Cambridge IGCSE · Computer Science 0478 · Notes

Data storage

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Read first: **Computer architecture**

What you need to know

By the end of this topic you should be able to:

1. **Say what primary storage is**: storage that the CPU accesses directly. Know the role of **RAM** (random access memory) and **ROM** (read only memory), why a computer needs both, and how they differ.
2. **Say what secondary storage is**: storage that the CPU does **not** access directly, needed to keep data more permanently.
3. **Describe how the three kinds of secondary storage work, and give examples of each:**
   - **magnetic**: platters divided into tracks and sectors, read and written by electromagnets; for example a hard disk drive (HDD);
   - **optical**: a laser makes and reads pits and lands; for example CD, DVD and Blu-ray;
   - **solid-state (flash memory)**: NAND or NOR technology, with transistors used as control gates and floating gates; for example a solid-state drive (SSD), SD card and USB flash drive.
4. **Describe virtual memory**: what it is, how it is created and used (pages of data move between RAM and virtual memory when needed) and why it is necessary.
5. **Say what cloud storage is**: data stored remotely on physical servers and storage that someone else runs, reached over a network, in contrast to storing data locally.
6. **Explain the advantages and disadvantages** of storing data in the cloud compared with storing it locally.

How big storage is (KiB, MiB, GiB …) belongs to the data storage and compression topic. The CPU, its registers and how cache speeds it up belong to computer architecture.

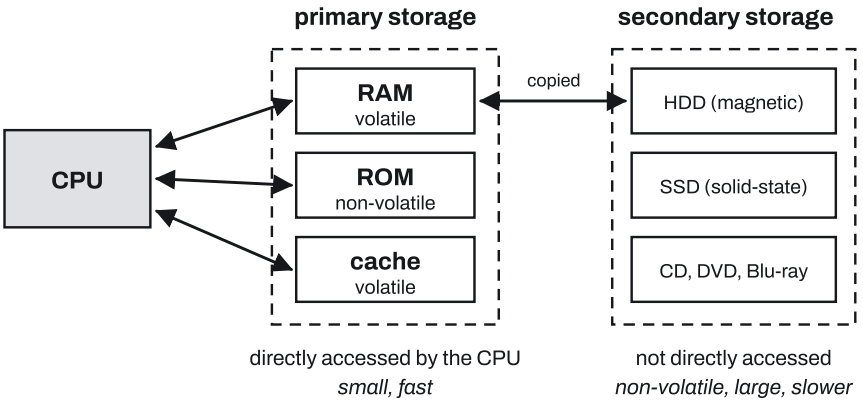
Understand it

Two kinds of storage

A computer keeps data in two very different places.

Primary storage is the storage the CPU can reach **directly**, over the buses, while it runs the fetch–decode–execute cycle. It is small and fast. RAM, ROM and cache are primary storage (the CPU's registers count too).

Secondary storage is everything the CPU can't reach directly: hard disks, SSDs, memory cards, optical discs. It is where data is kept **permanently**: the operating system, the applications, and the user's files. It is **non-volatile**, so it keeps its data with the power off. Before the CPU can use a program or file from secondary storage, it has to be **copied into RAM** first.



A word you will need all through this topic: **volatile** storage loses its contents when the power is turned off; **non-volatile** storage keeps them.

RAM

RAM holds the **data, programs and instructions that are in use right now**: the parts of the operating system that are running, the open apps, the document being edited. When you open a file, it is loaded from secondary storage into RAM so the CPU can reach it quickly.

- RAM is **volatile**: everything in it is lost when the power goes off. That is fine, because it only holds temporary, working data, and it changes all the time.
- RAM can be **read and written**: its contents are constantly replaced as you open and close things.
- The CPU accesses it **directly**, and much faster than secondary storage.
- Its capacity is larger than ROM's but much smaller than secondary storage's.

Careful wording matters: RAM stores the software **currently running**. The software itself is stored in secondary storage.

ROM

ROM holds instructions that must be there every time the computer starts, and must never change:

- the **start-up instructions** (the **bootstrap** or bootloader, and the **BIOS**), which check the hardware and load the operating system from secondary storage into RAM;
- **firmware**, the fixed software inside a device such as a washing machine or smartwatch.

ROM is **non-volatile** (it keeps its contents with the power off) and **read only** (its contents normally can't be changed). It is small.

Why a computer needs both

When a computer is switched on, RAM is empty, because it is volatile. Something non-volatile has to tell the CPU how to start: that is ROM. But ROM can't be changed, so it can't hold the programs and data you are working on: that is RAM's job.

