A-LEVEL COMPUTER SCIENCE • EXERCISE SHEET

# 3.1.2 Secondary storage: magnetic, solid state and optical

Name: _____ Class: _____ Date: _____ **Total: 48 marks**

**KEY WORDS** secondary storage 辅助存储器 • tracks 磁道 • sectors 扇区 • transistors 晶体管 • pits 凹坑

## Objective

Learn to answer exam questions on **secondary storage** 辅助存储器: why a computer needs it, how a **magnetic hard disk** 磁性硬盘, **solid state (flash) memory** 固态存储器 and an **optical disc** 光盘 drive work, and which one suits a given job. Primary memory was on sheet 3.1.1; input and output devices come on sheet 3.1.3.

**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 Worked examples

Study these first. Each one shows a **method** that a question later on this sheet needs.

### 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.

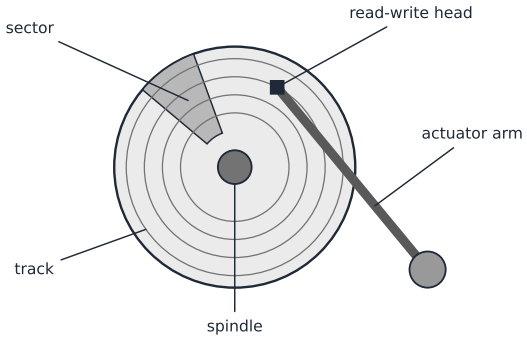
**"Describe the principal operation"** = one mark for each point: name the **parts**, say **what happens**, finish with **how a bit is stored or read**.

### 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.

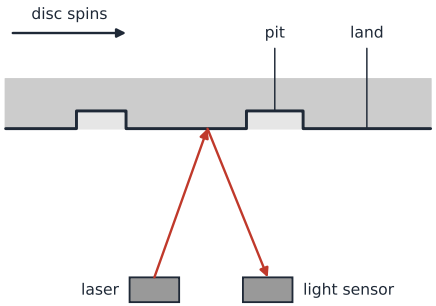



### Solid state (flash) memory

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**.

### 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.

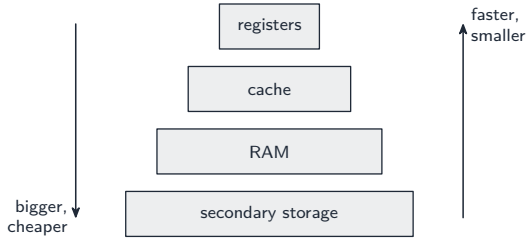



### Choosing a storage device

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 |

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).






## 2 Practice

Now use the methods above. The first questions need one idea each.

**2.1** Complete the description of a magnetic hard disk. Use words from the list. Each word is used once. [5]

*arm* · *magnetised* · *platters* · *sectors* · *tracks*

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.

**2.2** Tick (✓) **one** box in each row to show which storage device the statement describes. [5]

| 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. | | | |

**2.3** State **two** reasons why a computer needs secondary storage. [2]

**2.4** Give **two** uses of **removable** storage. [2]

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

Write the letters in the correct order. [2]

**2.6** Explain why a solid state drive has a faster access speed than a magnetic hard disk.[2]

## 3 Exam-style questions

**3.1** A photographer stores photographs on a magnetic hard disk.

(a) **Describe** the principal operation of a magnetic hard disk. [5]

(b) 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. [2]



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

(a) **Describe** how solid state (flash) memory stores data. [4]

(b) Give **three** reasons why solid state memory, not a magnetic hard disk, is used in a smartphone. [3]

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

(a) **Describe** how the data is read from the disc. [4]

(b) **Describe** how an optical disc **writer** stores data on a recordable disc. [2]

**3.4** 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.

(a) **State** the most suitable type of secondary storage for the servers. **Justify** your choice. [3]

(b) 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. [3]

(c) The hospital also copies the images onto removable storage every week. **Explain** why. [2]

(d) A manager suggests keeping all the images in RAM, "because RAM is faster". Give **two** reasons why this is not suitable. [2]

## Solutions

Each answer shows the steps, then the **result**.

**2.1**

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

**2.2**

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

**2.3** any **two** of:

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

**2.4** any **two** of:

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

**2.5**

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

**2.6**

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

**3.1**

(a) any **five** of:

- it has one or more platters with a surface that can be magnetised
- the platters are on a spindle and spin at high speed
- each surface is divided into tracks and sectors
- a read/write head on an actuator arm moves across the surface to the correct track



- to write, a current in the head creates a magnetic field that magnetises an area in one of two directions, for 1 and 0
- to read, the magnetised areas passing under the head produce a changing current in it

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

- 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

**3.2**

(a) any **four** of:

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

(b) any **three** of:

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

**3.3**

(a) any **four** of:

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

(b) a **higher-powered** laser heats spots on the dye (recording) layer

- the heated spots reflect light differently from the rest, so they are read like pits and lands

**3.4**

(a) **magnetic hard disk**

- 900 TB is a very large amount of data, and magnetic storage has the lowest cost per GB and very large capacities

- the images are opened only occasionally and the servers never move, so its slower access and lower robustness do not matter

(b) **solid state drive**

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

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

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

(d) any **two** of:

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