

Exercise walk-through

3.1.2

Secondary storage: magnetic, solid state and optical

A-Level Computer Science

You must be able to

- explain the need for secondary storage, including **removable** 可移动 storage
- describe the principal operation of a magnetic hard disk
- describe the principal operation of solid state (flash) memory
- describe the principal operation of an optical disc reader and writer
- choose a storage device for a given use, and justify the choice

1

The method

Method — Why secondary storage?

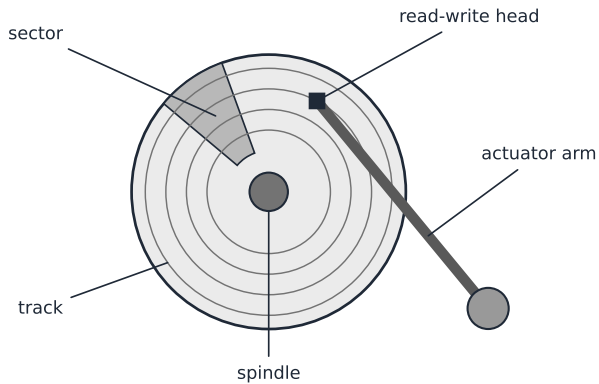
- RAM is **volatile** and small. **Secondary storage** is **non-volatile** and **large**: it keeps the operating system, programs and files when the power is off.
- The processor cannot read it directly: data is copied into RAM first.
- **Removable** storage (USB drive, memory card, optical disc) **moves files** between computers and keeps a **backup** in another place.

“**Describe the principal operation**” = one mark for each point: name the **parts**, say **what happens**, finish with **how a bit is stored or read**.

Method — Magnetic hard disk

- 1 One or more **platters** 盘片 with a surface that can be **magnetised** 磁化.
- 2 A **spindle** 主轴 spins the platters at high speed.
- 3 Each surface has circular **tracks** 磁道, divided into **sectors** 扇区.
- 4 A **read/write head** 读写头 on an **actuator arm** 磁头臂 moves to the correct track.
- 5 **Write:** a current in the head magnetises a tiny area in one of two directions: 1 or 0.
- 6 **Read:** the magnetised areas pass under the head and produce a changing current in it.

Method — Magnetic hard disk



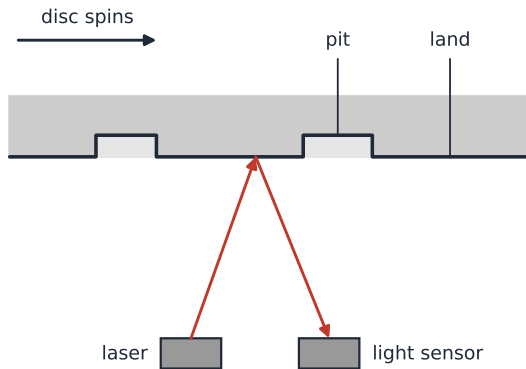
Method — Solid state (flash) memory

- 1 A grid of **transistors** 晶体管 (**NAND** or NOR flash). **No moving parts.**
- 2 Each cell has a **control gate** 控制栅 and a **floating gate** 浮栅.
- 3 A voltage pushes **electrons** 电子 onto the floating gate, where they are **trapped**, even without power.
- 4 Trapped electrons read as 0; no trapped electrons read as 1.
- 5 Data is erased and rewritten in **blocks**.

Method — Optical disc reader and writer

- 1 A motor **spins** the disc, which has **one spiral track**.
- 2 A **laser 激光** beam is focused on the track.
- 3 The track is made of **pits 凹坑** and **lands 平台**, which reflect the light differently.
- 4 A **light sensor** detects the reflection: a change (pit to land, or land to pit) is a 1, no change is a 0.
- 5 **Write:** a stronger laser heats spots in a dye layer, which changes how they reflect.

Method — Optical disc reader and writer



Method — Choosing a storage device

Fast storage is small and expensive; large storage is slow and cheap. No device is best at everything, so the **use** decides.

