Chapter 3 Hardware

3.1 Computers and their components

3	Hardware
3.1	**Computers and their components**

Candidates should be able to:	Notes and guidance
Show understanding of the need for input, output, primary memory and secondary (including removable) storage	
Show understanding of embedded systems	Including: benefits and drawbacks of embedded systems
Describe the principal operations of hardware devices	Including: Laser printer, 3D printer, microphone, speakers, magnetic hard disk, solid state (flash) memory, optical disc reader/writer, touchscreen, virtual reality headset
Show understanding of the use of buffers	
Explain the differences between Random Access Memory (RAM) and Read Only Memory (ROM)	Including their use in a range of devices and systems
Explain the differences between Static RAM (SRAM) and Dynamic RAM (DRAM)	Include their use in a range of devices and systems and the reasons for using one instead of the other depending on the device and its use
Explain the difference between Programmable ROM (PROM), Erasable Programmable ROM (EPROM) and Electrically Erasable Programmable ROM (EEPROM)	
Show an understanding of monitoring and control systems	Including: • difference between monitoring and control • use of sensors (including temperature, pressure, infra-red, sound) and actuators • importance of feedback

Primary memory

Primary memory is the part of computer memory which can be accessed directly from the CPU Secondary storage devices

Secondary storage

includes storage devices that are not directly accessible by the CPU. They are nonvolatile devices which allow data to be stored as long as required by the user. This type of storage is much larger than primary memory, but data access time is considerably slower than RAM and ROM. All applications, the operating system, device drivers and general files (for example, documents, photos and music) are stored in secondary storage.

Embedded systems

- Microprocessor designed to perform specific tasks/functions.
- e.g. for washing machines
    - o it controls the programs for the washing cycle
    - o it's part of the machine but doesn't perform any function within it
- e.g. for tv,
    - o the embedded system is built into / integrated into the TV
    - o combination of hardware and software designed for a specific function
    - o The system is not easily changed/updated by the TV owner
    - o Monitoring and Control/Sensors

Benefits	Drawbacks
✓ small in size and therefore easy to fit into devices ✓ relatively low cost to make ✓ usually dedicated to one task, making for simple interfaces ✓ often no requirement of an operating system ✓ consume very little power ✓ very fast reaction to changing input (operate in real time) ✓ with mass production comes reliability	✓ difficult to upgrade devices to take advantage of new technology ✓ troubleshooting faults in the device becomes a specialist task ✓ although the interface can appear to be simple, in reality it can be more confusing (changing the time on a cooker clock can require several steps, for example) ✓ any device that can be accessed over the internet is also open to hackers, viruses, and so on ✓ due to the difficulty in upgrading and fault finding, devices are often just thrown away rather than being repaired (wasteful)

Principal Operations Of Hardware Devices

Laser printer
- A document from the computer is sent to the printer
- Printer driver ensures that the document is in a format that printer can understand
- A check is made by the printer driver that selected printer is available and there's no issue such as paper jam, out of toner etc.
- Data from the printer is stored in printer buffer
- A printing drum rotates and it's given a positive charge
- The laser scans the drum in which leaves negative charge in areas which exactly match the document to be printed
- The toner is then given positive charge, and the drum is rolled over it, toner sticks to the areas scanned by laser
- A sheet of paper which is given negative charge is rolled over the drum, the toner from the drum now sticks onto the paper
- Paper is then passed through a fuser which melts the toner and fixes it permanently onto the paper
- The charge from the drum is removed after the print

Magnetic hard disk
- Hard disk is made up of one or more platters
- These platters/disks rotate at high speed
- On each platter a read/write head moves across the platter
- Electronic circuit controls the movement of the read/write head
- Surface of platter is divided into concentric sector and tracks
- One track in a sector is the basic unit for storage called a block
- Data is stored on these sectors and tracks
- Data is encoded as magnetic pattern
- When writing, variation in current of the writing head produces a variation in the magnetic field on the disk
- When reading, variation in magnetic field produces a variation in through the head

Solid state (flash) memory
- Most are NAND based technology.
- There are no moving parts
- Uses a grid of column and rows which has two transistors and each intersection
- One transistor is floating gate
- Other one is controlling gate
- Memory cells store voltages which can be represented as 0 or 1
- Essentially the movement of electrons is controlled to read/write
  - Not possible to overwrite data, data must be first erased and then new data can be written in the same location

Optical Disk

- A drive motor is used to spin the disk
- A red laser is used to read/write data
- A lens focuses the laser onto the disk
- Data is stored on pits and bumps on the spiral track
- Surface of disk is made up of a reflective metal
- Reflected light is then encoded as a bit pattern

Components of speaker

- Coil of wire
- Outer frame
- Diagram/Cone
- Dust cap
- Magnet
- Basket

Speaker

- Speaker basically operates by converting electric signals to physical vibration.
- A coil of wire is wrapped onto a permanent magnet, electric current in coil produces a magnetic field
- The permanent magnet is attached to a cone
- Change is audio signals cause change in current flowing through the coil, as the current changes direction of current changes
- As direction of current changes, direction of electromagnet also changes
- This electromagnet is attracted or repelled by the permanent magnet, this causes the coil to vibrate
- As coil vibrates, the diagram/cone vibrates
- The vibration of the cone causes the air ahead of it to vibrate, vibration is transmitted as sound waves
- The amount of movement will determine the frequency and amplitude of the sound wave.

Microphone

- Microphone has a diaphragm
- As the person speaks near to the microphone, the air vibrates, the air causes the diaphragm to vibrate
- This diaphragm is attached to a coil, the vibration causes the coil to move, as the coil moves it induces a current/electric signal which is interpreted as binary values and stored in computer.