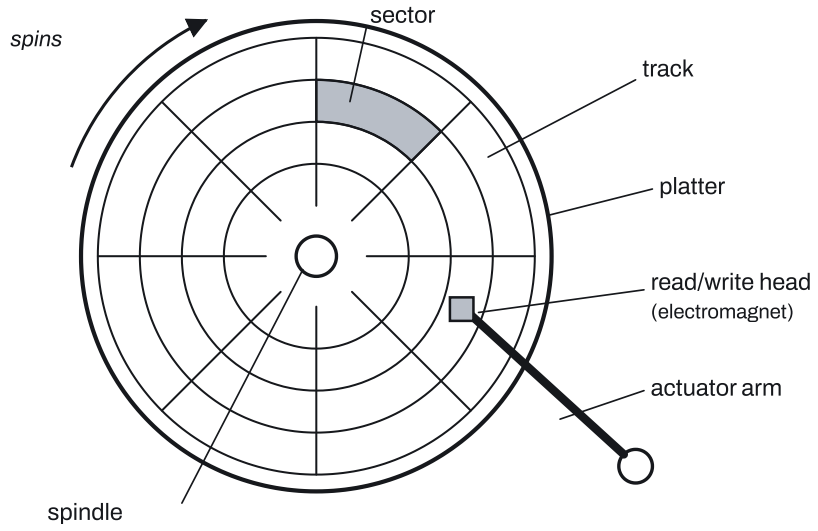
	RAM	ROM
Volatile?	Yes: contents lost when the power is off	No: keeps its contents
Can the contents change?	Yes, all the time (read and write)	No (read only)
Holds	Data, programs and instructions in use	Start-up instructions (bootstrap, BIOS), firmware
Size	Larger	Smaller

Cache is a third kind of primary storage: a small, very fast memory inside or next to the CPU that holds **frequently used** instructions and data, so the CPU doesn't have to fetch them from the slower RAM. It is volatile.

Magnetic storage

A **hard disk drive (HDD)** stores data on **platters**: flat, round discs coated with a magnetic material, stacked on a spindle. A motor spins the platters very fast.

- Each surface is divided into circular **tracks**, and each track into **sectors**. Every piece of data has a place (a track and sector).
- A **read/write head** sits on an **actuator arm** that moves across the spinning platter to the right track, then waits for the right sector to pass underneath.
- To **write**, an **electromagnet** in the head magnetises tiny areas of the surface in one of two directions: one direction stands for 1, the other for 0.
- To **read**, the head senses the direction of each magnetised area as it passes.

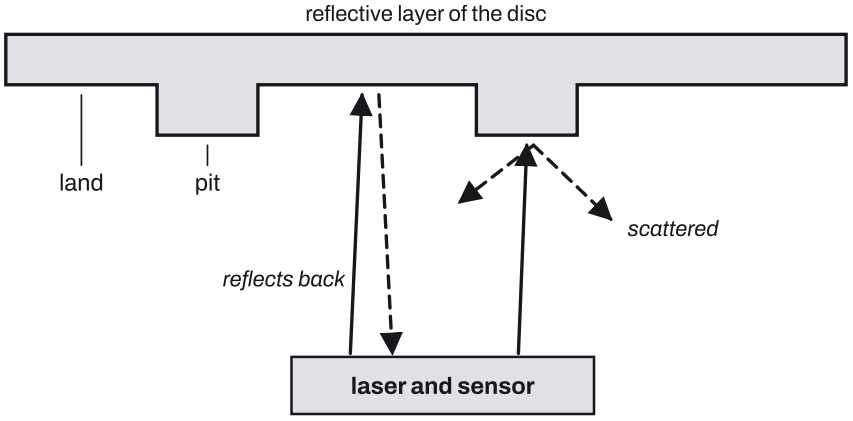


The data stays magnetised with no power, so an HDD is non-volatile. Because it has **moving parts**, an HDD is slower to access data than an SSD, can be damaged if dropped while running, uses more power and makes some noise. In return it gives a very large capacity at a low cost per gigabyte. Magnetic tape is another example of magnetic storage.

Optical storage

CDs, DVDs and Blu-ray discs are optical: they store data as a pattern on a disc that is read with light.