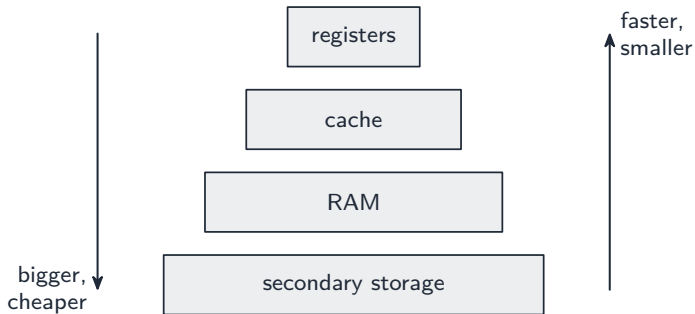
	magnetic hard disk	solid state drive	optical disc
access speed	slow (moving parts)	fast	slowest
capacity	very large	large	small
cost per GB	low	higher	low per disc
robustness	damaged by a knock	robust	scratches
power, noise, heat	more	less	more

Method — Choosing a storage device

Name the point **and** say why it matters. *Ten years of CCTV video on a server*: huge files, never moved, speed not important, so **magnetic hard disks** (lowest cost per GB, very large capacity).

Method — Choosing a storage device

Fast storage is small and expensive; large storage is slow and cheap.



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Practice

Practice 2.1 ■ 5 marks

Complete the description of a magnetic hard disk. Use words from the list. Each word is used once.

A magnetic hard disk has one or more that spin at high speed. Each surface is divided into circular , and each of these is divided into The read/write head is on an that moves across the surface. To store a bit, a tiny area of the surface is in one of two directions.

Solution 2.1

Method: Magnetic hard disk — p.5

Worked steps

- the parts, from the outside in: **platters** spin; a surface has **tracks**; a track has **sectors** **B1** **B1** **B1**
- the head is on an **arm** **B1**
- a bit is an area **magnetised** in one of two directions **B1**

Practice 2.2 ■ 5 marks

Tick (✓) **one** box in each row to show which storage device the statement describes.

Statement	magnetic hard disk	solid state	optical disc
A laser reads pits and lands.			
Electrons are trapped on a floating gate.			
A read/write head moves on an arm.			
It has one spiral track.			
It has no moving parts.			

Solution 2.2

Method: Choosing a storage device — p.10

Worked steps

- laser, pits and lands → **optical disc** (B1)
- trapped electrons on a floating gate → **solid state** (B1)
- a head on an arm → **magnetic hard disk** (B1)
- one spiral track → **optical disc** (a hard disk has many circular tracks) (B1)
- no moving parts → **solid state** (B1)

Practice 2.3 ■ 2 marks

State **two** reasons why a computer needs secondary storage.

Solution 2.3

Method: Choosing a storage device — p.10

Worked steps

any **two** of:

- RAM is volatile, so programs and files must be kept somewhere when the power is off **B1**
- secondary storage has a much larger capacity than primary memory **B1**
- it costs much less per GB than RAM **B1**

Practice 2.4 ■ 2 marks

Give **two** uses of **removable** storage.

Solution 2.4

Method: Why secondary storage? — p.4

Worked steps

any **two** of:

- to move files from one computer to another (B1)
- to keep a backup copy in a different place (B1)
- to give software or films to other people (B1)

Practice 2.5 ■ 2 marks

The steps below describe how data is read from an optical disc. They are in the wrong order.

Write the letters in the correct order.

- A** A light sensor detects the reflected light.
- B** The changes in the reflected light are read as 1s and 0s.
- C** A motor spins the disc.
- D** The laser beam is focused on the spiral track of pits and lands.

Solution 2.5

Method: Why secondary storage? — p.4

- A A light sensor detects the reflected light.
- B The changes in the reflected light are read as 1s and 0s.
- C A motor spins the disc.
- D The laser beam is focused on the spiral track of pits and lands.

Worked steps

- the disc must spin and the laser must shine on the track before anything can be detected, so C then D come first **B1**
- then the sensor detects the reflection, and the changes are read as bits: C, D, A, B **B1**

Practice 2.6 ■ 2 marks

Explain why a solid state drive has a faster access speed than a magnetic hard disk.

Solution 2.6

Method: Choosing a storage device — p.10

Worked steps

- a hard disk must wait while the arm moves to the track and the platter turns to the sector **B1**
- a solid state drive has **no moving parts**: any cell is reached electronically, with almost no delay **B1**

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Exam-style

Exam-style 3.1 ■ 7 marks

A photographer stores photographs on a magnetic hard disk.

Exam-style 3.1 (a) ■ 5 marks

Describe the principal operation of a magnetic hard disk.

