

**AQA Computer Science A-Level**  
**4.7.4 External hardware devices**  
Intermediate Notes



## **Specification:**

### **4.7.4.1 Input and output devices:**

Know the main characteristics, purposes and suitability of the devices and understand their principles of operation.

Devices that need to be considered are:

- barcode reader
- digital camera
- laser printer
- RFID

### **4.7.4.2 Secondary storage devices:**

Explain the need for secondary storage within a computer system.

Know the main characteristics, purposes, suitability and understand the principles of operation of the following devices:

- hard disk
- optical disk
- solid-state drive (SSD)

Compare the capacity and speed of access of various media and make a judgement about their suitability for different applications.



## Input and output devices

In order to make use of data, computers must be able to use various devices which allow the computer to have data **input** and **output**.

### Barcodes and barcode readers

When you buy something in a supermarket, the chances are that a **barcode reader** is used by the computer to identify what it is you're buying.

Barcodes are **printed diagrams** that consist of **light and dark portions**. They **contain information** which can be read by a computer using a barcode reader.



Barcode readers consist of a **laser light source**, a **lens**, **photodiodes** and a **mirror**. The mirror directs light from the laser onto a printed barcode. The light reflected by the barcode passes through the lens and is incident on the photodiode which **turns light into electrical charge**. This electrical charge can be **measured** and processed to form a **digital signal** representing the content of a barcode.

Light portions of a barcode **reflect the most light** while dark sections absorb incident light. The pattern of light and dark stripes in a barcode corresponds to binary 1s and 0s.

Barcodes can have **error detection** and prevention methods such as **parity bits** and **check digits** built in, allowing computers to tell whether a barcode has been read correctly. If a barcode **fails to scan** correctly, perhaps because the barcode is dirty, the reader will **continue to scan** until the barcode is read successfully. Barcode readers can scan barcodes **1000s of times a second**, so the time delay caused by rescanning is **hardly perceptible** to humans.

### Synoptic Link

**Parity bits and check digits** are ways to check for errors in data transmission.

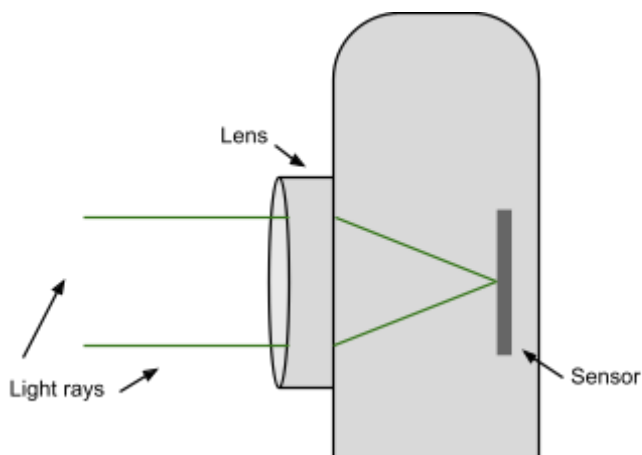
These are covered in **information coding systems** under **fundamentals of data representation**.



## Digital cameras

Digital cameras consist of a **lens** that focuses light onto a **sensor**. The path of light between the lens and the sensor is controlled by a **shutter**.

Sensors used in digital cameras convert incident light into electrical charge. Charge builds up in cells, each of which **represents a pixel** in the image. Once the photograph has been taken, the charge in each of the cells is **measured** and converted to a digital value which is then processed by the camera and stored as a digital image.



In colour cameras, there are **multiple cells for each pixel**, each of which has a **filter** that only allows in **certain colours** of light. This lets the camera build up a **separate image** for the intensity of **each colour** which can then be **combined** to form a full colour photograph.



