **0–1**; B: **2–4**; C: **5–5**; free = **4** blocks.

File	Start block	End block
A	0	1
B	2	4
C	5	5

🧱 **Worked example: A file needs 5 data blocks with one-level indexed allocation. How many blocks are used in total (index + data)?**
1 index block + 5 data blocks = **6** blocks.

5. Defragmentation and formatting

Fragmentation spreads a file's blocks around the disk so the head jumps more. **Defragmentation** packs related blocks closer to speed sequential reads (more relevant to HDDs than SSDs). **Formatting** prepares a disk with a file system structure (and usually erases previous contents) so the OS can store files.

💡 On SSDs, heavy classic defragmentation is usually unnecessary and can add wear; the OS still maintains free-space maps.

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🚀 **Beyond the syllabus (2026 update)** *Not required for the exam – read for interest.* In 2026 school PCs still meet NTFS (Windows), APFS (Mac) and ext4 (Linux). USB sticks may still use exFAT/FAT32 for compatibility. Cloud drives (OneDrive, Google Drive) look like folders but the blocks live in a data centre – the OS still uses the same open/read/write calls.

Key Words

File – Named collection of related bytes.	**File type / extension** – .exe .jpg .txt etc. hint how to open the file.
Directory / folder – Container in the file hierarchy.	**File system** – On-disk organisation of files and free space (e.g. FAT).
FAT – File Allocation Table – a classic simple file system.	**Access privileges** – Read/write/execute rights for users or groups.
Contiguous allocation – File stored in neighbouring blocks.	**Linked allocation** – Blocks chained by pointers.
Indexed allocation – Index block lists all data-block addresses.	**Fragmentation** – File pieces scattered so access slows.
Defragmentation – Rearranging blocks to pack a file closer together.	**Formatting** – Preparing a disk with a file-system structure.

Sample Q&A

1. Why do file types / extensions matter?

> **Answer:** They hint which program should open the file and how the bytes should be interpreted.

2. What is a file system?

> **Answer:** The on-disk method of organising directories, files and free space (e.g. FAT, NTFS, ext4).

3. Name three storage allocation methods.

> **Answer:** Contiguous, linked and indexed.

4. What problem does contiguous allocation often face?

> **Answer:** External fragmentation – free holes that are too small for new files.

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5. What does defragmentation do?

> **Answer:** Moves scattered blocks of a file closer together to improve sequential access.

6. Why format a disk?

> **Answer:** To create a fresh file-system structure the OS can use (usually erasing old data).

MCQ

1. A directory is

A. a folder that organises files in a hierarchy
B. a type of RAM only
C. a password algorithm
D. a network cable
E. a CPU register

2. FAT stands for

A. File Average Time
B. File Allocation Table
C. Firmware Auto Test
D. Fast Access Tape
E. Folder Access Token

3. Contiguous allocation stores a file in

A. neighbouring disk blocks
B. random non-linked sectors with no map
C. a single bit
D. the CPU cache alone
E. only in RAM registers

4. Linked allocation uses

A. no pointers at all
B. page tables for RAM only
C. pointers from each block to the next
D. DNS names
E. only contiguous runs forever

5. Indexed allocation keeps

A. no list of blocks
B. an index block of pointers to data blocks
C. the file only in registers
D. passwords in the boot sector always
E. nothing on disk

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6. External fragmentation is typical of

A. pure linked allocation with no holes concern
B. CPU scheduling
C. GUI themes
D. contiguous allocation
E. sound volume

7. Defragmentation mainly helps

A. speeding sequential access by packing blocks
B. increasing screen brightness
C. changing the keyboard language
D. stopping all I/O
E. removing the OS

8. Formatting a disk usually

A. changes the CPU model
B. adds more RAM chips
C. repairs the monitor
D. installs a game only
E. creates a file-system structure (and may erase data)

9. Access privileges control

A. who may read/write/execute a file
B. the clock speed only
C. the fan noise only
D. only the desktop colour
E. DNS servers only

10. Path /home/amma/notes.txt starts at

A. a CPU register
B. the root directory
C. a random empty sector with no name
D. the printer
E. the BIOS only

11. With contiguous allocation A=2,B=3,C=1 from block 0 on a 10-block disk, free blocks =

A. 10
B. 1
C. 6
D. 4
E. 0

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12. One-level index + 5 data blocks uses how many blocks?

