3 Input and output devices

Introduction:

- All computer systems make use of input and output devices.
- These devices **work differently** and have **variety of applications**.

Input devices:

- An input device is any **hardware device** that sends data to a computer, allowing you to **interact** with and **control it**.
- The input devices included in our syllabus are:
  1. scanners
  2. barcode readers/scanners
  3. quick response (QR) code readers
  4. digital cameras
  5. keyboards
  6. pointing devices
  7. microphones
  8. touchscreens
  9. sensors
  10. interactive whiteboards

1) Scanners:

2D Scanner

3D Scanner

Scanners are either two-dimensional (2D) or three-dimensional (3D):

1) Two-dimensional (2D) scanners:

- 2D scanners are the most **common** form of scanners.
- They are generally used to **input hard-copy** (paper) documents.
- The scanned image is **converted** into an **electronic form** which can be stored on computer.

i) Working of a 2D scanner:

- The scanner **shines light** onto the surface of a document.
- The **light source** is automatically **moved across** the document.
- An image of document is produced as **reflected light is captured using a series of mirrors and sent to the lens.**
- The lens focuses the image which falls onto a **charge couple device (CCD).**
- Each light-sensitive pixel of CCD creates an **electric charge** when light falls on it.
- An **electronic form is produced** which is finally converted to a **2D digital image.**

ii) Charge couple device (CCD):

- It consists of **integrated circuits etched into silicon.**
- It is made up of thousands of **light-sensitive pixels.**

iii) After scanning:

- Computers equipped with **optical character recognition** (OCR) software can **convert the scanned text into a text file format.**
- Otherwise, if the scanned document was a photograph, then it **forms an image file such as JPEG.**

iv) Application of 2D scanners at an airport:

1) They are used at **airports** to **scan** and then **read passports:**

- **OCR technology** is used to produce **digital images** of passport pages.
- Due to OCR, these **images can be manipulated.**
- **Example:** OCR software is able to review these images, select the text part and then automatically put the text into correct fields of an existing database.

2) They are used at **airports** to **scan 2D photograph** in passport:

- It is stored as jpeg image.
- The passengers face is then photographed using a digital camera.
- The **two digital images are compared using face recognition/detection software.**
- **Key parts** of the face are compared such as:

1. Distance between eyes
2. Width of the nose
3. Shape of the cheekbones
4. Length of the jaw line
5. Shape of the eyebrows

- It is done to ensure that the two images **represent the same face** and for **security clearance purposes**.

What does the following terms mean?

i) OCR:

- Optical character recognition (OCR) is a technology that enables you to **convert different types of documents**, such as scanned paper documents, PDF files or images captured by a digital camera **into editable and searchable data.**
- It simply allows **scanned text** from a document to be **converted into text file format for manipulation and editing.**

ii) OMR:

- Optical mark recognition (OMR) is the process of **capturing human-marked data from document forms** such as surveys and tests.
- They are **used to read questionnaires, multiple choice examination papers in the form of lines or shaded areas.**
- It is simply a system that **reads pencil or pen marks** on a piece of paper in **pre-determined positions.**

iii) Facial recognition software

- A facial recognition system **uses biometrics to map facial features** from a photograph or video.
- It **compares** the information with a **database of known faces to find a match.**
- **Key parts** of the face such as distance between eyes, width of nose etc. are compared.
- It can help **verify personal identity**.

2) Three-dimensional (3D) scanners:

- 3D scanners **scan solid objects and produce a three-dimensional image**.
- They scan the **x, y and z** coordinates **taking images at several points** which produces a digital image that represents the solid object formed.
- The scanned images can be used in **computer aided design (CAD) or sent to a 3D printer** to produce a working model of the scanned image.
- **Technologies used are lasers, magnetic resonance and white light etc.**

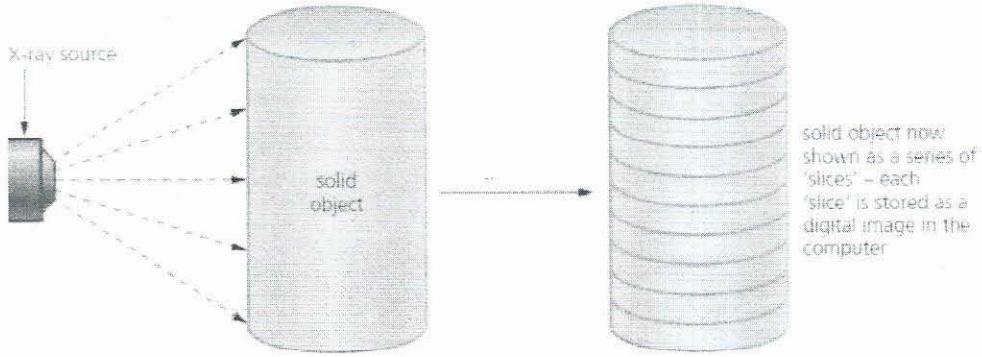
i) Working of a 3D scanner:

- The scanner **shines a laser or light source** over the surface of a 3D object.
- It **records the measurements** of the dimensions of the object such as the width, height and depth.
- Then the **measurements are converted into digital file.**
- Hence, it **produces a 3D digital model.**

ii) Application of 3D scanners:

1) **Computed tomographic (CT) scanners** are used to create a **3D image** of a solid object.

- This is based on **tomography technology** (shown below) which basically builds up an image of the solid object through a **series of very thin slices.**
- These **2D slices together make up a representation of the 3D solid object.**
- Each slice is built up by use of **X-rays, radio frequencies or gamma imaging.**
- Each slice is then **stored as a digital image** in computer memory. The whole of solid object is **represented digitally** in the computer memory.



iii) Tomographic scanners can have different names depending on technology used:

1. X rays technology	2. Radio frequencies technology	3. Gamma rays technology
CT scanners (computerized tomography)	**MRI** (magnetic resonance imaging)	**SPECT** (single photon emission computed tomography)

Exam Style Questions:

Q1. An airport has a security system that uses:

- **Computers**
- **Scanners**
- **Digital cameras**

Each passenger must have a passport or ID card which contains a recent photograph and other personal data.

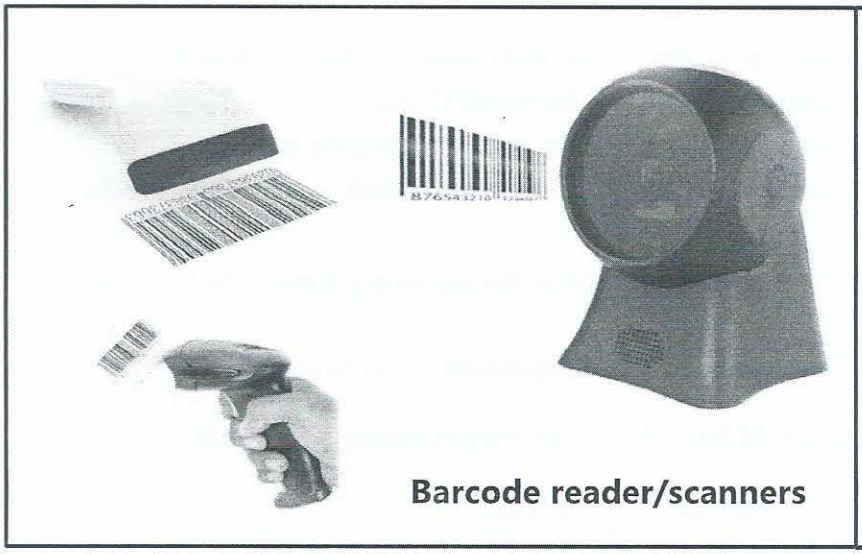
- **The passenger places their passport or ID card on a scanner that reads machine-readable characters and scans the photograph.**
- **Look toward the camera that takes an image of the passengers face.**

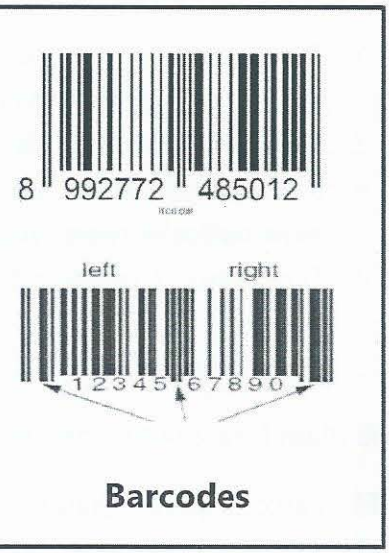
Describe how a computer checks whether the image just taken by the camera matches the scanned photograph.

- Facial recognition software is used to scan the face.
- The captured image of face is converted to digital data by the camera.
- The scanned photo stored in a passport is converted into digital data.
- The key features of the face are compared in both images such as distance between the eyes, width of the nose etc.

2) Barcode readers/scanners:

They are **automatic data capture** devices which means that they can save and collect data with no actual need for human interaction.