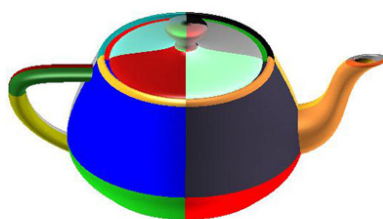
Red light intensity



Green light intensity



Blue light intensity

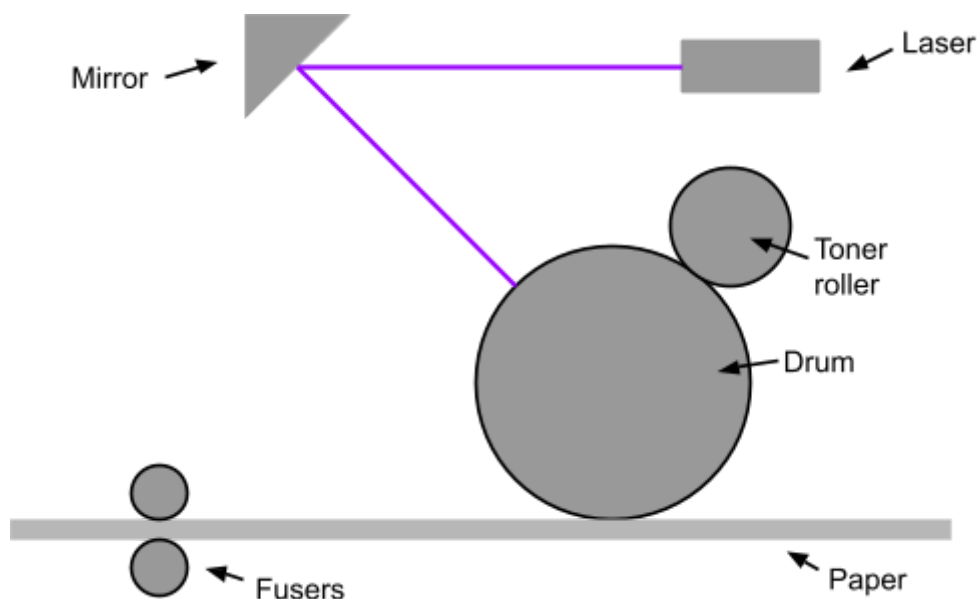


Red, green and blue combined



## Laser printer

A laser printer produces images on paper from digital signals. They consist of a [laser light source](#), a [mirror](#), a [drum](#), a [toner roller](#) and [fusers](#).



When a document is printed, the drum is [electrically charged](#) all over before the laser is directed at its surface by the mirror. Areas on which the laser is incident are [discharged](#), leaving behind an [impression of the page](#) in electrical charge on the drum.

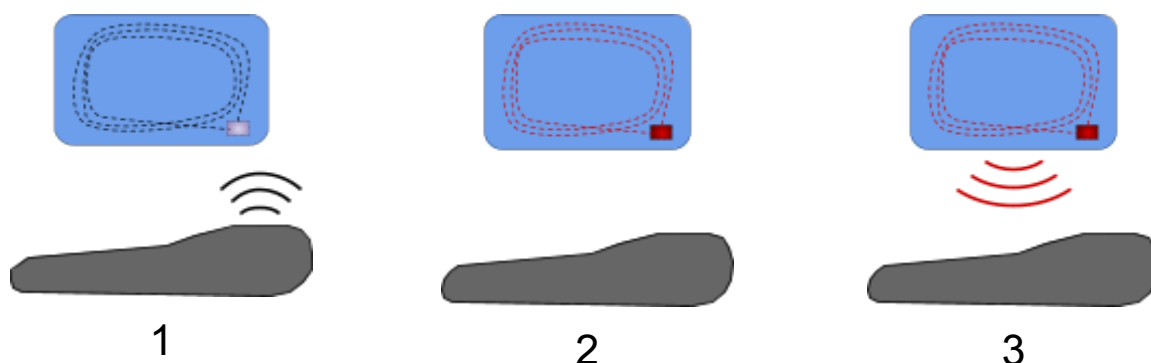
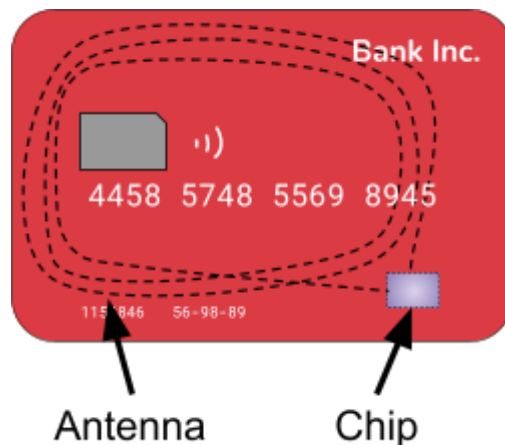
The toner roller dispenses [charged toner](#) (a type of plastic powder) onto the drum. The charged toner is attracted to the charged portions of the drum. The toner is then applied to the paper by the drum before the paper is [heated](#) by fusers, fixing the toner to the paper.



