1. Computer 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

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- IO
  - Input
    Accepts information from human operations, electromechanical devices, other computers, etc.
  - Output
    Sends results of processing
- Storage
  - Primary storage
    - Primary storage can be accessed directly from the CPU
    - Contains ROM (random access memory) and RAM (read-only memory)
  - Secondary storage

        - Storage devices that are not directly accessible by the CPU
        - Non-volatile devices
- Embedded systems
    - Microprocessor within a larger system (e.g. washing machine, cooker, refrigerator…)
    - Microprocessor that perform one specific task (e.g. connect to a web so the system can be turned on or off by a program on smartphone)
- Principal operations
    - Laser printer
        - The revolving drum is initially given an electrical charge
        - A laser beam scans back and forth across the drum
        - … discharging certain points (which matches with the shape of texts and images to be printed)
        - The drum is coated with oppositely charged toner
        - The drum rolls over electro-statically charged paper
        - The “pattern” on the drum is transferred to the paper
        - The paper is passed through the fuser to seal the image
        - The electrical charge is removed from the drum using discharging bulb
    - 3D printer
        - Produces solid, 3D objects/prototypes
        - Used in CAD/CAM
        - Make use of tomography/slices of an object
    - Microphone
        - The microphone has a diaphragm
        - The incoming sound waves cause vibrations of the diaphragm
        - … causing a coil to move past a magnet
        - A electrical signal is produced
    - Speakers
        - Takes an electrical signal and translates it into physical vibrations to create sound waves
        - An electric current in the coil creates an electro-magnetic field
        - Changes in the audio signal causes the direction of the electric current to change
        - The direction of the current determines the polarity of the

electromagnet
    - The electro-magnet is repelled by or attracted to the permanent magnet
    - Causing the coil to vibrate
    - The movement of the coil causes the cone/diaphragm to vibrate
    - That vibration is transmitted to the air in front of the cone
    - The amount of movement will determine the frequency and amplitude of the sound wave produced
- Magnetic hard disk
    - The hard disk has one or more platters made of aluminum or glass
    - Each surface of the platter is capable of being magnetized
    - The disks are mounted on a central spindle
    - The disks are rotated at high speed
    - Each surface of the disk has a read/write head mounted on an arm positioned just above the surface
    - Electronic circuits control the movement of the arm and hence the heads
    - The surface of the disk is divided into concentric tracks and sectors
    - One track in one sector is the basic unit of storage called a block
    - The data is encoded as magnetic pattern for each block
    - When writing to disk, a variation in the current in the head produced a variation in magnetic field on the disk
    - When reading, variation in the magnetic field produced a variation in current through the head
- Solid state memory
    - No moving parts
    - Solid stats memory is non-volatile
    - Makes use of NAND gates (transistors)
    - SSD controller manages the components
    - Uses a grid of columns and rows that has two transistors at each intersection
    - One transistor is called a floating gate
    - The second transistor is called the control gate
    - Memory cells store voltages which can represent either a 0 or a 1
    - Essentially the movement of electrons is controlled to read/write

        - The old data needs to be erased in order to write the new data in the same location
    - Optical disc reader/writer
        - Drive motor is used to spin the disc
        - Tracking mechanism moves the laser assembly
        - A lens focuses the laser onto the disc
        - Laser beam is shone onto disc to read/write
        - Surface of disc has a reflective metal layer
        - Tracks on the disc have sequence of pits and lands
        - Reflected light is then encoded as a bit pattern
    - Touchscreen
        - Resistive touchscreen
            - Consists of two charged plates
            - Upper layer made if plastic and bottom layer made of glass
            - Gap between the layers
            - Pressure causes the plates to touch
            - Top layer moves to touch the bottom layer
            - The circuit is completed when 2 layers touch
            - The point of contact is registered
            - The position is calculated using coordinates
        - Capacitive touchscreen
            - Made from materials that store electric charge
            - Acts like capacitors
            - When touched, the charge is transferred to the finger
            - There is a change in the electrostatic field
            - Sensors at the screen corners detect the change
            - One board microprocessor
            - Point of contact is registered
            - Coordinates is used to calculate the position
    - Virtual reality headset
        - Video is sent from a computer to the headset
        - Two feeds are sent to an LCD/OLED display
        - Lenses placed between the eyes and the screen allow for focusing and reshaping the image for each eye, thus giving a 3D effect

        - Most headsets use 110 field of view, which is enough to give a pseudo 360 surround image
        - A frame rate of 60 to 120 images per second
        - As user moves their head, a series of sensors measure this movement, which allows the image/video on the screen to react to the user's head movements
        - Headsets also use binaural sound
        - Infra-red sensors to monitor eye movement
- Buffers
- RAM vs ROM
    - RAM (Random Access Memory)
        - Stores the runtime data (e.g. data read from sensors)
        - Memory location can be accessed independent of which memory location was last used
        - Can be written to or read from, and the data stored can be changed by the user or by the computer
        - Used to store data, files, part of an application or part of the operating system currently in use
        - Volatile (memory contents are lost on powering off the computer)
        - Memory sizer is often larger than ROM
        - Can be increased in size to improve the operational speed of computer
    - ROM (Read Only Memory)
        - Store the start-up instructions
        - It cannot be written to or changed
        - Permanent memory device
        - Non-volatile memory device
        - Data stored cannot be altered
        - Sometimes used to store BIOS and other data needed at start up
- SRAM vs DRAM
    - SRAM is much faster than DRAM when it comes to data access
    - DRAM is the most common type of RAM used in computers
- PROM vs EPROM vs EEPROM
    - PROM (Programmable Read-Only Memory)
        - Can be altered once

        - Made up of a matrix of fuses
    - EPROM (Erasable Programmable Read-Only Memory)
        - Use floating gate transistors and capacitors
        - Reusable
        - Using UV light to erase
        - ROM (primary)
    - EEPROM (Electronically Erasable PROM)
        - Used in solid state storage device
        - Faster but more expensive than flash drive
        - Using pulsed voltage to erase
        - SSD (secondary)
- Monitoring and control system
    - Monitoring system
        - If the new data is outside the acceptable range, a warning message is sent to a screen or an alarm is activated
        - The microprocessor or computer has no effect on what is being monitored - it is simply “watching” the process
        - Examples
            - Monitoring a patient in a hospital for vital signs such as heart rate, temperature, etc.
            - Checking for intruders in a burglar alarm system
            - Checking the temperature level in a car engine
            - Monitoring the pollution level in a river
    - Control system
        - If the new data is outside the acceptable range, the microprocessor or computer sends signals to control valves, motors, etc.
        - The output from the system affects the next set of inputs from the sensors
        - Examples
            - Turning street lights on at night and turn them off again during daylight
            - Controlling the temperature in a central heating/air conditioning system
            - Controlling the traffic lights at a road conjunction
            - Controlling the environment in a green house