- To **write**, the disc is spun and a **laser** burns tiny **pits** into the surface along a single **spiral track**. The flat parts between the pits are **lands**.
- To **read**, the disc is spun and a laser is shone onto the track. A land reflects the light straight back to a sensor; a pit scatters it, so less comes back. The pattern of pits and lands stands for the binary data.



the disc spins so the spiral track passes over the laser

CDs use infra-red light, DVDs a red laser and Blu-ray a **blue** (blue-violet) laser. Blue light has a shorter wavelength, so its pits can be smaller and packed closer together: a Blu-ray disc holds about 25 GB, a DVD about 4.7 GB and a CD about 0.7 GB, so one Blu-ray holds as much as about $25 \div 4.7 \approx 5$ DVDs. Optical discs are cheap, light and easy to post or store, but they have a small capacity, are slow to access, have moving parts (the spinning disc) and can be scratched.

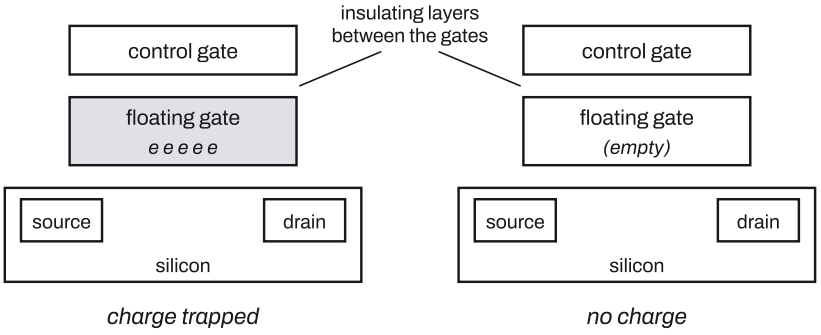
Solid-state (flash memory) storage

Solid-state storage has **no moving parts**. It stores data in semiconductor chips made of millions of **transistors** laid out in a **grid**, using **NAND** or **NOR** technology (NAND is the kind used in SSDs, SD cards and USB drives).

Each transistor (a **cell**) has two gates, one above the other:

- the **control gate**, which is connected to the circuit;
- the **floating gate**, under it, which is surrounded by insulating material.

To store data, a voltage on the control gate pushes **electrons** onto the floating gate, where the insulation **traps** them. Whether a floating gate holds this charge or not stores a 0 or a 1. The gates control the flow of electrons, and because the trapped charge stays without power, flash memory is **non-volatile**.



the two states store a 0 or a 1; the charge stays with the power off

Examples: **SSD** (solid-state drive), **SD card**, **USB flash drive**. Because there are no moving parts, solid-state storage is fast to read and write, robust if dropped, silent, light and small, and uses little power. It costs more per gigabyte than magnetic storage.

Comparing the three

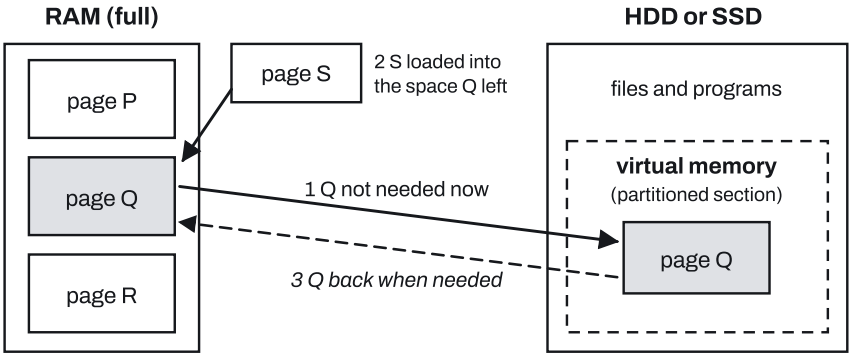
	Magnetic (HDD)	**Optical (CD, DVD, Blu-ray)**	**Solid-state (SSD, SD card, USB drive)**
How data is stored	Magnetised areas on platters	Pits and lands on a disc	Charge trapped on floating gates
Written/read by	Electromagnets in a read/write head	A laser	Transistors (control and floating gates)
Moving parts?	Yes (spinning platters, moving arm)	Yes (spinning disc)	No
Access speed	Medium	Slowest	Fastest
Capacity	Very large	Small	Large
Cost per GB	Low	Lowest	Highest

	Magnetic (HDD)	Optical (CD, DVD, Blu-ray)	Solid-state (SSD, SD card, USB drive)
Durability	Damaged by knocks	Scratches easily	Robust
Power, noise	More power, some noise	Needs a drive to spin it	Little power, silent

Virtual memory

What if RAM fills up, for example while editing a large video? Without help, the computer could slow to a stop or crash. **Virtual memory** is the fix.