A. 5
B. 10
C. 1
D. 4
E. 6

13. Which term means: “Named collection of related bytes”?

A. Directory / folder
B. Access privileges
C. Linked allocation
D. Defragmentation
E. File

14. Which term means: “.exe .jpg .txt etc. hint how to open the file”?

A. Formatting
B. File type / extension
C. Indexed allocation
D. Contiguous allocation
E. File system

15. Which term means: “Container in the file hierarchy”?

A. Fragmentation
B. FAT
C. File
D. Directory / folder
E. Linked allocation

16. Which term means: “On-disk organisation of files and free space (e.g. FAT)”?

A. Defragmentation
B. Access privileges
C. File system
D. File type / extension
E. Indexed allocation

17. Which term means: “File Allocation Table – a classic simple file system”?

A. Directory / folder
B. Contiguous allocation
C. Formatting
D. FAT
E. Fragmentation

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18. Which term means: “Read/write/execute rights for users or groups”?

A. File
B. Linked allocation
C. Access privileges
D. Defragmentation
E. File system

19. Which term means: “File stored in neighbouring blocks”?

A. FAT
B. Indexed allocation
C. Contiguous allocation
D. Formatting
E. File type / extension

20. Which term means: “Blocks chained by pointers”?

A. Access privileges
B. Directory / folder
C. Fragmentation
D. File
E. Linked allocation

Structured Questions

1. Explain why file types are needed and name three extensions. *(3 marks)*

> Tell OS/apps how to interpret bytes (1); e.g. .exe .jpg .txt (1); mismatch can open wrongly (1).

2. Describe a directory hierarchy with a short path example. *(3 marks)*

> Tree from root (1); path names each step (1); example /home/user/file (1).

3. Compare contiguous and linked allocation (one advantage each, one drawback each). *(2 marks)*

> Contiguous: fast sequential / fragmentation (2); linked: easy grow / slow random (2).

4. A 10-block disk stores A=2,B=3,C=1 contiguously from 0. Give ranges and free count. *(2 marks)*

> A 0–1, B 2–4, C 5–5 (2); free 4 (1).

5. Explain defragmentation and formatting briefly. *(2 marks)*

> Defrag packs scattered blocks (1); format builds file-system structure / may erase (2).

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Summary

- Files have types/extensions and attributes; directories form a hierarchy.
- File systems (e.g. FAT) organise data on disk.
- Security uses passwords and access privileges.
- Allocation: contiguous, linked, indexed – each with trade-offs.
- Defragmentation packs blocks; formatting prepares a file system.

MCQ answer key – 5.2

1. **A** – Hierarchy container.
2. **B** – Classic file system.
3. **A** – One run of blocks.
4. **C** – Block chain.
5. **B** – Index + data.
6. **D** – Holes between contiguous files.
7. **A** – Pack file pieces.
8. **E** – Prepare file system.
9. **A** – Permissions.
10. **B** – Root of the tree.
11. **D** – 2+3+1=6 used; 10−6=4.
12. **E** – 1+5=6.
13. **E** – File – Named collection of related bytes.
14. **B** – File type / extension – .exe .jpg .txt etc. hint how to open the file.
15. **D** – Directory / folder – Container in the file hierarchy.
16. **C** – File system – On-disk organisation of files and free space (e.g. FAT).
17. **D** – FAT – File Allocation Table – a classic simple file system.
18. **C** – Access privileges – Read/write/execute rights for users or groups.
19. **C** – Contiguous allocation – File stored in neighbouring blocks.
20. **E** – Linked allocation – Blocks chained by pointers.

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5.3 Process Management: States, PCB, Schedulers and Waiting Time

Syllabus 5.3. A **process** is a program in execution. The OS creates processes, handles **interrupts**, tracks **states**, stores facts in a **PCB**, switches context, and uses **schedulers**. In this part you also meet **turnaround, response, throughput and waiting time**, with worked **FCFS / SJF** waiting-time calculations.