Solution 3.1 (a)

Method: Choosing a storage device — p.10

Worked steps

any **five** of:

- it has one or more platters with a surface that can be magnetised **B1**
- the platters are on a spindle and spin at high speed **B1**
- each surface is divided into tracks and sectors **B1**
- a read/write head on an actuator arm moves across the surface to the correct track **B1**
- to write, a current in the head creates a magnetic field that magnetises an area in one of two directions, for 1 and 0 **B1**

Solution 3.1 (a)

- to read, the magnetised areas passing under the head produce a changing current in it **B1**

Exam-style 3.1 (b) ■ 2 marks

The photographer drops the disk while it is running, and it stops working. **Explain** why a magnetic hard disk is damaged easily in this way.

Solution 3.1 (b)

Worked steps

the head moves very close to the surface of a platter that is spinning at high speed

B1

- a knock can make the head touch the surface and scratch it, or damage the moving parts, so the data can no longer be read B1

Exam-style 3.2 ■ 7 marks

A smartphone stores its apps and photos in solid state (flash) memory.

Exam-style 3.2 (a) ■ 4 marks

Describe how solid state (flash) memory stores data.

Solution 3.2 (a)

Method: Choosing a storage device — p.10

Worked steps

any **four** of:

- it is made of transistors arranged in a grid, using NAND (or NOR) flash technology (B1)
- each cell has a control gate and a floating gate (B1)
- a voltage moves electrons onto the floating gate, where they are trapped by an insulating layer (B1)
- trapped electrons represent 0, and no trapped electrons represent 1 (B1)
- the electrons stay without power, so the data is kept (B1)
- data is erased and rewritten in blocks (B1)

Exam-style 3.2 (b) ■ 3 marks

Give **three** reasons why solid state memory, not a magnetic hard disk, is used in a smartphone.

Solution 3.2 (b)

Worked steps

any **three** of:

- no moving parts, so it is not damaged when the phone is dropped or shaken **B1**
- it uses less power, so the battery lasts longer **B1**
- it is smaller and lighter **B1**
- faster access, so apps open quickly **B1**
- it produces less heat and no noise **B1**

Exam-style 3.3 ■ 6 marks

A film company sends a finished film to cinemas on a Blu-ray disc.

Exam-style 3.3 (a) ■ 4 marks

Describe how the data is read from the disc.

Solution 3.3 (a)

Method: Why secondary storage? — p.4

Worked steps

any **four** of:

- a motor spins the disc (B1)
- a laser beam is focused on the disc's single spiral track (B1)
- the track is made of pits and lands, which reflect the light differently (B1)
- a light sensor detects the reflected light (B1)
- a change between a pit and a land is read as 1, and no change as 0 (B1)

Exam-style 3.3 (b) ■ 2 marks

Describe how an optical disc **writer** stores data on a recordable disc.

Solution 3.3 (b)

Worked steps

- a **higher-powered** laser heats spots on the dye (recording) layer **B1**
- the heated spots reflect light differently from the rest, so they are read like pits and lands **B1**

Exam-style 3.4 ■ 10 marks

A hospital must keep every patient's X-ray images for 30 years. The images take up 900 TB. They are looked at only occasionally, and they are kept on servers in a locked room.

Exam-style 3.4 (a) ■ 3 marks

State the most suitable type of secondary storage for the servers.
Justify your choice.

Solution 3.4 (a)

Worked steps

magnetic hard disk **B1**

- 900 TB is a very large amount of data, and magnetic storage has the lowest cost per GB and very large capacities **B1**
- the images are opened only occasionally and the servers never move, so its slower access and lower robustness do not matter **B1**

Exam-style 3.4 (b) ■ 3 marks

A doctor carries a laptop between several hospitals and opens large image files on it all day. **State** the most suitable type of secondary storage for the laptop. **Justify** your choice.

Solution 3.4 (b)

Worked steps

solid state drive B1

- the laptop is carried around, and a solid state drive has no moving parts, so it is not damaged by knocks B1
- it gives fast access to large files, and it uses less power, so the battery lasts longer B1

Exam-style 3.4 (c) ■ 2 marks

The hospital also copies the images onto removable storage every week. **Explain** why.

Solution 3.4 (c)

Worked steps

it is a **backup**: if the servers fail, or are damaged by fire or stolen, the images are not lost **B1**

- removable storage can be kept in a **different place** from the servers **B1**

Exam-style 3.4 (d) ■ 2 marks

A manager suggests keeping all the images in RAM, “because RAM is faster”. Give **two** reasons why this is not suitable.

Solution 3.4 (d)

Worked steps

any **two** of:

- RAM is volatile, so every image would be lost when the power went off **B1**
- 900 TB of RAM would cost far too much **B1**
- a computer cannot hold that much RAM **B1**