- Barcodes are a **series of black and white parallel lines** with varying thicknesses.
- The **digits from 0 to 9 are each represented by a unique series of lines.**
- Normal barcodes can hold up to **30 digits.**
- The actual left-hand and right-hand sides of the barcode are **separated using guard bars.**

i) Remember:

- The width of lines representing each digit is the same, thus the **speed of scanning is also same.**
- The arrangement of bars on left and right side allows a barcode to be **scanned in any direction.**

ii) Working:

- It is first read by a **red LED or a red laser.**
- Light is **reflected back** off the barcode (dark areas reflect little or no light at all and hence, the dark and light areas are determined).
- The reflected light is **read by sensors (photoelectric cells).**
- As the laser or red LED light is scanned across the barcode, it **generates a pattern** which is then **converted to digital values** that allows the computer to understand the barcode.
- A **microprocessor** then **interprets** the data.

iii) Binary values of:

- Binary value of light area = 0
- Binary value of dark area = 1

iv) After scanning,

1. The barcode number is **looked up in the stock database** and the price and stock item **details are sent to the check-out/point of sale terminal (POS).**
2. The number of **stock items is reduced by one** each time the barcode is read.
3. If the stock **items are lesser or equal to a user-specified** value then stocks are **automatically reordered.**
4. Once stock is reordered, a **flag is put to stop re-ordering every time** until the stock has arrived.
5. When new stock items arrive, the **stock levels are updated** in the database.

v) Explain how the barcode system could help the supermarket manage its stock.

- Barcode can be used to **look up product** in a database.
- The **data about stock levels can be stored** on a system.
- Stock can be **automatically deducted** from the system.
- Stock can be **automatically re-ordered** if below a certain level.
- It automatically **updates new stock level.**

vi) Advantages of barcodes to the management:

1. It is **easier** and **faster to change price** on stock items.
2. It provides **more updated** sales information.
3. There is no need to price every stock item on the shelves (which **saves time and cost**).
4. It allows for **automatic stock control.**
5. It is possible to **analyze customer buying habits** more easily by linking barcodes to loyalty cards.

vii) Advantages of barcodes to the customers:

1. The **queues are faster** as staff doesn't need to remember prices.
2. The **errors in charging customers are reduced.**
3. The customer is given an **itemized bill.**
4. The **cost savings** can be passed on to the customer.
5. It allows a **better track of 'sales-by-dates';** so food should be fresher.

viii) Input and output devices found at the checkout in supermarkets along with Barcode readers:

Input/output device	How it is used
Keypad	To key in the number of same items bought; to key in a weight.
Screen/monitor	To show the cost of an item and other information.
Speaker	To make a beeping sound every time a barcode is read correctly; or another sound if there is an error when reading the barcode.
Printer	To print out a receipt/bill.
Magnetic stripe reader	To read the customer's credit/debit card.
Touchscreen	To select items by touching an icon; or to select payment method.

ix) Applications:

1) Barcode readers are used in **supermarket checkouts:**

- They are used to **find prices and descriptions.**
- They allow for **automatic stock control.**

2) Barcode readers are used in **library systems:**

- They can **track books** on loan.
- They allow for **linking books to borrowers** using barcoded cards.

3) Barcode readers are used at **airport check-ins:**

- They are placed on luggage to track its **whereabouts.**

Exam Style Questions:

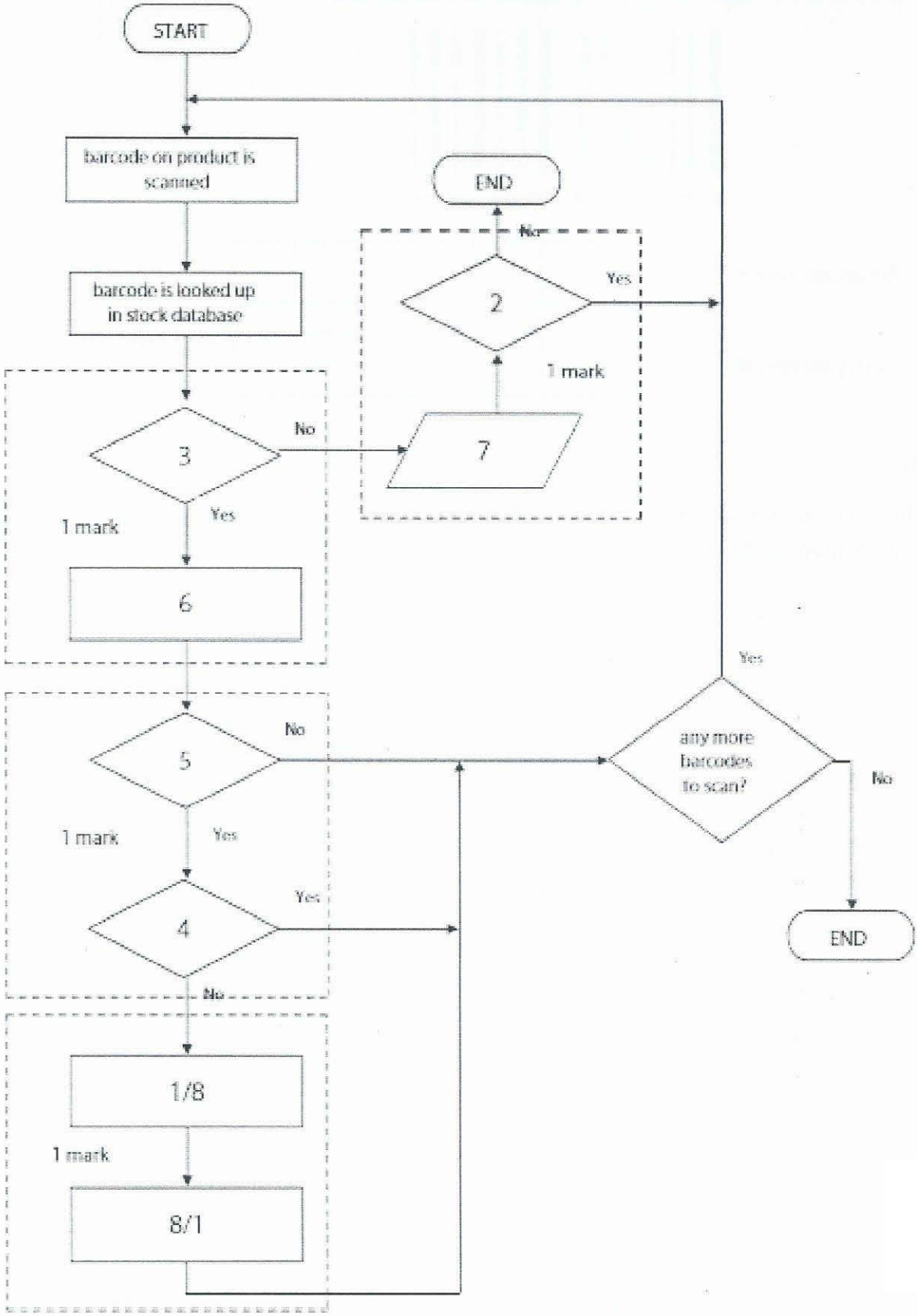
Q1. The flowchart on the opposite page shows what happens when the barcode on a product is scanned at the checkout in a supermarket. The barcodes are used in an automatic stock control system.

Several of the statements in the flowchart are missing.

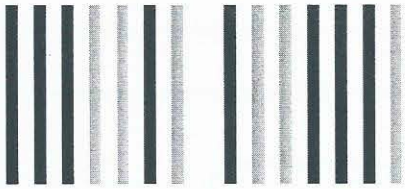
Using **item number only** from the list below, complete the flowchart.