Virtual reality headset

- Video is sent from a computer to the headset (either using an HDMI cable or a smartphone fitted into the headset).
- Two feeds are sent to an LCD/OLED display (sometimes two screens are used, one for the left side of the image and one for the right side of the image); lenses placed between the eyes and the screen allow for focusing and reshaping of the image/video for each eye, thus giving a 3D effect and adding to the realism.
- Most headsets use 110° field of view which is enough to give a pseudo 360° surround image/video.
- A frame rate of 60 to 120 images per second is used to give a true/realistic image.
- As the user moves their head (up and down or left to right), a series of sensors and/or LEDs measure this movement, which allows the image/video on the screen to react to the user's head movements (sensors are usually gyroscopic or accelerometers; LEDs are used in conjunction with mini cameras to further monitor head movements).
- Headsets also use binaural sound (surround sound) so that the speaker output appears to come from behind, from the side or from a distance, giving very realistic 3D sound.
- Some headsets also use infrared sensors to monitor eye movement (in addition to head movement), which allows the depth of field on the screen to be more realistic; an example of this is to make objects in the foreground appear fuzzy when the user's eyes indicate they are looking into the distance (and vice versa)

Touchscreen

Resistive Touchscreen

- Made up of two charged plates
- When the plates touch due to pressure applied
- a circuit is completed
- Microprocessor calculates the coordinates of touch
- Coordinates used to calculate the position and the desired action is performed by the microprocessor

Capacitive Touchscreen

- Made up from material that stores electric charge
- When the touchscreen is touched, the charge flows from the screen to the user's finger •
- A sensor detects the change and point of contact is registered
- The coordinates are used to calculate the position.

Buffer

Buffers are used to temporarily store data in memory for processing. They are commonly used in computer programming to hold input or output data that is being transferred between different parts of a program or between multiple programs. Buffers can help improve the performance of a program by reducing the amount of disk I/O or network traffic that is required for data processing. They can also be used to prevent data loss or corruption in case of a system failure or interruption.

Random Access Memory (RAM) and Read Only Memory (ROM)

RAM
- Random Access Memory
- volatile
- Data is not stored permanently, only applications and part of operating system currently in use is stored in RAM.

ROM
- Read Only Memory
- Non-Volatile Memory Data is stored permanently mostly instructions regarding BIOS are stored and general instructions for startup.
- Rom cannot be altered.

PROM, EPROM & EEPROM
- PROM can be set once
- EPROM and EEPROM can be overwritten multiple times.
- EPROM needs to be removed from device EEPROM can be erased in situ.
- EPROM and can be erased using UV light, EEPROM can be erased using voltage // is flash storage
- EPROM must be entirely erased before rewriting, EEPROM does not have to be entirely erased before rewriting.

Explain the differences between Static RAM (SRAM) and Dynamic RAM (DRAM)

DRAM needs to be refreshed constantly after every 15 microseconds, otherwise the capacitor loses its charge.	SRAM doesn't need to be refreshed constantly
DRAM makes use of single transistor and capacitor	SRAM has more complex circuitry
DRAM stores each bit as a charge	SRAM uses flipflops
DRAM consumes more power	SRAM consumed less power
DRAM is cheaper	SRAM is more expensive
DRAM has more storage capacity	SRAM has lower storage
DRAM has slower data access time	SRAM has faster data access time
DRAM is used in main memory	SRAM is used for cache memory

Monitoring & Control Systems

- Sensors send data to microprocessor
- Data is converted from analog to digital if necessary
- Microprocessor calculates a value based on the results from sensor
- Microprocessor compares this value with the stored value or acceptable range
- **Monitoring System** o If value is within range then computer might not do anything
    - o If value is outside range, microprocessor sends a signal to a buzzer/printer which is converted from analog to digital if necessary to alarm/inform the user that sensor reading is outside range.
- **Control System** o If value is outside the range microprocessor sends a signal to the actuator which is converted from analog to digital is necessary, the device then affects the next set of readings from sensor.

- Process is continuous
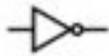

Importance of feedback in a control system
- to ensure the system operates with the given criteria
- ... by enabling system output to affect subsequent system input
- ... thus allowing conditions to be automatically adjusted

3.2 Logic Gates and Logic Circuits

Candidates should be able to:	Notes and guidance

Use the following logic gate symbols:

NOT   AND   OR

NAND   NOR   XOR

Understand and define the functions of :

NOT, AND, OR, NAND, NOR and XOR (EOR) gates

All gates except the NOT gate will have two inputs only.

Construct the truth table for each of the logic gates above

Construct a logic circuit

From:

- a problem statement
- a logic expression
- a truth table

Construct a truth table

From:

- a problem statement
- a logic circuit
- a logic expression

Construct a logic expression

From:

- a problem statement
- a logic circuit
- a truth table

YES
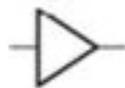
INPUT	OUTPUT
A	
0	0
1	1

NOT
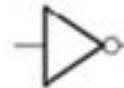
INPUT	OUTPUT
A	
0	1
1	0

AND

INPUT		OUTPUT
A	B	
0	0	0
1	0	0
0	1	0
1	1	1

OR
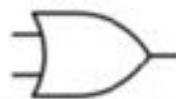
INPUT		OUTPUT
A	B	
0	0	0
1	0	1
0	1	1
1	1	1

XOR

INPUT		OUTPUT
A	B	
0	0	0
1	0	1
0	1	1
1	1	0

NAND

INPUT		OUTPUT
A	B	
0	0	1
1	0	1
0	1	1
1	1	0

NOR

INPUT		OUTPUT
A	B	
0	0	1
1	0	0
0	1	0
1	1	0

XNOR

INPUT		OUTPUT
A	B	
0	0	1
1	0	0
0	1	0
1	1	1