- **How it is created:** part of the secondary storage (an HDD or SSD) is **partitioned** off to act as an **extension of RAM**.
- **How it is used:** data in RAM is divided into **pages**. When RAM is full and a new page is needed, a page that **isn't needed immediately** is moved from RAM into virtual memory. That frees space in RAM for the new page. When the moved page is needed again, it is moved back into RAM (and another page that isn't needed goes out to make room).
- **Why it is necessary:** it lets the computer run programs and files that need more memory than the RAM has, and stops it crashing when RAM is full.



Virtual memory is secondary storage, so it is much slower than RAM: if pages are swapped in and out too often, the computer slows down. Adding more RAM is the lasting fix.

Cloud storage

Cloud storage means your data is stored **remotely**, on **physical servers** (usually many, in data centres) that belong to and are run by a **third party**, and you reach it over a network, usually the **internet**. The cloud is still real hardware; it just isn't yours or near you. **Local storage** is storage in your own device or on your own site, such as a laptop's SSD or an external hard drive on your desk.

Advantages of the cloud over local storage:

- the data can be **accessed from anywhere, on any device**, with an internet connection, and shared easily;

- the third party **buys, maintains and secures the hardware**, and usually **backs up** the data, so you don't have to;
- you can **increase (or decrease) the storage** whenever you need, without buying new hardware;
- your devices need less storage of their own, and a company needs no space to house servers; if a device is lost or broken, the data is still safe.

Disadvantages:

- you need an **internet connection**; with no connection (or a slow one) you can't reach your data;
- the **security** and privacy of the data is in the hands of the **third party**; you rely on them to keep it safe and to keep the service running;
- there is usually an **ongoing cost** (a subscription), and large files take time to upload and download.

"It could be hacked" is **not** a disadvantage of the cloud on its own: data stored locally can be hacked too.

Key facts and formulas

There are no formulas in this topic. These are the facts to learn; nothing here is given in the exam.

Fact	Status
Primary storage is directly accessed by the CPU; secondary storage is not	Learn it
RAM: volatile, read/write, holds data and programs currently in use	Learn it
ROM: non-volatile, read only, holds start-up instructions (bootstrap, BIOS) and firmware	Learn it
Cache: primary, holds frequently used instructions and data	Learn it
Secondary storage is non-volatile and stores data, software and the OS permanently	Learn it
Magnetic: platters, tracks and sectors, read/write head, electromagnets; HDD, magnetic tape	Learn it
Optical: laser, pits and lands, spiral track; CD, DVD, Blu-ray	Learn it
Solid-state: NAND/NOR, transistors, control and floating gates, no moving parts; SSD, SD card, USB flash drive	Learn it
Virtual memory: a partition of secondary storage that pages move to and from when RAM is full	Learn it
Cloud storage: remote physical servers run by a third party, accessed over the internet	Learn it

How to do it

In the Paper 1 questions we have tagged for this topic (37 questions, 2021–2025), the types came up this often. 22 of the 37 questions mix more than one type, so the counts add up to more than 37.

Question type	Questions
Describe how magnetic, optical or solid-state storage works	10
Give examples of a storage type, or name the type of a device	10
Give an example of primary storage and what it stores	9
Explain what makes storage primary or secondary; the differences	9
Match statements to magnetic, optical or solid-state	7
Explain why a computer needs RAM or ROM; describe RAM	6
State the purpose of secondary storage	6
Choose or compare storage for a situation and justify	6
Virtual memory	5
Cloud storage	3

1. Describe how magnetic, optical or solid-state storage works (10 questions)

Either "give two features of magnetic storage" (1 mark each) or "describe how data is written to ..." (3–4 marks, one per step).

1. **Name the parts** the technology uses (the syllabus words score): platters, tracks, sectors, read/write head, electromagnet; laser, pits, lands, spiral track; NAND/NOR, transistors, control gate, floating gate, electrons.
2. **For "describe how", go in order**, one step per line:
   - **HDD**: platters are spun → the read/write head on an arm moves to the track and sector → an electromagnet magnetises tiny areas → the direction of each area is a 1 or a 0.
   - **Optical (writing)**: the disc is spun → a laser is shone onto it → pits are burnt into a spiral track → pits and lands represent the binary.
   - **Optical (reading)**: the disc is spun → a laser is shone onto the track → lands reflect the light back, pits scatter it → a sensor turns the reflections into binary.
   - **Solid-state**: transistors laid out in a grid → a voltage on the control gate → electrons are trapped on the floating gate → the charge (or none) is the binary value, and stays without power.

Variations you will meet:

- **"Give three other features"** when the question has already given one ("it uses platters"): don't repeat it.
- **A word-bank gap-fill** on solid-state: the words are usually non-volatile, transistors, grid, electrons.