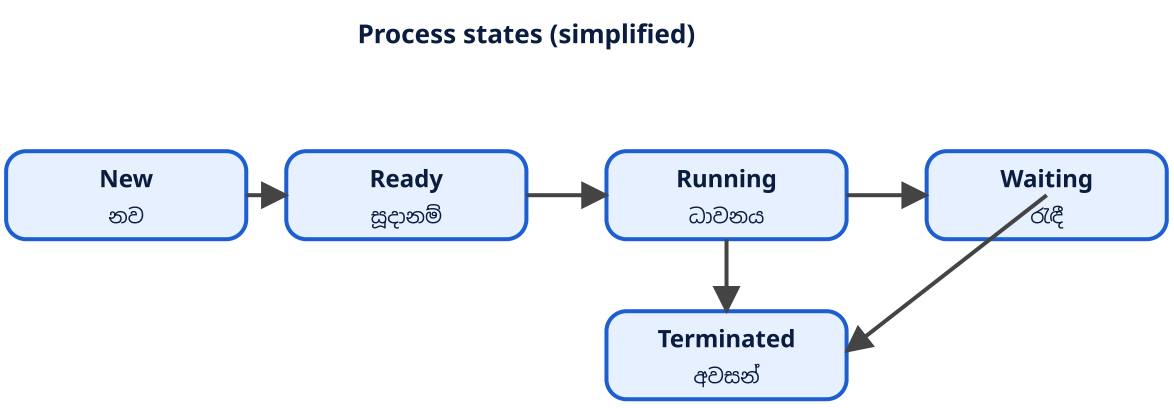
1. Program vs process

A **program** is passive (bytes on disk). A **process** is active: it has a program counter, registers, stack and an address space. Creating a process allocates a **PCB**, loads code, and sets the first state to ready (or new→ready).

2. Interrupts

An **interrupt** is a signal that something needs the CPU's attention (I/O finished, timer tick, error). The OS runs an **interrupt handler**, may save the current process's state, then resumes or schedules another process.

3. Process states and transitions



Simplified process states

- **New** → being created.
- **Ready** → waiting for CPU.
- **Running** → on the CPU.
- **Waiting / blocked** → waiting for I/O or an event.
- **Terminated** → finished or killed.

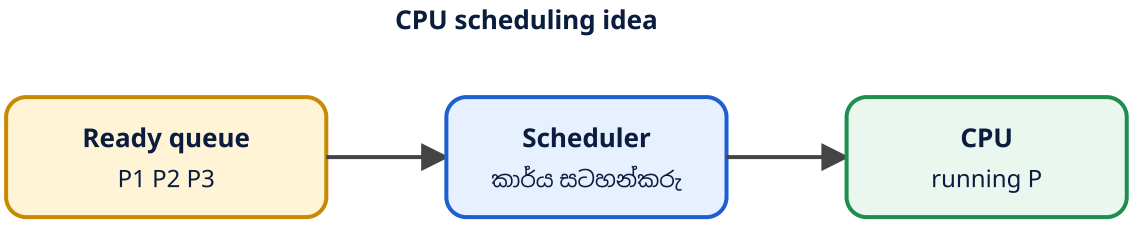
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> 💡 Syllabus diagrams may show up to **seven** states (including suspend/ready-suspend). The five above are the core idea.

4. PCB and context switch

The **Process Control Block (PCB)** holds the process ID, state, program counter, registers, scheduling info, memory maps and open files. A **context switch** saves one PCB's volatile state and loads another's so the CPU can run a different process.

5. Schedulers



Scheduler picks the next process

Scheduler	When	Job
Long-term	Job admission	Controls multi-programming degree
Short-term (CPU)	Very often	Picks who runs next on the CPU
Medium-term	When memory is tight	Swaps / suspends processes

Multi-programming keeps several processes in memory. **Time-sharing** gives interactive slices. Metrics: **turnaround** = finish − arrival; **waiting** = turnaround − burst; **response** ≈ first-run − arrival; **throughput** = jobs finished per unit time.

> 🧱 **Worked example: 20 jobs finish in 10 seconds. What is the throughput?**
> Throughput = 20/10 = **2 jobs/s**.

6. Worked example – FCFS waiting times

FCFS (First-Come-First-Served) runs processes in arrival order with no preemption.

> 🧱 **Worked example: Jobs P1–P4 with arrivals 0,1,2,3 and bursts 5,3,8,6 (ms). Find each waiting time and the average.**
> Waits = 0, 4, 6, 13. Average waiting time = **5.75 ms**.

Process	Arrival	Burst	Start	Finish	Wait
P1	0	5	0	5	0

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P2	1	3	5	8	4
P3	2	8	8	16	6
P4	3	6	16	22	13

7. Worked example – SJF (non-preemptive)

SJF picks the ready job with the **shortest burst** next.