## RFID

RFID, which stands for radio frequency identification, is a method of transferring information **wirelessly** between a **tag** and a **reader**. RFID is used in contactless credit and debit cards as well as in some hotel room cards.

Inside an RFID tag is a **chip** which contains a small amount of memory. The chip is attached to a coil of wire which acts as an **antenna**.



When an RFID tag is scanned, the reader emits **radio waves** which are picked up by the tag's antenna (stage 1). The power induced in the tag's antenna from these waves is enough to power the chip (stage 2) which then uses its antenna to emit its own radio wave (stage 3), which contains the information held on the chip. This wave is picked up by the reader which **decodes** the information and returns the information to a computer.

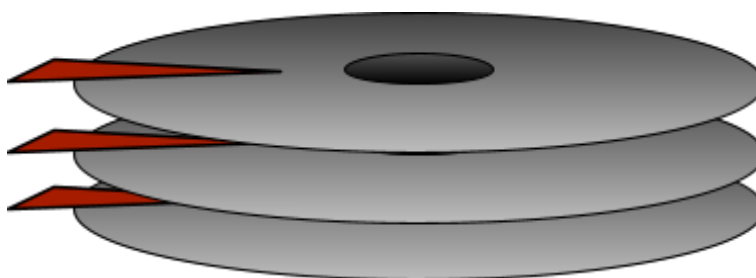


## Secondary storage devices

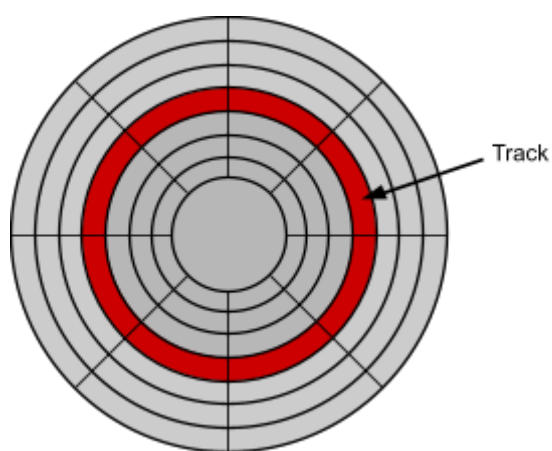
A computer's primary storage is memory such as RAM and ROM. Secondary storage, which is used to store files and applications, includes hard disk drives (HDDs), solid-state drives (SSDs) and optical disks.

### Hard disk drives

A hard disk drive consists of a number of circular **platters** which are made from a magnetic material. Above each platter hovers an **actuating arm** on which is a **read/write head**.



The actuating arm allows the read/write head, which changes the magnetic **polarity** of parts of the platter, to access **all portions** of each platter.



Data is written in **concentric tracks**, each of which is further divided into **sectors**. The platter rotates **thousands of times per minute**, allowing for good read and write speeds.

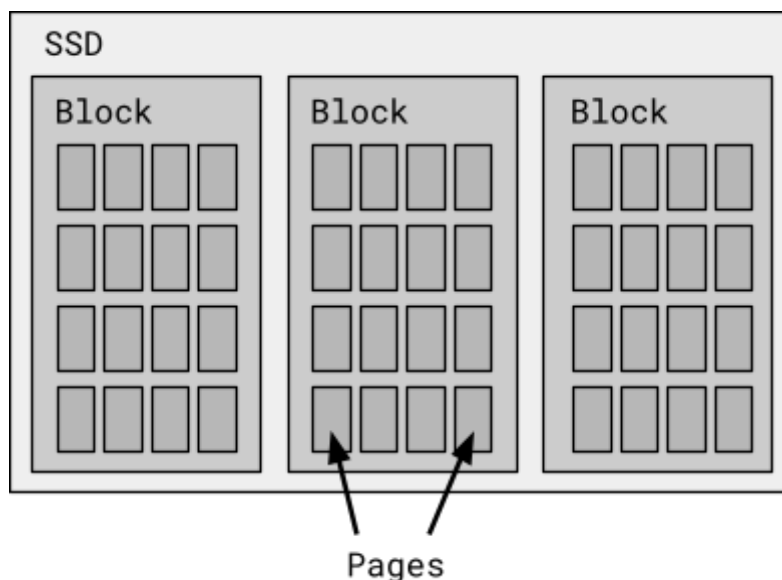
Because of the number of **moving parts** in hard disk drives, they are susceptible to **damage from movement**. This makes them unsuitable for use in portable devices like phones and tablets.