- **Features can include properties**: "no moving parts" and "non-volatile" score for solid-state; "has moving parts" for magnetic.

2. Give examples of a storage type, or name the type of a device (10 questions)

Pure recall, 1 mark each:

- **Magnetic**: HDD, magnetic tape.
- **Optical**: CD, DVD, Blu-ray.
- **Solid-state**: SSD, SD card, USB flash drive.

Variations you will meet:

- **"Circle three optical (or secondary) storage devices"** from a list. The traps are ROM, RAM, CPU and registers (primary or not storage at all), and SSD, SD card or USB drive (solid-state, not optical).
- **"One example is an SSD; identify one other example of solid-state"**: not SSD again.
- **Name the type of a device** in a table: an external HDD is magnetic, a USB flash drive is solid-state, a DVD is optical. A USB flash drive is **solid-state**: "USB" is only the connection.
- **Storage built into a phone or tablet**: an SSD (solid-state).

3. Give an example of primary storage and what it stores (9 questions)

1. **Give the example**: RAM, ROM or cache (a register is also accepted). If the question already names RAM, give ROM or cache.
2. **Match what it stores to the example**:
   - RAM: data, programs or instructions **currently in use**;
   - ROM: the start-up instructions (bootstrap, BIOS), firmware;
   - cache: **frequently used** instructions and data.
3. If a purpose is asked for (2 marks), add the reason: RAM lets the CPU access data directly and quickly, and holds it temporarily (volatile); ROM keeps its instructions with the power off (non-volatile) and they shouldn't change.

Variations you will meet:

- **Multiple choice** "which is an example of primary storage?": RAM, not CD, HDD or SSD.
- **Multiple choice on cache**: it stores **frequently used** instructions (not "the next instruction", which is the program counter's job, and not "so they are not lost with the power off", which is ROM).
- **"Identify one other item of data stored in ROM"** when start-up instructions are given: BIOS, bootstrap, or firmware.

4. Explain what makes storage primary or secondary; the differences (9 questions)

The key idea, worth a mark nearly every time: **primary storage is directly accessed by the CPU; secondary storage is not.**

For **differences** (usually 4 marks for two), write each one as a **contrasting pair** in one sentence with "whereas":

- primary is directly accessed by the CPU, **whereas** secondary is not;
- RAM (and cache) is volatile, **whereas** secondary storage is non-volatile;
- primary stores data currently in use (and the start-up instructions), **whereas** secondary stores user files, the OS and applications permanently;
- primary usually has a small capacity, **whereas** secondary has a large capacity;
- primary is faster to access, **whereas** secondary is slower.

Variations you will meet:

- **"Explain why an HDD is secondary storage"** (2 marks): it is not directly accessed by the CPU; it stores data permanently (non-volatile) until the user deletes it.
- **"Explain why RAM is primary and not secondary"**: RAM is directly accessed by the CPU, whereas secondary is not; RAM is volatile, whereas all secondary storage is non-volatile.
- **"Is an internal SSD primary or secondary? Justify"**: secondary, because the CPU doesn't access it directly and it stores data permanently. Being **internal** doesn't make it primary. Justify the **type**, don't list the SSD's advantages.
- **"State the characteristic of ROM that makes it primary storage"**: it is directly accessible by the CPU. "Non-volatile" is wrong here, since secondary storage is non-volatile too.

5. Match statements to magnetic, optical or solid-state (7 questions)

One mark per row. Look for the **key word** in each statement:

Key word in the statement	Type
platter, tracks and sectors, electromagnet, read/write head, magnetised	Magnetic
pits and lands, laser (red or blue), reflect, burn	Optical
NAND or NOR, control gate, floating gate, transistor, flow of electrons, no moving parts	Solid-state

Variations you will meet:

- **"Each type may be used more than once"**: expect two or three rows of the same type.
- **Tick tables with several columns** where one row can have more than one tick: "non-volatile" applies to all three, and "can store data permanently" too.
- **RAM, an internal SSD and a USB drive compared**: only RAM is primary and volatile; only RAM is directly accessed by the CPU; none of the three has moving parts. An SSD and a USB flash drive work in exactly the same way.
- **Sneaky wording**: "a read/write arm that moves a laser" is still **optical** (the laser decides it); "it uses control gates and flow gates" is still **solid-state**.