🧮 **Worked example: Jobs: P1(0,7), P2(2,4), P3(4,1), P4(5,4). Find the average waiting time under non-preemptive SJF.**
Order runs P1, then P3, then P2, then P4. Waits = 0, 6, 3, 7. Average = **4 ms**.

Process	Arrival	Burst	Start	Wait
P1	0	7	0	0
P3	4	1	7	3
P2	2	4	8	6
P4	5	4	12	7

🚀 **Beyond the syllabus (2026 update)** *Not required for the exam – read for interest.* In 2026 desktop and phone OS still combine multi-level feedback queues, CFS (Linux) and similar fair schedulers. The exam still expects you to compute FCFS/SJF waiting times by hand – that trains the definitions of waiting and turnaround time.

Key Words

Process – A program in execution with its own state.

Interrupt – Signal that needs CPU attention now.

PCB – Process Control Block – OS record for a process.

Context switch – Saving one process state and loading another.

Ready state – Waiting for the CPU.

Waiting state – Blocked for I/O or an event.

Long-term scheduler – Admits jobs into the system.

Short-term scheduler – Chooses the next process for the CPU.

FCFS – First-Come-First-Served scheduling.

SJF – Shortest-Job-First scheduling.

Waiting time – Time spent in the ready queue (turnaround − burst).

Throughput – Number of jobs finished per unit time.

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Sample Q&A

1. Distinguish a program and a process.

> **Answer:** A program is passive code on storage; a process is that code running with state (PC, registers, memory).

2. What does a PCB store?

> **Answer:** PID, state, PC, registers, scheduling data, memory info, open files (typical contents).

3. What is a context switch?

> **Answer:** Saving the current process's CPU state and loading another process's state.

4. Name the three scheduler types.

> **Answer:** Long-term, short-term (CPU) and medium-term.

5. Define waiting time and turnaround time.

> **Answer:** Turnaround = finish − arrival; waiting = turnaround − burst (time in ready queue).

6. In the FCFS example, what is the average waiting time?

> **Answer:** 5.75 ms.

MCQ

1. A process is

A. a monitor brand
B. a program in execution
C. a static PDF icon
D. a keyboard cable
E. only a file on disk

2. PCB stands for

A. Public Code Base
B. Printer Cable Bus
C. Process Control Block
D. Primary Cache Buffer
E. Page Count Byte

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3. A process in the ready state is

A. waiting only for a printer with no CPU need
B. not yet created
C. finished forever
D. waiting for the CPU
E. in ROM only

4. Context switching

A. formats the disk
B. saves one process state and loads another
C. turns off interrupts forever
D. changes the wallpaper only
E. deletes the OS

5. The short-term scheduler

A. never runs
B. only draws icons
C. only creates user accounts
D. only formats USB sticks
E. selects which ready process runs next

6. FCFS scheduling serves

A. largest memory first
B. random only
C. shortest job first always
D. only I/O bound last
E. in arrival order

7. SJF picks the ready job with

A. the shortest burst time
B. the most open files
C. the longest burst
D. no burst information
E. the latest arrival only

8. Waiting time equals

A. burst − arrival
B. page size
C. turnaround time − burst time
D. arrival only
E. throughput × 2

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9. Throughput is

A. jobs finished per unit time
B. RAM size only
C. number of icons
D. password length
E. screen resolution

10. If 20 jobs finish in 10 s, throughput is

A. 200 jobs/s
B. 2 jobs/s
C. 0.5 jobs/s
D. 20 jobs/s
E. 10 jobs/s

11. In the lesson FCFS example, average waiting time is

A. 5.75 ms
B. 50 ms
C. 100 ms
D. 1 ms
E. 0 ms

12. In the lesson SJF example, average waiting time is

A. 0 ms
B. 1 ms
C. 50 ms
D. 100 ms
E. 4 ms

13. Which term means: “A program in execution with its own state”?

A. PCB
B. Waiting state
C. Waiting time
D. Process
E. Short-term scheduler

14. Which term means: “Signal that needs CPU attention now”?

A. Throughput
B. FCFS
C. Context switch
D. Interrupt
E. Long-term scheduler

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15. Which term means: “Process Control Block – OS record for a process”?