Item number	Statement
1	Add flag to product record to indicate re-order made
2	Any more barcodes to scan?
3	Has the scanned barcode been found in the file?
4	Has the re-order flag already been added to the product record?
5	Is number of product in stock <= re-order level?
6	Number of product in stock is reduced by 1
7	Output an error message
8	Automatically send out order for new product

Answer:


START
barcode on product is scanned
barcode is looked up in stock database
3
No
Yes
1 mark
6
5
No
Yes
1 mark
4
Yes
No
1/8
1 mark
8/1
2
No
Yes
1 mark
7
END
any more barcodes to scan?
Yes
No
END

Q2. Write the binary numbers that would be produced from this barcode:



Binary number A Binary number B

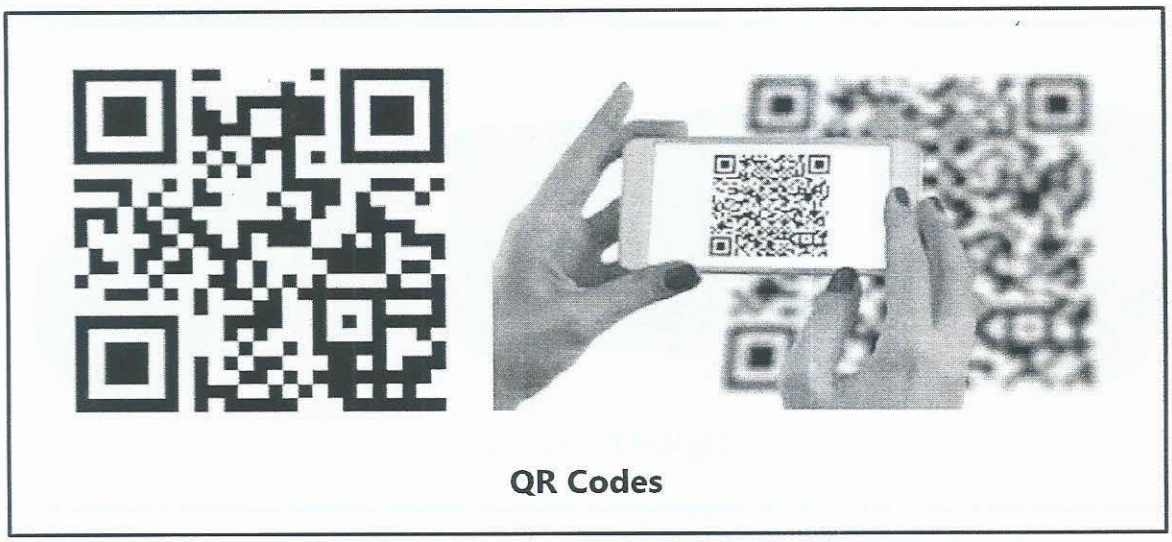
Binary number A:

Binary number B:

Answer:

- Binary number A = 1110010
- Binary number B = 1001110

3) Quick response (QR) code:



QR Codes

- It is **another type** of barcode.
- It is made up of a **matrix of filled-in dark squares** on a light background.
- These codes can hold up to **7000 digits.**

i) Use:

1. These are used for **redirecting devices to specific web pages** after these codes are scanned.
2. They are **used in shopping malls** and on **public transport** for advertising.

ii) Working:

- QR code is **captured by a built-in-camera** in smartphone.
- It is then **processed by an appropriate QR code reading application** on phone.
- The **three large squares are used for alignment.**
- It **reflects light. Black squares reflect less light** than white squares which enables the squares to be read.
- Each small square is **converted to a binary value.**
- The data is then **decoded.**
- The user is **redirected to a specific web page or opens a document.**

iii) Advantages:

1. There is **no need for the user to manually write down or key in a website address;** scanning the QR code does this automatically.
2. QR codes can **store website addresses/URLs** that appear in **magazines, trains, buses or even on business cards,** giving a very **effective method of advertising.**

4) Digital cameras:

Digital Cameras

- A digital camera is a similar to a traditional film-based camera, but it **captures images digitally.**
- When you take a picture with a digital camera, **the image is recorded by a sensor, called a charged coupled device (CCD).**
- Some digital cameras have built-in memory, but most use an **SD or Compact Flash card.**

i) Linkage:

- Modern digital cameras simply link to a computer system via a **USB port or by using Bluetooth.**

ii) Working:

- The photograph is captured when **light passes through the lens onto a light sensitive cell.**
- This cell is made up of **tiny elements known as pixels.**
- The number of **pixels determines the size of the file** used to store the photograph.

Q1. Explain how the images captured by the camera are converted to digital photo files.

- The image is converted from **analogue to digital using ADC** (analogue-to-digital converter).
- It is then **turned into pixels.**
- Each **pixel is given a binary value and has a color.**
- The **pixels form a grid** to create the image.
- Pixels are then **stored in sequence** in a file.
- It is stored in a **suitable photo file format e.g. JPEG.**

iii) Use:

1. Digital cameras are used for **digital photographic art.**
2. They are used to **record a meeting or an event.**
3. They are used to **capture objects for presentation.**
4. They are used for **virtual reality tours** of houses, shopping malls etc.:
   Photos are taken from a single point and the camera is rotated around the room. The images are **"stitched" together** using software, **resized and configured** for Internet use.

iv) Advantages:

1. It requires **no film processing.**
2. It **doesn't run out of film** and **saves the cost** of buying film as well.
3. It allows **seeing photographs instantaneously.**
4. Digital camera **won't need manual emptying.**

v) Functions:

- These cameras are **controlled by a microprocessor** which can automatically carry out the following tasks:
  1. Adjust the **shutter speed.**
  2. **Focus** the image automatically.
  3. Operate the **flash** automatically.
  4. Adjust the **aperture size.**
  5. Adjust the **size of the image.**
  6. **Remove 'red eye'** when the flash has been used.

vi) The quality of the photograph depends on factors such as:

1. The **type of lens** used.
2. The **lighting.**

vii) What is the meaning of pixels?

- Pixel means **picture element.**
- It is the **smallest controllable element of a picture represented on the screen.**

viii) Advantages of buying a camera with a higher resolution:

1. It results in **higher quality** photos.
2. When the image is enlarged/magnified, it is **less likely for photo to pixelate.**

ix) Disadvantages of buying a camera with a higher resolution:

1. It **uses up more memory** on card.
2. It **takes longer to upload or download a photo.**
3. The **file size will be greater.**

5a) Keyboards:

Keyboard

Ergonomic Keyboard

- Keyboards are by far the most common method **used for data entry.**
- They are **used as input devices on computers, tablets, mobile phones etc.**

i) Connection:

- The keyboard is connected to the computer by using **USB connection or a wireless connection.**
- The keyboard is **virtual or type of touch screen technology** in tablets and mobile phones.

ii) Working:

Q1. Describe how key presses on a keyboard are processed by the computer.

- A **matrix/membrane or a circuit board** is present at the base of keys.
- A key is pressed that **presses a switch.**
- When a key is pressed it **completes the circuit changing the current** in it.
- The **location** of the key pressed is **calculated**.
- An **index of characters is searched** to find the corresponding key presses.
- Each character has an **ASCII value** (which in turn has a binary value).
- The **binary value can then be processed by the CPU** to action the key press.

Quite simply, each character on a keyboard has an ASCII value. Each **character pressed** on a keyboard is **converted into a digital signal, which the computer interprets.**

iii) Advantages:

1. It is the **easiest way** to enter text into a computer.

iv) Disadvantages:

1. It is a **relatively slow** method of data entry hence **takes a lot of time.**
2. It is also **prone to errors** hence **easier to make mistakes.**

v) Possible injury and solution:

- Frequent use of these devices can lead to injuries such as **repetitive strain injury (RSI)** in the **hand, wrist and back** if sitting for too long.
- **Ergonomic keyboard** can help to overcome this problem as they have **keys arranged differently.**
- They are **designed to provide more support to hands and wrist** when doing a lot of typing.

vi) Applications:

1. It is used for **typing messages** for communication (e.g. typing a mail).
2. It is used for **using shortcuts** in a computer system (e.g. pressing ALT and F4 together).
3. It is used for **writing data manually** in word processor, spreadsheet, database etc. for purposes such as report writing.
4. It is used for keying in data manually in a **control room interface** for purposes such as flow speed of liquid.

b) Concept keyboard:

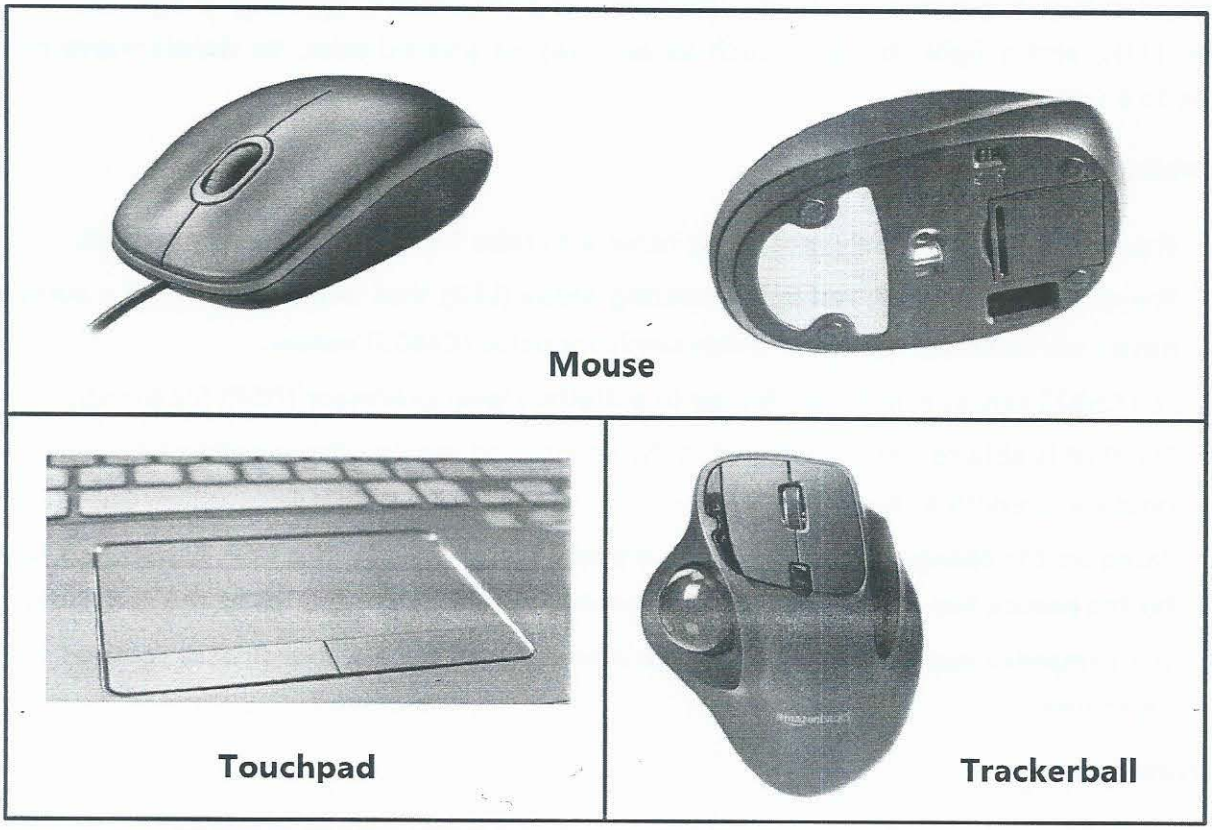
Concept Keyboard

- A concept keyboard is a specialized keyboard with **no preset keys.**
- It is a **flat board** that contains a **grid of buttons.**
- Each **button can be programmed** with a wide range of different functions for the users to do whatever they want.
- An **overlay sheet with pictures or symbols is placed on the grid** so that the user can tell what pressing on different areas will do.

Q1. A restaurant has a concept keyboard that is overlaid with images of food items available from their menu. Staff can click on an image to add the food item to a customer order. Explain the benefits of using a concept keyboard.

1. **Fewer typing errors** may be made because one button is pressed to order an item.
2. It **speeds up the time** to enter an order because fewer buttons are pressed to complete the order.
3. It **requires less training of staff** because it is easier to identify an order item from its image rather than typing it.

6) Pointing devices:



Mouse

Touchpad

Trackerball

- The **selection of an application** often requires the user to click on an icon.
- Selection of the item is usually done with a pointing device such as a **mouse or tracker ball or by using a touch screen.**

a) Mouse:

The mouse is the most common pointing device and comes in various forms:

1. The more **traditional type with a mechanical ball arrangement**; connected to the computer through a **USB port.**
2. The more **modern type that use red LEDs** to detect movement in the **x-y direction**; these are type of **optical mouse.**
3. Mice that use either of the above types of technology but use a **wireless connection to the computer.**

b) Optical mouse:

An optical mouse is a computer mouse which **uses a light source, typically a light-emitting diode (LED), and a light detector, such as an array of photodiodes, to detect movement** relative to a surface.

i) Working:

- The optical mouse actually uses a **tiny camera to take 1,500 pictures every second.**
- The mouse has a **small, red light-emitting diode (LED) that bounces light off a surface onto a complementary metal-oxide semiconductor (CMOS) sensor.**
- The **CMOS sensor sends each image to a digital signal processor (DSP)** for analysis.
- The **DSP is able to detect patterns** in the images and see how those patterns have moved since the previous image.
- Based on the **change in patterns over a sequence of images, the DSP determines how far the mouse has moved and sends the corresponding coordinates to the computer.**
- The **computer moves the cursor on the screen based on the coordinates** received from the mouse.

ii) Advantages:

1. It has **no moving parts** which mean **less wear and a lower chance of failure.**
2. There's **no way for dirt to get inside** the mouse and interfere with the tracking sensors.
3. It allows for an **increased tracking resolution meaning smoother response.**
4. It **does not require a special surface**, such as a mouse pad.

c) Tracker ball:

- A trackball is a **pointing device consisting of a ball held by a socket containing sensors to detect a rotation of the ball about two axes** (like an upside-down mouse with an exposed protruding ball).
- It is a **plastic case containing a ball on the top** that moves a computer cursor around on the screen.
- The user can **move the ball** with their thumb or fingers, and **sensors inside the case detect which direction the ball is moving.**

i) Use:

1. It is used in an **industrial environment** such as a **control room** as they don't need to move and therefore no need for any desk space or special surface.
2. It is used in **selecting objects on plan control or monitoring screens.**

ii) Advantages:

1. It **does not depend on hand movements** of a user to finish actions.
2. It enables you **fluid and precise control** with your movements.
3. Operator is **less likely to suffer from injury** such as RSI.

iii) Disadvantages:

1. **Left-handed tracker balls** are **difficult to find.**
2. It is **expensive.**
3. It **requires a fine control of the ball** with just one finger or thumb.
4. It is **difficult to use.**

d) Touchpad

- Most **laptop computers** have a **built-in touchpad.**
- This contains a **tactile sensor** which allows the user to control a cursor by simply moving a finger over the surface of the pad.

i) Advantages:

1. It **requires no space** for using it because it is embedded in to laptop.
2. The touchpad has a **better and fast selection control.**
3. It is **easy to operate.**
4. It is a **more sensitive device.**

ii) Disadvantages:

1. It is **hard to use when a user has limited finger movement.**
2. **Controlling the pointer is harder** than using a mouse.

7) Microphones:

- A microphone, colloquially named mic is a device that **converts sound into an electrical signal.**
- These are used to **input sound into a computer** for purposes such as:

1. Doing a **'voice over'** in a presentation.
2. Part of a **speech recognition** system.
3. Part of a **voice recognition** system.
4. Enabling a **disabled person to communicate** with computer.

i) Connection:

- They are **either built into the computer or external devices connected through USB port/wireless connectivity.**

ii) Working:

- When a microphone **picks up sound**, the **sound waves hit a diaphragm.**
- This **causes the diaphragm to vibrate producing an electric signal.**
- This **signal goes to a sound card** and is **converted into digital values and stored** in the computer.

iii) Advantages:

1. It is **faster to provide voice as input using microphone** than to type text using keyboard.
2. **Sound waves can be manipulated** in real time.
3. It can **help in improving safety and security of drivers and riders when used with voice activation systems** e.g. switching on radio, keeping phone in speaker mode etc.
4. They are **inexpensive** in general.
5. Most of the microphones **tolerate extreme high sound pressure levels.**
6. It **does not require power supply** except few.

iv) Disadvantages:

1. Sound files **require large memory for storage** for further processing and use.
2. Voice recognition software is **not as accurate as manual typing**. For example, it cannot distinguish between "there" and "their".
3. Sound signals are **required to be amplified for proper reconstruction.** Hence amplifiers are needed.
4. It has **reduced performance at high frequencies.**

v) Uses:

1. It is used in **live and recorded audio engineering.**
2. It is used in **sound and music recording.**
3. It is used in **radio and television broadcasting.**
4. It is used in **computers for recording voice.**
5. It is used in **speech recognition.**

a) Voice recognition:

- If the microphone is being used in a VOICE RECOGNITION system, **the user's voice is detected and then converted into digital.**
- A few words spoken **produce a digital wave pattern.**
- A software **compares this wave pattern to wave patterns stored in memory** to see if they match.

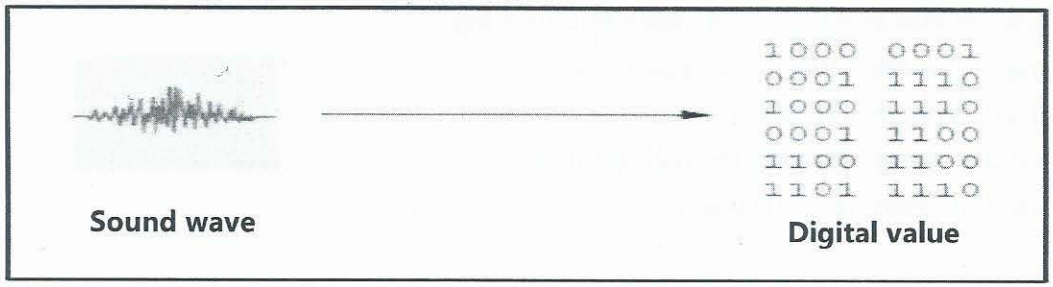
i) Use:

1. This technology can be used in **security systems** (e.g. a user may be asked to say their name and if the user's voice is identified then he/she is given access).

b) Speech Recognition:

- It is a **different** and **more complex technology.**
- It uses a microphone to **input words spoken by a user.**
- The **spoken words are recognized and shown on a screen, input into a word processor or used in other application.**

i) Example:



1. Suppose a person says any word; the **sound card in the computer will convert the sound wave into a digital form.**
2. The **software takes the digital image and breaks it up into phonemes** (these are the smallest elements that make up a language).
3. These **phonemes are compared with words found in the built-in dictionary.**
4. That **word would then be suggested by the software** in whatever application is being run.

ii) Why complex?