6. Explain why a computer needs RAM or ROM; describe RAM (6 questions)

- **Why RAM** (usually 3 marks): to store the data, instructions and software **currently in use**; so the CPU can access them **directly and faster** than from secondary storage; as **temporary (volatile)** storage for data that changes all the time.
- **Why ROM** (usually 2 marks): to store the **start-up instructions** / bootstrap / BIOS / firmware; because it is **non-volatile**, they are there every time the device is switched on, and they can't be changed by mistake.
- **"Why is data only stored temporarily in RAM?"**: RAM is volatile, so it is lost when the power is off; and the data in use changes constantly, so it is always being replaced.
- **"Describe RAM"**: volatile; directly accessed by the CPU; stores the data and instructions currently running.

In a device question (a smartwatch, a TV), tie the point to the device: "ROM stores the start-up instructions **so the watch can boot when it is switched on**".

7. State the purpose of secondary storage (6 questions)

1. **The core answer**: to store data, files and software **permanently** (non-volatile).
2. **Add the consequence** when 2 marks are available: otherwise the software and files would have to be downloaded or installed again every time the computer was turned on.
3. **Other accepted points**: it lets software be installed on the computer; it stores the user's files; it is used to create virtual memory.

Variations you will meet:

- **"Why won't the computer work without secondary storage?"**: the operating system and application software are stored there, so there is nothing to load into RAM.
- **"Give two examples of software stored on the SSD"**: the operating system and an application (say its kind: a word processor, a web browser). Never a brand name.
- Examiners warn: answer **why** it is needed, not a list of things kept on it.

8. Choose or compare storage for a situation and justify (6 questions)

1. **Name the type** (usually 1 mark). For anything portable (phone, tablet, handheld scanner, drone) the answer is **solid-state**.
2. **Give reasons, each tied to the situation** with "so ...":
   - small and thin, **so** it fits inside the device;
   - light, **so** the device is easy to carry;
   - no moving parts, **so** it is robust and the data survives if the device is dropped;
   - fast read/write speeds, **so** apps and files open quickly;
   - low power, **so** the battery lasts longer;
   - runs cool and silent, **so** it doesn't heat up the device or disturb the user.

Variations you will meet:

- **"Describe three differences between solid-state and optical"** (6 marks): pairs, one mark per half, but **at most 3 marks from one side only**, so write both sides every time: "solid-state has no moving parts, **whereas** optical has moving parts (the spinning disc)". Other pairs: faster vs slower access; more robust vs scratches easily; larger vs smaller capacity; more expensive vs cheaper per GB; less vs more power; silent vs noisier; charge on floating gates vs pits and lands burnt by a laser.
- **A fixed computer** (a web server, a supermarket's stock system) is not moved around, so "portable" and "light" earn nothing. Use capacity, speed and reliability instead: an HDD for a very large capacity at low cost, or an SSD for fast access.
- **Backing up large files such as films** to hand to someone: an external HDD or SSD (large capacity) beats optical.
- **Optical is rarely the right choice**: the capacity is small and access is slow.

9. Virtual memory (5 questions)

1. **Name it**: "a partitioned section of secondary storage used when RAM is full" = **virtual memory**.
2. **State its purpose**: to let programs run when there isn't enough RAM, and stop the computer crashing when RAM is full.
3. **Describe how it works** (3–4 marks), in order:
    - part of the secondary storage (HDD or SSD) is **partitioned** to create virtual memory, which acts as an **extension of RAM**;
    - a **page** that is **not needed immediately** is moved from RAM to virtual memory;
    - this **makes space** in RAM for the page that is needed;
    - when the moved page is needed again, it is **moved back** into RAM.

Variations you will meet:

- **A scenario with named pages** ("pages A, B and C are in RAM; page D is needed; page B is not needed immediately"): use the question's letters in every step. Say which page goes out, which comes in, and when the first one comes back.
- **A word-bank gap-fill**: the RAM is full → the HDD is partitioned → data is divided into **pages** → pages move between RAM and virtual memory.

10. Cloud storage (3 questions)

1. **Describe it** (2 marks): data stored **remotely** on (a collection of) **servers**; accessed using the **internet**; the hardware is **owned and managed by a third party**.
2. **Advantages** (usually 2 marks each: point, then consequence for the people in the question):
    - access from any location or device, **so** employees can work from anywhere;
    - the third party maintains the hardware and its security, **so** the company doesn't have to;
    - storage can be increased easily, **so** no new hardware has to be bought;

- less storage needed on the device, **so** it can stay small and cheap; if the device is lost, the data is still available;
- the provider backs up the data, **so** the company doesn't need to.

3. **Disadvantages**: an internet connection is needed, **so** with no (or an unstable) connection the data can't be accessed; the data's security depends on a third party; for employees, being able to reach work data anywhere can mean pressure to work outside working hours.