A. Ready state
B. Process
C. PCB
D. Short-term scheduler
E. SJF

16. Which term means: “Saving one process state and loading another”?

A. Context switch
B. Interrupt
C. Waiting state
D. FCFS
E. Waiting time

17. Which term means: “Waiting for the CPU”?

A. Long-term scheduler
B. PCB
C. Ready state
D. Throughput
E. SJF

18. Which term means: “Blocked for I/O or an event”?

A. Waiting time
B. Process
C. Context switch
D. Waiting state
E. Short-term scheduler

19. Which term means: “Admits jobs into the system”?

A. Throughput
B. Long-term scheduler
C. Ready state
D. Interrupt
E. FCFS

20. Which term means: “Chooses the next process for the CPU”?

A. Process
B. Waiting state
C. SJF
D. PCB
E. Short-term scheduler

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Structured Questions

1. Distinguish program and process; list three PCB contents. *(2 marks)*

> Program passive / process active (1); PCB: PID, state, PC/registers (or similar) (2).

2. Describe ready, running and waiting states. *(3 marks)*

> Ready: wants CPU (1); running: on CPU (1); waiting: blocked for I/O/event (1).

3. Compare long-term and short-term schedulers. *(2 marks)*

> Long-term admits jobs / degree of multi-programming (1); short-term picks next CPU process often (2).

4. For the FCFS data in the notes, show waits and the average. *(2 marks)*

> Waits 0,4,6,13 (2); average 5.75 (1).

5. Define waiting, turnaround and throughput; give the 20-jobs-in-10-s throughput. *(2 marks)*

> Definitions (2); throughput 2 jobs/s (1).

Summary

- A process is a running program; a PCB stores its OS data.
- States include new, ready, running, waiting, terminated.
- Schedulers: long-term, short-term, medium-term.
- Waiting = turnaround − burst; throughput = jobs per time.
- FCFS and SJF examples show how to compute average waiting time.

MCQ answer key – 5.3

1. **B** – Active execution.
2. **C** – OS process record.
3. **D** – Ready queue.
4. **B** – Switch processes on CPU.
5. **E** – CPU scheduler.
6. **E** – First come first served.
7. **A** – Shortest job first.
8. **C** – Time in ready queue.
9. **A** – Jobs/time.
10. **B** – 20/10=2.
11. **A** – (0+4+6+13)/4.
12. **E** – Computed SJF average.
13. **D** – Process – A program in execution with its own state.

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14. **D** – Interrupt – Signal that needs CPU attention now.
15. **C** – PCB – Process Control Block – OS record for a process.
16. **A** – Context switch – Saving one process state and loading another.
17. **C** – Ready state – Waiting for the CPU.
18. **D** – Waiting state – Blocked for I/O or an event.
19. **B** – Long-term scheduler – Admits jobs into the system.
20. **E** – Short-term scheduler – Chooses the next process for the CPU.

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Grade 12 A/L ICT · Lesson 5

5.4 Memory Management, Paging, Device Drivers and Spooling

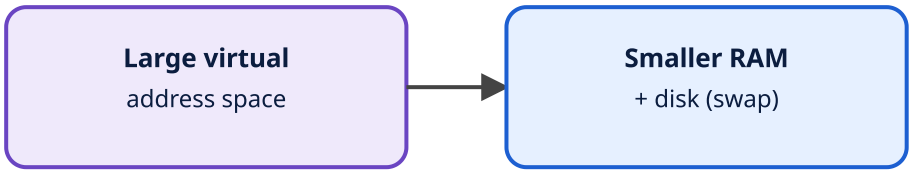
Syllabus 5.4. The OS manages **memory** with help from the **MMU**, supports **virtual memory** and **paging**, and controls **I/O devices** through **device drivers**. **Spooling** queues output (for example to a printer). In this part you practise **address calculations**: page number, offset and physical address.

1. Why manage memory?

Many programs share limited RAM. The OS must **allocate**, **protect** and **map** memory so each process sees a private address space and cannot overwrite another. The **Memory Management Unit (MMU)** is hardware that translates addresses and checks permissions.

2. Virtual memory and paging

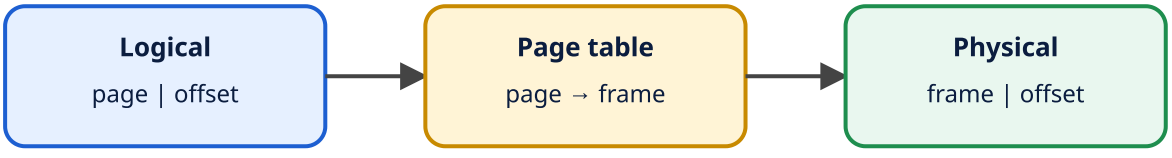
Virtual memory idea



Virtual memory idea

Virtual memory lets a process use a large logical address space. Parts that do not fit in RAM live on disk (swap/page file). **Paging** splits memory into fixed-size **pages** (logical) and **frames** (physical). A **page table** maps page → frame.