- It is a complex technology since **computer is unable to differentiate between similar sounding words** (e.g. their and there) due to different dialects and accents of human beings.

iii) Use:

1. This technology can be used in **phones for giving commands such as "open camera".**
2. This technology can be used in **cars for giving commands such as "switch on GPS".**

Exam Style Questions:

Q1. Describe the difference between speech recognition and speech synthesis.

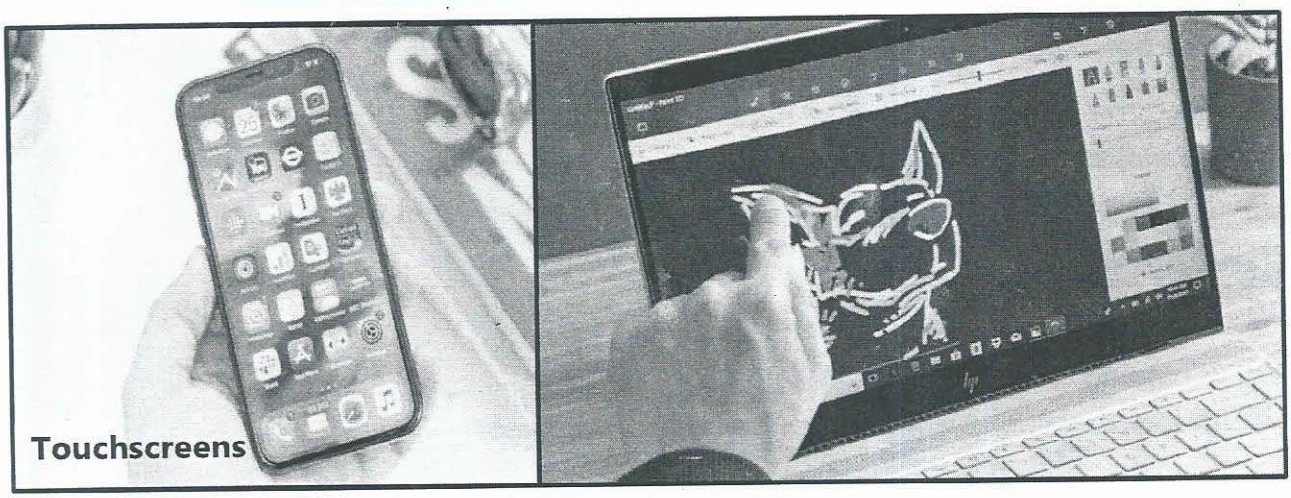
Speech recognition:

- Speech recognition is a **form of input.**
- It **requires a microphone.**
- It is an **example of an expert system** (artificial intelligence).

Speech synthesis:

- Speech synthesis is a **form of output.**
- It **requires speakers.**
- In speech synthesis, **words are chosen from a database.**

8) Touchscreen:



- It is now a **very common form** of input.
- It **allows users to interact with devices** just by touching the screen.

There are 3 types of touch screens technologies:

1. Capacitive
2. Infra-red
3. Resistive

i) Use:

1. Touchscreens are **used in mobile phones, tablets etc.**
2. They are **used in laptop displays.**
3. They are **used in cash registers and information kiosks.**

It is an **easy and fast method to input data** into a system. Icons are used for application selection.

1) Capacitive:

i) Working:

- An **electrostatic field is created** across the screen as **current flows out from all 4 corners** of the screen.
- **Sensors are located around the screen** which is used to **read the electrostatic field.**
- When finger touches screen, the **electrostatic charge is transferred to the user's finger and the current changes.**
- **Coordinates of touch** are **calculated by an onboard microprocessor.**

ii) Advantages:

1. It is a **medium cost** technology.
2. The **screen visibility is good** even in strong sunlight.
3. The **screen is very durable**; it takes a major impact to break the glass.
4. It **allows multi-touch capability.**

iii) Disadvantages:

1. It **cannot be used when wearing gloves** as it allows only the use of bare fingers for input.

Q1. Why gloves cannot be used in capacitive technology?

- The gloves are **not conductive.**
- They **block current from finger** and hence **stop electrostatic field being changed.**

Q2. How to use capacitive technology with gloves?

1. Use a **conductive stylus** as they **allow charge to be disturbed/changed.**
2. Use **capacitive gloves** as they **allow charge to disturbed/changed.**

2) Infra-red:

i) Working:

- **Infrared rays are sent across screen** from the edges.
- It has **sensors around edges.**
- Infrared rays **form an invisible grid across the screen.**
- Infrared **ray is broken by a finger** blocking a beam.
- **Calculation** is made **on where beam is broken to locate the 'touch'.**

a) Heat-sensitive infra-red system:

- It **uses glass as the screen material and needs a warm object** (e.g. fingers) to carry out an input operation.

b) Optical infra-red system:

- It **uses glass as the screen material and uses an array (group) of sensors in the form of a gird;** the point of contact is based on which grid coordinate is touched.

ii) Advantages:

1. The **screen is very durable**; it takes a major impact to break the glass.
2. It **allows multi-touch capability.**
3. Optical system **allows use of bare fingers, gloved fingers or stylus** for input.

iii) Disadvantages:

1. It is an **expensive** technology.
2. It is **sensitive to dust or dirt.**
3. **Heat-sensitive system only allows use of bare fingers** for input.

3) Resistive:

i) Working:

- It uses an **upper layer of polyester (type of plastic) and a bottom layer of glass that transmit electric currents.**
- When the **top polyester layer is touched,** the **top and bottom layer complete a circuit.**
- As a result, the **electric current changes** and **signals are sent out.**
- They are **interpreted by a microprocessor** and **calculations determine the coordinates** of the touch.

ii) Advantages:

1. It is an **inexpensive** technology.
2. It **allows use of bare fingers, gloved fingers or stylus for input.**

iii) Disadvantages:

1. The **screen visibility is poor** in strong sunlight.
2. It **does not allow multi-touch capability.**
3. The **screen is vulnerable to scratches** and wears out through time.

iv) A table that compares capacitive and resistive technologies:

Statement	Resistive (✓)	Capacitive (✓)
This touch screen has multi-touch capabilities		✓
This touch screen cannot be used whilst wearing gloves		✓
This touch screen is made up of two layers with a small space in between	✓	
This touch screen uses the electrical properties of the human body		✓
This touch screen is normally cheaper to manufacture	✓	
This touch screen has a quicker response time		✓

9) Sensor:

- It is a device that **detects or measures a physical property** (e.g. temperature) and records, indicates, or otherwise responds to it.
- A **system can be developed using sensors**, converters, a feedback cycle and a control system.

i) Analogue Data:

- It is a **continuous data.**
- It is **non-discrete.**
- **Example:** data such as a sound wave.

ii) Digital Data:

- It is **discrete data** that has **only two values.**
- **Example:** binary data 1's and 0's.

iii) ADC and DAC:

- **ADC** is **analogue-to-digital converter** and **DAC** is **digital-to-analogue converter.**

Q1. Why is there a need for ADC and DAC?

- **Computers cannot make any sense** of physical quantities.
- The **data needs to be converted into a digital format** so that the computer can understand.
- This is usually **achieved by an analog to digital converter.**
- This **device converts physical values into discrete digital values.**
- When the **computer is used to control devices** such as a motor or a valve, it is **necessary to use a digital to analog converter since these devices need analogue data to operate** in many cases.

iv) Examples of sensors:

1) **temperature** sensor
2) **moisture** sensor
3) **light** sensor
4) **infra-red/motion** sensor
5) **pressure** sensor
6) **acoustic/sound** sensor
7) **gas** sensor
8) **pH** sensor
9) **magnetic field** sensor

v) Sensors along with their applications:

Application	Sensor
Controlling street lights	Light
Monitoring a river for pollution	Gas, pH, temperature, light
Controlling traffic lights	Pressure, magnetic field

Sensor	Application
1. Temperature	1. Control a central heating/cooling system 2. Control/monitor a chemical process 3. Control/monitor the temperature in a greenhouse
2. Moisture/humidity	1. Control/monitor the moisture levels in soil in a greenhouse 2. Control/monitor the humidity levels in the air in a greenhouse 3. Monitor dampness levels in an industrial application
3. Light	1. Switch street lightning on at night and off during the day 2. Monitor/control light levels in a greenhouse 3. Automatically switch on a car's headlights when it gets dark
4. Infra-red/motion	1. Turn on the windscreen wipers on a car automatically 2. Detect intruders in a burglar alarm system 3. Count people entering/leaving a building
5. Pressure	1. Detect intruders in a burglar alarm system 2. Weigh things (e.g. check the weight of a vehicle) 3. Monitor/control a process where gas pressure is important
6. Acoustic/sound	1. Pick up noise levels (e.g. footsteps) in a burglar alarm system 2. Detect the noise of liquids dripping in a pipe
7. Gas (e.g. O_2 or CO_2)	1. Monitor pollution levels in a river or in the air 2. Measure O_2 and CO_2 levels in a greenhouse 3. Check for CO_2 leaks in a power station
8. pH	1. Monitor/control acidity/alkalinity levels in the soil in a greenhouse 2. Pollution/environmental monitoring in rivers
9. Magnetic field	1. Any application where detection of changes in a magnetic field is required (e.g. in cell phones, CD players, etc.) 2. Used in anti-lock braking systems in motor vehicles

vi) Uses:

Sensors are used in both monitoring and control applications:

a) Examples of monitoring include:

1. monitoring a **patient in a hospital** for vital signs such as heart rate, temperature, etc.
2. monitoring of **intruders** in a **burglar alarm system.**
3. checking the **temperature levels** in a **car engine.**
4. monitoring **pollution levels** in a **river.**

b) Examples of control include:

1. **turning street lights on** at night **and turning them off** again during daylight.
2. **regulating the temperature** in a **central heating/air conditioning system.**
3. **changing the traffic lights** at a road junction.
4. **operating anti-lock brakes** on a car when necessary.
5. regulating the environment in a **greenhouse.**

vii) Remember:

- The topic "sensors" from input and output devices is the **most frequently asked topic** in computer science exams since the **highest number of questions** ever asked are from sensors.
- A question from sensor is almost in every paper, every year. It is asked for **4 to 7 marks.**
- The answer of each question related to sensor is very similar and consists of **statements and keywords in a sequence.** Just **memorizing the standard procedures** stated below and writing them in exams will earn you complete marks.
- However, situation would be changed. The examiner can give you any scenario and ask about functioning of any sensor accordingly.
- The **procedures** stated below **will always be the same;** you only need to **make slight changes in answer** according to question statement.
- **8 complete questions** of sensors (worth **5-6 marks**) that have been asked in recent years are given below with their answers so that you can realize the **pattern of answering** and **how to make changes in your answer** according to question statement.

a) Standard working procedure of sensors in monitoring application:

1. Sensor **sends a signal to the microprocessor.**
2. Analogue signals are **converted from analogue to digital using ADC** (analogue to digital converter).
3. The **microprocessor compares the data received to a pre-set/pre-determined/stored value.**
4. If the **value is outside the acceptable range, a signal is sent by the microprocessor to display a warning message** on a monitor or activate an alarm.
5. If the **value is within an acceptable range, no action is taken.**
6. The process is a **continuous loop.**

b) Standard working procedure of sensors in controlling application:

1. Sensor **sends a signal to the microprocessor.**
2. The signals are **converted from analogue to digital using ADC** (analogue to digital converter).
3. The **microprocessor compares the data received to a pre-set/pre-determined/stored value.**
4. If the **value is outside the acceptable range, a signal is sent by the microprocessor to actuator, control valves, motors etc. to cause an action to occur.**
5. If the **value is within an acceptable range, no action is taken.**
6. The process is a **continuous loop.**

Exam Style Questions:

Q1. Identify two sensors that the security system could use to detect intruders. Describe how each sensor could be used in the security system.

1) Infrared sensor:

- It receives infrared rays/heat.
- It sends data to microprocessor.

1. It can be placed in the corner of a room.
2. It is used to detect heat of an intruder.

2) Pressure sensor:

- It receives current if circuit is created and stops receiving current if circuit is broken.
- It sends data to microprocessor.

1. It can be placed on a window or a door.
2. It is used to detect a change in pressure.

Q2. The flowchart on the opposite page shows how a light sensor and microprocessor are used to switch a street lamp on or off. When the sensor reading is <= 50 light units, the lamp is turned on automatically.

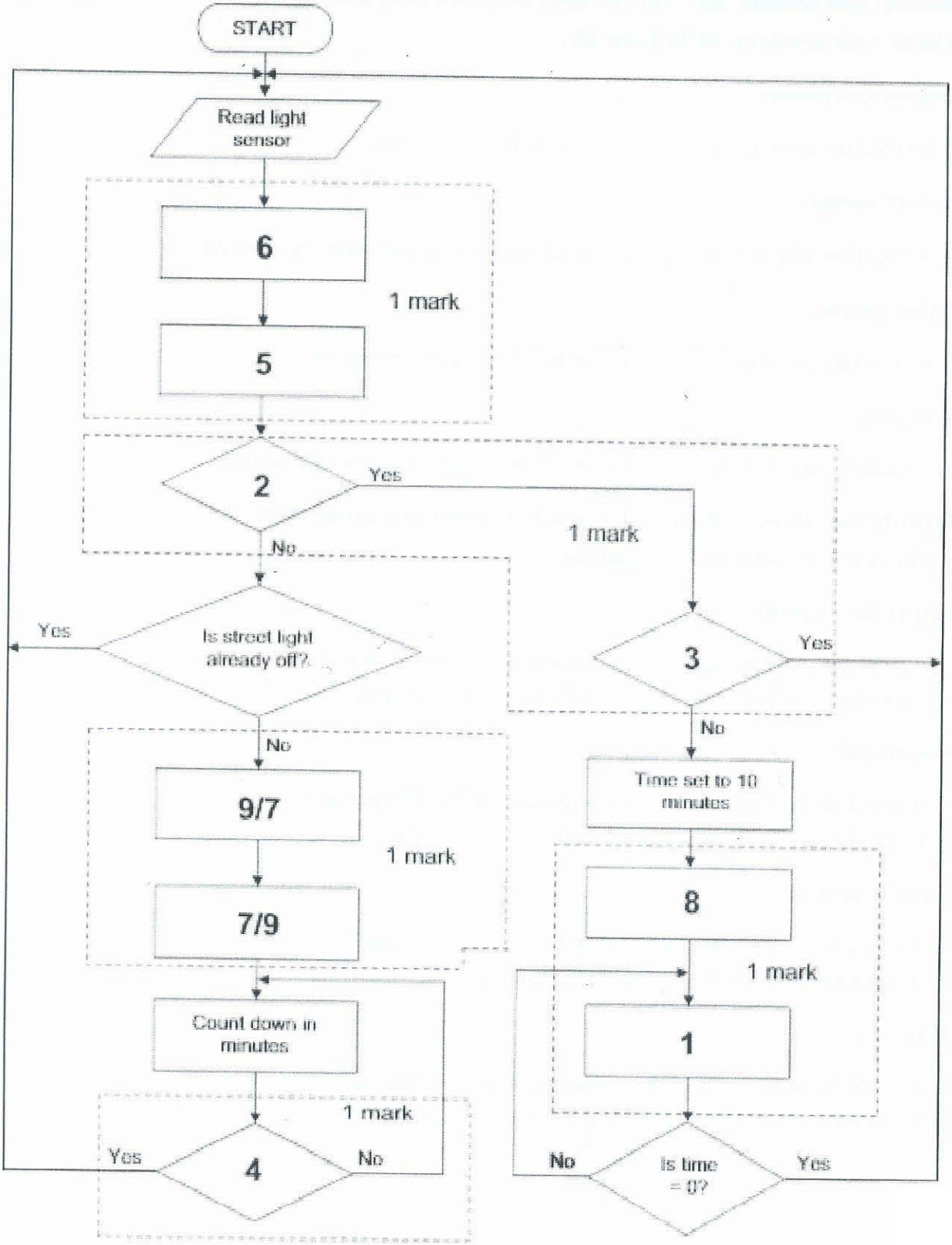
Several of the instructions have been omitted from the flowchart.

Using **item numbers only** from the list below, complete the flowchart.

Item number	Instruction
1	Count down in minutes
2	Is light reading <= 50?
3	Is street lamp already on?
4	Is time = 0?
5	The microprocessor compares the sensor reading with stored values
6	The sensor reading is sent to the microprocessor
7	Switch the street lamp off
8	Switch street lamp on
9	Time set to 10 minutes

[5]

Answer:


START
Read light sensor
6
5
1 mark
2
Yes
No
1 mark
Is street light already off?
Yes
No
3
Yes
No
9/7
7/9
1 mark
Time set to 10 minutes
8
1
1 mark
Count down in minutes
4
1 mark
Yes
No
Is time = 0?
No
Yes

Q3. Identify four sensors that could be used in the washing machine. State what each sensor could be used for.

1) Temperature sensor:

1. It could be used to monitor the temperature of the water.

2) Pressure sensor:

1. It could be used to monitor the level of the water in the washing machine.

3) Motion sensor:

1. It could be used to monitor whether the drum is still in motion.

4) pH sensor:

1. It could be used to monitor the level of detergent present in the water.

Q4. Identify four sensors that could be used in a farm that grows fruit. State what each sensor could be used for.

1) Temperature sensor:

1. It could be used to measure the temperature of the environment.
2. It can alert when it is too hot/too cold for the fruit to grow.

2) Light sensor:

1. It could be used to measure the brightness of the environment.
2. It can alert when the fruit has too little/too much light.