Variations you will meet:

- **Multiple choice "which is not a characteristic of cloud storage?"**: "data is stored **locally**".
- **"Hacking" on its own is not accepted** as a disadvantage: local data can be hacked too.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **B1** mark for a correct result on its own, with no method needed.

Example 1

A smart TV has random access memory (RAM) and read only memory (ROM).

(a) State the characteristic of RAM and ROM that makes them primary storage. **[1]**

(b) Explain why the smart TV needs ROM. **[2]**

(c) Explain why the smart TV needs RAM. **[3]**

(d) Give **two** differences between RAM and ROM. **[2]**

(a) They are directly accessed by the CPU. **B1**

(b) ROM stores the start-up instructions (the bootstrap / firmware) that the TV needs every time it is switched on **B1**. ROM is non-volatile, so these instructions are not lost when the TV is switched off, and they can't be changed **B1**.

(c) Any three: RAM stores the apps and data **currently in use**, such as the streaming app and the part of the film being played **B1**; the CPU can access it directly, and faster than secondary storage **B1**; it gives temporary (volatile) storage for data that changes all the time **B1**.

(d) RAM is volatile, whereas ROM is non-volatile **B1**. The contents of RAM can be changed, whereas the contents of ROM are read only **B1**. (RAM has a larger capacity than ROM would also score.)

Example 2

(a) Complete the table by writing the type of secondary storage (magnetic, optical or solid-state) for each statement. Each type may be used more than once. **[5]**

Type of storage	Statement
	A read/write head moves across a spinning platter.
	Electrons are trapped on a floating gate.
	A laser is reflected off the surface.
	It has no moving parts.
	Data is stored as tiny magnetised areas.

(b) A school backs up its student records every night onto an external hard disk drive (HDD). Describe how the data is written to the HDD. **[4]**

(a) Magnetic **B1**; solid-state **B1**; optical **B1**; solid-state **B1**; magnetic **B1**.

(b) Any four, in order:

- the platters are spun by a motor **B1**;
- the read/write head on the actuator arm moves to the correct track and sector **B1**;
- an electromagnet in the head magnetises tiny areas of the platter's surface **B1**;
- each area is magnetised in one of two directions to represent a 1 or a 0 **B1**;
- the data stays magnetised with no power (non-volatile).

Example 3

A computer has pages P, Q and R stored in RAM, and the RAM is full. The user opens another program, and page S needs to be loaded into RAM. Page Q is not needed immediately.

(a) Identify the part of secondary storage that is used to hold pages when the RAM is full. **[1]**

(b) Explain how this part of secondary storage is used in this scenario. **[4]**

(a) Virtual memory. **B1**

(b)

- Part of the secondary storage (the HDD or SSD) is partitioned to create the virtual memory **B1**.
- Page Q is moved from RAM to the virtual memory **B1**,
- ... which makes space in RAM, so page S is loaded into RAM **B1**.
- When page Q is needed again, it is moved back from virtual memory into RAM, and a page that is no longer needed (such as P) is moved out **B1**.

The fifth diagram in "Understand it" shows these steps.

Example 4

A delivery driver uses a handheld device to scan parcels and record customers' signatures. At the end of each delivery, the records are uploaded to the company's cloud storage.

(a) Identify the most suitable type of secondary storage for the handheld device. Justify your choice. **[4]**

(b) Describe what is meant by cloud storage. **[2]**

(c) Explain **one** advantage and **one** disadvantage to the company of storing the records in cloud storage rather than locally. **[4]**

(a) Solid-state **B1**. Any three reasons in context:

- it has no moving parts, so it is robust and the records are unlikely to be lost if the driver drops the device **B1**;
- it is small and light, so it fits in a device that is carried all day **B1**;
- it uses little power, so the battery lasts a whole shift **B1**;
- it has fast read/write speeds, so each scan is saved quickly.

(b) Data is stored remotely on physical servers that are owned and managed by a third party **B1**, and it is accessed over the internet **B1**.

(c) Advantage: staff can access the records from any location or device **B1**, so the office can see each delivery as soon as it is uploaded, wherever the driver is **B1**. (Or: the third party maintains and backs up the hardware, so the company doesn't have to.)

Disadvantage: an internet connection is needed **B1**, so if the driver has no signal, the records can't be uploaded and the office can't see them **B1**.

Common mistakes

- **Saying primary storage is "the main storage" or "the most important".** The defining point is that the CPU accesses it **directly**; learn that sentence.
- **Calling an internal SSD or HDD primary storage** because it is inside the computer. Internal or external doesn't matter: the CPU doesn't access it directly, so it is secondary.
- **Giving RAM when the question already names RAM** ("one **other** example of primary storage"). Give ROM or cache.
- **Saying RAM stores "software" or "programs"** with no more detail. Software is stored in secondary storage; RAM holds the software **currently running**.
- **Answering "volatile" when asked what makes ROM primary**. ROM is non-volatile, and so is secondary storage; the answer is "directly accessed by the CPU".