Logical address → physical address



Logical address to physical address

Logical address = **page number** × page size + **offset**. Physical address = **frame number** × page size + **offset** (same offset).

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🧱 **Worked example: Page size = 1024 bytes (1 KB). Logical address 3500. Find page number and offset.**
page = 3500 ÷ 1024 = **3**; offset = 3500 mod 1024 = **428**.

🧱 **Worked example: If page 3 is loaded in frame 5, what is the physical address?**
PA = 5 × 1024 + 428 = **5548**.

🧱 **Worked example: A process needs 10 KB. Page size = 1 KB. How many pages?**
10240 ÷ 1024 = **10 pages**.

🧱 **Worked example: A system uses 16-bit logical addresses and a 1024-byte page. How many bits are the offset and the page number? How many pages can a process address?**
Offset bits = $\log_2(1024)$ = **10**; page bits = 16 − 10 = **6**; max pages = 2^6 = **64**.

💡 **Mapping** means translating logical → physical using the page table (and MMU cache / TLB in real machines).

3. I/O device management

Keyboards, disks, printers and USB devices differ. The OS talks to them through **device drivers** – software modules that hide hardware details and present a uniform interface (read, write, control).

- **Need for drivers:** each device has its own registers and protocols.
- When you plug in a printer or USB stick, the OS loads the matching driver (or asks you to install one).
- Without the right driver the device is invisible or limited.

4. Spooling

Spooling (Simultaneous Peripheral Operations On-Line) stores data destined for a slow device (classically a printer) on disk first, then feeds the device in the background. Many users can "print" at once without waiting for the paper.

🧱 **Worked example: Why is a print spooler useful in a school computer lab?**
Many students send jobs; the spooler queues them on disk so each PC can continue working while the shared printer prints one job after another.

🚀 **Beyond the syllabus (2026 update)** *Not required for the exam – read for interest.* In 2026, phones use zRAM and sophisticated paging; laptops mix SSD swap with large RAM. GPU drivers and USB-C dock drivers are still the usual reason a new peripheral "does not work until you install software". Cloud print queues are spooling in another building.

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Key Words

MMU – Memory Management Unit – hardware address translation and protection.

Physical memory – The real RAM chips and their addresses.

Virtual memory – Large logical space backed by RAM + disk.

Paging – Fixed-size pages mapped to frames.

Page – Fixed-size block of a process's logical address space.

Frame – Fixed-size block of physical RAM.

Page table – Maps page numbers to frame numbers.

Offset – Displacement within a page/frame.

Device driver – Software that controls a specific device for the OS.

Spooling – Queueing device I/O (e.g. print jobs) on disk.

Mapping – Translating logical addresses to physical addresses.

Swap / page file – Disk space holding pages that do not fit in RAM.

Sample Q&A

1. What does the MMU do?

> **Answer:** Translates virtual/logical addresses to physical addresses and helps enforce memory protection.

2. What is virtual memory?

> **Answer:** A technique that gives processes a large logical address space using RAM plus disk backing store.

3. Define page and frame.

> **Answer:** A page is a fixed-size logical block; a frame is a same-size block of physical RAM.

4. Why are device drivers needed?

> **Answer:** Each device has different hardware details; drivers hide them so the OS can use a common interface.

5. What is spooling?

> **Answer:** Storing output (e.g. print jobs) on disk and sending it to a slow device later/in the background.

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6. For LA=3500 and page size 1024, what are page and offset?

> **Answer:** Page 3, offset 428.