3) Moisture sensor:

1. It could be used to measure the water content of the soil.
2. It can alert when the soil is too dry or too wet.

4) pH sensor:

1. It could be used to measure how acidic/alkaline the soil is.
2. It can alert when there is something polluting the soil.

Sensors Working-related Questions:

Q1. A security light is controlled by sensors and a microprocessor.

Describe how the sensors and microprocessor interact to switch on the security light when an intruder is detected. [6]

- An infrared/motion/pressure sensor is used.
- When sensor detects movement, it continuously sends signal to the microprocessor.
- The analogue signals are converted from analogue to digital using ADC.
- The microprocessor compares the data received to a pre-set/pre-determined/stored value.
- If the value is outside the acceptable range, a signal is sent by the microprocessor to switch on the light and keep it on for a period of 30 seconds.
- If the value is within an acceptable range, no action is taken.
- The process is a continuous loop.

Q2. A cold store is kept at a constant low temperature using a sensor, a microprocessor and a cooling unit.

Explain how the sensor and the microprocessor will maintain a constant low temperature. [6]

- A temperature sensor is used.
- The sensor sends a signal to the microprocessor.
- The analogue signals are converted from analogue to digital using ADC.
- The microprocessor compares the data received to a pre-set/pre-determined/stored value.
- If the temperature value is too high or low, a signal is sent by the microprocessor to turn on or off the cooling unit.
- An actuator is used to turn the cooling unit on or off.
- If the temperature matches the stored value, no action is taken.
- The process is a continuous loop.

Q3. A factory uses a security system to control a security light. The system uses a sensor and a microprocessor.

Explain how the security system makes use of the sensor and the microprocessor to control the security light. [6]

- An infrared/motion sensor is used.
- The sensor sends a signal to the microprocessor.
- The analogue signals are converted from analogue to digital using ADC.
- The microprocessor compares the data received to a pre-set/pre-determined/stored value.
- If the value is outside the acceptable range, a signal is sent by the microprocessor to turn the security light on and wait for a suitable period.
- If no motion is detected, lights are turned off.
- If the value is within an acceptable range, no action is taken.
- The process is a continuous loop.

Q4. A system uses pH sensors and a microprocessor to help monitor pollution in a river. The pH of the water should be between 6 and 8. The system outputs and alert if the pH of the water is not in this range.

Explain how the system uses the pH sensors and the microprocessor to help monitor the pollution. [5]

- The sensor sends a signal to the microprocessor.
- The analogue signals are converted from analogue to digital using ADC.
- The microprocessor compares the data received to a pre-set/pre-determined/stored value.
- If the reading is > 8 or < 6, a signal is sent by the microprocessor to display a warning message on a monitor or activate an alarm.
- If the value is within an acceptable range, no action is taken.
- The process is a continuous loop.

Q5. An elevator (lift) has a maximum weight limit of 2400 kg. The weight carried is monitored by a sensor and a microprocessor.

Describe how the sensor and the microprocessor are used to make sure the maximum weight limit is not exceeded. [6]

- A pressure sensor is used.
- The sensor sends a signal to the microprocessor.
- The analogue signals are converted from analogue to digital using ADC.
- The microprocessor compares the data received to a pre-set/pre-determined/stored value.
- If the value is > 2400 kg, a signal is sent by the microprocessor to display a warning message to passengers and signal sent to actuator for stopping the lift from operating.
- If the value is <= 2400 kg, no action is taken.
- The process is a continuous loop.

Q6. An office has an automated lighting system. When movement is detected in the office the lights are switched on. If movement is not detected for a period of 2 minutes the lights are switched off. The system uses a sensor and a microprocessor.

Describe how the automated lighting system uses a sensor and a microprocessor. [6]

- A motion sensor is used.
- The sensor sends a signal to the microprocessor.
- The analogue signals are converted from analogue to digital using ADC.
- The microprocessor compares the data received to a pre-set/pre-determined/stored value.
- If the value is outside the acceptable range, a signal is sent by the microprocessor to actuator for switching lights on.
- A timer is set for 2 minutes and every time a movement is detected, the timer is reset.
- If the value is within an acceptable range, no action is taken.
- The process is a continuous loop.

Q7. A sensor and a microprocessor are used to monitor the pH of the cleaning products. The system records each reading that is taken. If the reading is greater than 7 a waning message is displayed on a monitor.

Explain how the sensor and microprocessor are used in the system. [6]

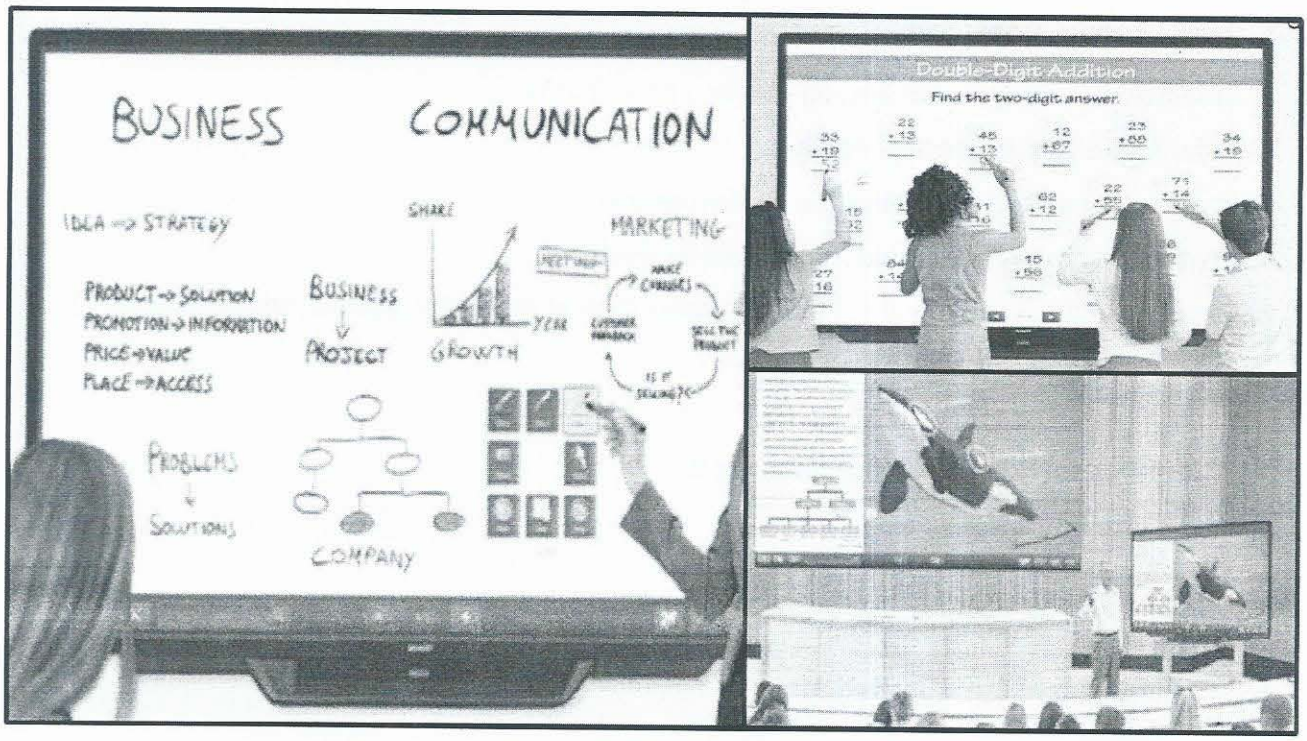
- The sensor sends a signal to the microprocessor.
- The analogue signals are converted from analogue to digital using ADC.
- The microprocessor compares the data received to a pre-set/pre-determined/stored value of 7.
- If the value is >7, a signal is sent by the microprocessor to display a warning message on a monitor or activate an alarm.
- If the value is within an acceptable range, no action is taken.
- The process is a continuous loop.

Q8. A business wants to use a biometric security system to control entry to the office. The system will use a biometric device and a microprocessor.

Explain how the biometric security system will make use of the biometric device and the microprocessor to control entry to the office. [6]

- A fingerprint scanner can be used. User will place their finger on touchscreen device so their finger gets scanned.
- The sensor in the fingerprint scanner will take readings of user.
- The readings are converted from analogue to digital using ADC.
- The readings are sent to the microprocessor.
- The readings are compared to stored values.
- If readings match, user can enter.
- If readings do not match then user is declined entry and alarm may sound to alert the security.