- **Mixing up the technologies**: putting pits and lands on a magnetic disk, or electromagnets on an optical disc. Examiners see this often: tie each word to one type (see the key-word table).
- **Thinking a USB flash drive is its own kind of storage.** It works in exactly the same way as an SSD: solid-state, NAND, non-volatile.
- **Describing flash memory too vaguely.** "It uses transistors" earns a mark; explaining that the control gate traps electrons on the floating gate, and the charge stays with the power off, earns more.
- **Optical descriptions that stop at "a laser reads it".** Say the disc spins, the laser burns pits into a spiral track, and pits and lands represent the binary.
- **Giving generic advantages that don't fit the situation.** A supermarket's SSD is never moved, so "portable" and "light" earn nothing; a phone's is, so "robust if dropped" does.
- **Listing what is stored on secondary storage** when asked **why a computer needs it**. The answer is permanent (non-volatile) storage, so software doesn't have to be reinstalled every time.
- **Virtual memory answers that miss the "how"**. Examiners found this very hard in 2025: most only said secondary storage is partitioned. Also say which page moves out, that it frees space for the new page, and that the page comes back when needed.
- **"The cloud can be hacked"** as a disadvantage. Local storage can be hacked too, so it doesn't compare the two. Use the internet connection instead.

How to get the marks

- **"Identify", "give", "state"** (1 mark each): a short, exact answer: "ROM", "solid-state", "directly accessed by the CPU". Brand names (a product or company name) never score.
- **"Describe"** (how something works): one step per mark, in order, using the syllabus words: platters, tracks, sectors, electromagnets; laser, pits, lands; control gate, floating gate, electrons, NAND/NOR.
- **"Explain"**: each point needs a reason ("RAM is volatile, **so** the data is lost when the power is off").
- **"Difference" and "compare"**: write both sides in one sentence with **"whereas"**. A point about one side only often earns nothing, and some mark schemes cap one-sided answers.
- **Scenarios** (a smartwatch, a video editor, a delivery driver): use them. Name the device and the people in each reason, and use the question's own page letters for virtual memory.
- **Don't repeat what the question gives you**: if it says "one feature is that it uses platters", your features must be different.
- **Tick or circle exactly the number asked for**; extra ticks or circles lose marks.
- **Tables**: one mark per row, and a type can appear more than once.

Quick check

1. Circle the **three** solid-state storage devices: SD card, Blu-ray disc, USB flash drive, magnetic tape, SSD, DVD.
2. Give **two** reasons why a computer needs secondary storage.

3. State the type of secondary storage that uses: (a) tracks and sectors; (b) NAND technology; (c) pits and lands.
4. A computer's RAM holds pages 1, 2, 3 and 4 and is full. Page 5 now needs to be loaded, and page 2 won't be needed for a while. Describe how virtual memory is used.
5. A student writes: "A disadvantage of storing my homework in the cloud is that it could be hacked." Explain why this would not earn the mark, and give a disadvantage that would.

Answers

1. SD card, USB flash drive, SSD. (Blu-ray and DVD are optical; magnetic tape is magnetic.)
2. Any two: to store data, files and software permanently, because it is non-volatile; otherwise software would have to be reinstalled or downloaded every time the computer was switched on; to store the operating system and applications so they can be loaded into RAM; to store the user's files; to create virtual memory.
3. (a) Magnetic. (b) Solid-state. (c) Optical.
4. Part of the secondary storage is partitioned to create virtual memory. Page 2 is moved from RAM into virtual memory, which frees space in RAM, so page 5 is loaded into RAM. When page 2 is needed again, it is moved back into RAM (and a page that isn't needed is moved out).
5. Data stored locally, on the student's own laptop, could be hacked too, so it isn't a disadvantage of the cloud compared with local storage. A disadvantage that scores: an internet connection is needed, so the homework can't be reached without one; or the security of the homework depends on the third party that runs the servers.

Past questions to try

- **0478/13/M/J/23 Q10**: virtual memory with named pages A to D.
- **0478/13/O/N/23 Q6**: cloud storage, with an advantage and a disadvantage for a company.
- **0478/13/M/J/24 Q4**: matching six statements to magnetic, optical or solid-state.
- **0478/11/O/N/23 Q8**: features of magnetic and solid-state storage, and an example of each type.