### Solid-state drives

Solid-state drives (SSDs) consist of **NAND flash memory cells** and a **controller** that manages the structure of data on the drive. The memory cells store information by **trapping electrical charge**.

Data is stored on SSDs in **pages**, which are combined to form **blocks**.



Unlike hard disk drives, SSDs are **not capable of overwriting** data. Instead, an SSD's controller must **completely erase** the entirety of a page before writing **new information** to it.

Because SSDs **don't have any moving parts**, they are capable of **far higher read and write speeds** than HDDs and are suitable for use in portable devices like phones and tablets.



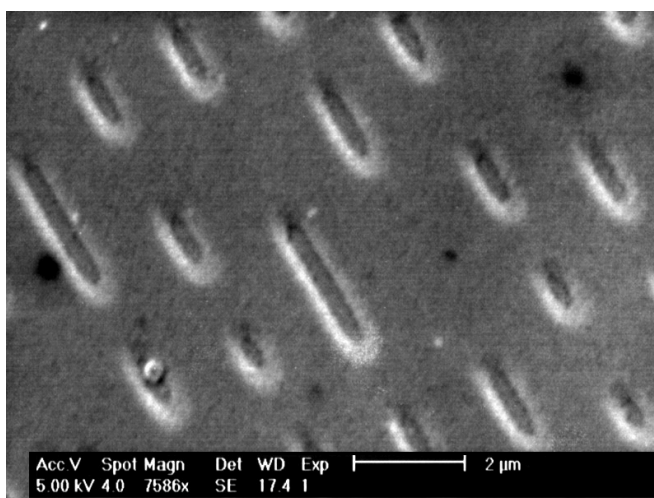


## Optical disks

Optical disks include CDs, DVDs and Blu-rays. They store information which can be read **optically** by a laser. Optical disks can be either read-only, recordable or rewritable depending on what they are to be used for.

Different types of optical disk vary slightly but all follow the same basic principles of operation.

The image below shows a microscope view of the surface of a read-only optical disk. The stripes in the image are called **pits**, and the areas surrounding them called **lands**. Pits are burnt into the disk by a **high-power laser** which **permanently deforms** the surface.



Unlike hard-disk drives which use tracks and sectors, optical disks have **just one continuous track** which **spirals** from the center of the disk to the outside edge.

When a **low-power** laser beam is passed over the flat surface of an optical disk, it **reflects back** onto a **photodiode**. However, when the laser is incident on a pit, the light from the beam is scattered in different directions rather than reflected back at the photodiode. The resulting pattern of reflections and scatters can be converted into a **digital signal** of binary 1s and 0s.

On recordable and rewritable optical disks, a pattern of reflections and scatters is created not by pits and lands but by a dye on the disk's surface. Where there is no dye, the disk reader's laser beam is reflected off the optical disk's surface. Where there is dye, the laser beam is absorbed by the dye and not reflected at all.

Recordable optical disks use a special photosensitive dye that changes from opaque to transparent under a high-power laser used to write information to the disk. This dye remains unaffected by the low-power laser used to read the disk.



Rewritable optical disks, on the other hand, use a phase-change dye that can be converted multiple times between transparent and opaque. This phase-change dye changes its state depending on the temperature it is heated to, allowing data to be erased and rewritten multiple times.

### Comparison of secondary storage devices

	Hard-disk drive	Solid-state drive	Optical disk
Typical capacity	High capacity. Typically between 500GB and 5TB.	Relatively low capacity. Typically under 1TB.	Very low capacity. Blu-rays have the highest capacity at 25GB.
Read / write speeds	Good speeds. $\approx 100\text{MB/s}$	Very high speeds. $\approx 500\text{MB/s}$	Relatively low speeds. $\approx 30\text{MB/s}$
Latency	High	Very low	High
Portability	Bulky, heavy and easily damaged by movement.	Lightweight and rarely damaged by movement.	Very small and lightweight, can be damaged by scratches and dirt.
Power consumption	High	Low	High
Suitability	Good for desktop PCs and servers.	Good for laptops, phones and tablets.	Good for sharing and distributing small volumes of data.