MCQ

1. The MMU mainly

A. prints pages
B. stores passwords only
C. translates addresses and helps protect memory
D. formats USB only
E. draws desktop icons

2. Virtual memory allows

A. processes to use more logical space than physical RAM
B. only one file on disk
C. turning off the MMU forever
D. removing the CPU
E. no address translation

3. In paging, a frame is

A. a keyboard key
B. an IP address
C. a user password
D. a GUI window only
E. a fixed-size block of physical memory

4. Logical address =

A. frame only
B. page number × page size + offset
C. file name length
D. MAC address
E. CPU temperature

5. For LA 3500 and 1 KB pages, the page number is

A. 3500
B. 10
C. 3
D. 0
E. 1024

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6. With page 3 in frame 5 and offset 428, PA is

A. 3500
B. 0
C. 5
D. 5548
E. 1024

7. A 10 KB process with 1 KB pages needs

A. 100 pages
B. 1 page
C. 1024 pages
D. 10 pages
E. 0 pages

8. A device driver is

A. a power cable only
B. software that lets the OS control a device
C. a font file
D. a type of RAM chip
E. a desk chair

9. Spooling is often used for

A. CPU register renaming only
B. screen brightness only
C. cooling fans only
D. BIOS flashing only
E. print jobs queued on disk

10. Offset bits for a 1024-byte page are

A. 10
B. 8
C. 16
D. 64
E. 1

11. With 16-bit logical addresses and 10 offset bits, page bits =

A. 32
B. 6
C. 0
D. 10
E. 16

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12. Mapping in this lesson means

A. changing wallpapers
B. drawing a geography map
C. logical → physical address translation
D. sorting files by colour
E. deleting drivers

13. Which term means: “Memory Management Unit – hardware address translation and protection”?

A. Mapping
B. Virtual memory
C. Frame
D. Offset
E. MMU

14. Which term means: “The real RAM chips and their addresses”?

A. Physical memory
B. Paging
C. Device driver
D. Page table
E. Swap / page file

15. Which term means: “Large logical space backed by RAM + disk”?

A. MMU
B. Spooling
C. Offset
D. Virtual memory
E. Page

16. Which term means: “Fixed-size pages mapped to frames”?

A. Mapping
B. Frame
C. Device driver
D. Paging
E. Physical memory

17. Which term means: “Fixed-size block of a process’s logical address space”?

A. Page table
B. Virtual memory
C. Spooling
D. Swap / page file
E. Page

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18. Which term means: “Fixed-size block of physical RAM”?

A. Mapping
B. Frame
C. Offset
D. MMU
E. Paging

19. Which term means: “Maps page numbers to frame numbers”?

A. Swap / page file
B. Device driver
C. Page table
D. Physical memory
E. Page

20. Which term means: “Displacement within a page/frame”?

A. Offset
B. MMU
C. Virtual memory
D. Frame
E. Spooling

Structured Questions

1. Explain why memory management and the MMU are needed. *(2 marks)*

> Share limited RAM safely (1); MMU translates and protects (2).

2. Describe virtual memory and paging in three clear points. *(3 marks)*

> Large logical space (1); pages/frames (1); page table maps (1).

3. For LA=3500, page size 1 KB, frame 5: find page, offset, PA. *(3 marks)*

> Page 3 (1); offset 428 (1); PA 5548 (1).

4. Explain device drivers and why installing them matters. *(3 marks)*

> Software interface to hardware (1); without driver device limited/unusable (1); example printer/USB (1).

5. Define spooling and give a school-lab printer example. *(3 marks)*

> Queue output on disk (1); printer prints in background (1); many students share one printer (1).

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Summary

- The MMU translates and protects memory addresses.
- Virtual memory + paging map pages to frames via a page table.
- Logical address = page × size + offset; physical uses frame × size + offset.
- Device drivers let the OS control varied hardware.
- Spooling queues slow-device output (e.g. printing) on disk.

MCQ answer key – 5.4

1. **C** – Address translation hardware.
2. **A** – RAM + disk backing.
3. **E** – Physical page-sized block.
4. **B** – Page and offset.
5. **C** – 3500//1024=3.
6. **D** – 5*1024+428.
7. **D** – 10.
8. **B** – Per-device software.
9. **E** – Classic printer spool.
10. **A** – log2(1024)=10.
11. **B** – 16−10=6.
12. **C** – Page-table translation.
13. **E** – MMU – Memory Management Unit – hardware address translation and protection.
14. **A** – Physical memory – The real RAM chips and their addresses.
15. **D** – Virtual memory – Large logical space backed by RAM + disk.
16. **D** – Paging – Fixed-size pages mapped to frames.
17. **E** – Page – Fixed-size block of a process’s logical address space.
18. **B** – Frame – Fixed-size block of physical RAM.
19. **C** – Page table – Maps page numbers to frame numbers.
20. **A** – Offset – Displacement within a page/frame.

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