10) Interactive whiteboard:



- It is a **large input device** that is usually fixed to a wall.
- It **allow computer images to be displayed on a whiteboard using a digital projector.**
- A user can **calibrate the device to make sure the sensors align with a projected image.**

i) Working:

- It **allows a user to write on a surface** using a pen; **text and drawings are then captured electronically and stored** for later use.
- The user can **use either their finger or a special pen** to make selections.
- It is **possible to edit image by adding labels or descriptions.**

ii) Use:

1. It is used **mostly in meetings** to **discuss an idea and everyone can interact** by simply using their fingers on the Whiteboard surface.
2. The **information which is hand-drawn or hand written is stored** so **nothing from the meeting is lost.**
3. It is **used in classrooms** for teaching students.

iii) Advantages:

1. It **improves learning** among students and employees.
2. It **increases engagement** among meeting participants.
3. It facilitates **better communication.**
4. It allows for **effective annotation of documents.**
5. It allows for **interconnectivity with mobile devices.**
6. It **offers various tools** making the job **easier** such as magnifier, pointer, screen capture etc.

iv) Disadvantages:

1. It **requires sufficient training** for using it.
2. It **has size limitations.**
3. It **sometimes has projection problems.**
4. It is **comparatively expensive.**
5. It has **touch sensitive limitations.**

Output devices:

- An output device is any **hardware device** that **provides data in different forms**, some of which include **audio, visual and hard copy media**.
- The devices are usually used for **display, projection** or for **physical reproduction**.
- The output devices included in our syllabus are:
    11. inkjet printers
    12. laser printers
    13. 3D printers
    14. 2D/3D cutters
    15. actuators
    16. loudspeakers
    17. LCD/LED monitors
    18. projectors (LCD and DLP)

1) Inkjet printers:

Inkjet Printers

i) They consist of:

- A **print head** which consists of **nozzles** that **spray droplets of ink** on to the paper to form characters.
- An **ink cartridge** or cartridges.
- A **stepper motor and belt** which moves the print head assembly across the page from side to side.
- A **paper feed** which automatically feeds the printer with pages as they are required.

It has **small ink cartridge** and **small paper tray**.

ii) Working:

- It uses **rollers** which **move the paper** through the printer.
- The **nozzles spray ink** onto the paper.
- A **print head** moves across the paper to **distribute the ink**.
- **Different color inks** are mixed to create required colors.

iii) The droplets of ink are propelled onto paper using either thermal bubble or piezoelectric technology:

1) Thermal bubble:

- **Tiny resistors** create **localized heat** which makes the **ink vaporize**.
- Ink forms a **tiny bubble** and as it **expands** some of the **ink is ejected** from print head onto the paper.
- Then the **bubble collapses** and a **small vacuum is created** which allows fresh ink to be drawn into print head.

2) Piezoelectric:

- A **crystal** is located at the **back of the ink reservoir for each nozzle**.
- The crystal is given a **tiny electrical charge** which makes it **vibrate**.
- This **vibration forces droplets of ink** to be ejected onto paper through the nozzle.

iv) Advantages:

1. It prints out **high quality photos/pages**.
2. It is **more reliable**.

v) Disadvantages:

1. It is **expensive** as cost per page is high.
2. It is **slower** compared to laser printer.

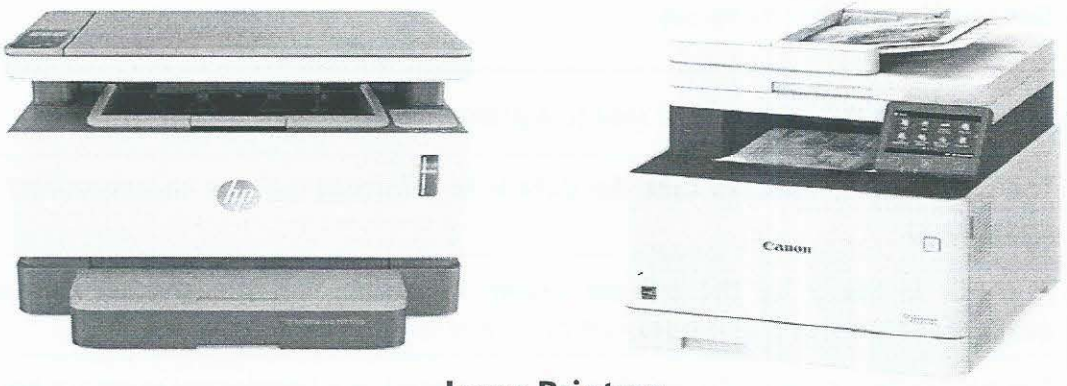
vi) Application:

1. It is used for **production of one-off photographs** of very **good quality**.
2. It is used when only a few pages of **good quality, color printing** are needed.
3. It is used when **small quantities of documents** are to be printed.

vii) Sequence of events during printing:

Stage in process	Description of what happens
1	The data from the document is sent to a **printer driver**.
2	The printer driver **ensures that the data is in a format** that the chosen printer can understand.
3	A **check is made by the printer driver** to ensure that the **chosen printer is available to print** (e.g. is it busy, is it off line, is it out of ink, and so on).
4	The **data is then sent to the printer** and it is **stored in a temporary memory known as a printer buffer.**
5	A **sheet of paper is then fed** into the main body of the printer; a **sensor detects whether paper is available** in the paper feed tray – if it is out of paper (or the paper is jammed) then an **error message is sent back** to the computer.
6	As the sheet of paper is fed through the printer, the **print head moves from side to side across the paper** printing the text or image; the **four ink colors are sprayed** in their exact amounts to produce the desired final color.
7	At the end of each full pass of the print head, the **paper is advanced very slightly to allow the next line to be printed**; this continues until the whole page has been printed.
8	If there is more data in the printer buffer, then the **whole process from stage 5 is repeated until the buffer is finally empty.**
9	Once the printer buffer is empty, the **printer sends an interrupt** to the processor in the computer; this is a request for more data to be sent to the printer; the whole process continues until the whole of the document has been printed.

2) Laser printers:



Laser Printers

It has **large toner cartridge** and **large paper tray**.

i) Working:

- It makes uses of the **properties of static electricity**.
- Dry powder ink called **toner** is used.
- A **laser beam removes positive charges** in certain areas.
- It then uses **positive and negative charged rotating drums**.
- The paper then goes through a **fuser which makes the ink permanent**.
- Then a **discharge lamp removes all electric charges** from drum making it ready to print further pages, if any.
- It does **not have any moving head.**

ii) Advantages:

1. It has a **very high printing speed**.
2. It produces a **very high quality output**.

iii) Disadvantages:

1. It is **expensive** to buy.

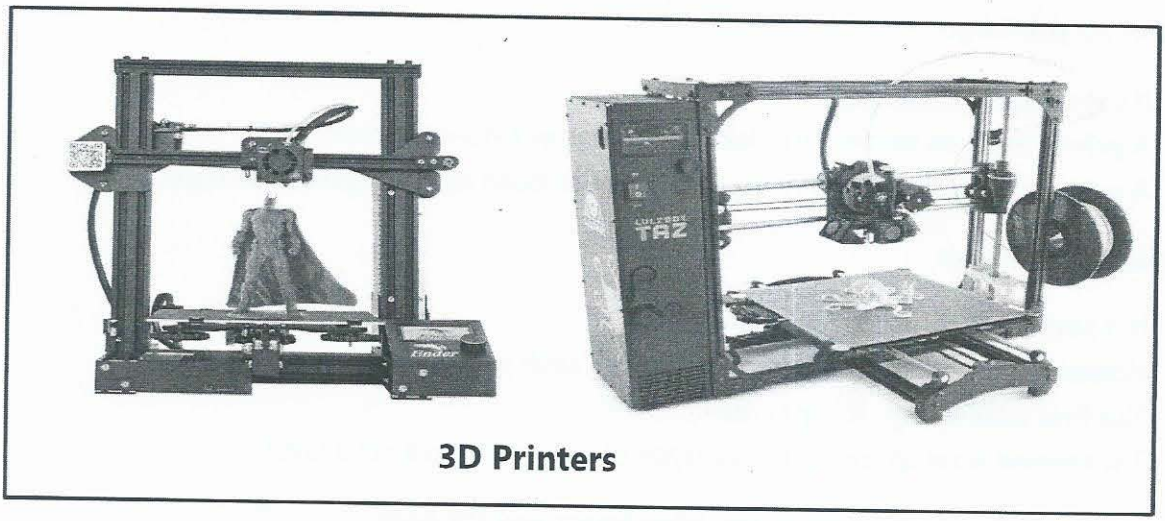
iv) Application:

1. It is used for **producing a large number (e.g. 2000) of high quality flyers, leaflets, magazines and posters** for advertising.
2. It is used when **large quantities of documents** are to be printed.

v) Sequence of events during printing:

Stage in process	Description of what happens
1	The data from the document is sent to a **printer driver.**
2	The printer driver **ensures that the data is in a format** that the chosen printer can understand.
3	A **check is made by the printer driver** to ensure that the **chosen printer is available to print** (e.g. is it busy, is it off line, is it out of ink, and so on).
4	The data is then **sent to the printer** and it is **stored in a temporary memory known as a printer buffer.**
5	The start of the printing process involves a **printing drum being given a positive charge**; as this drum rotates, a **laser beam is scanned** across it **removing the positive charge** in certain areas; this **leaves negatively charged areas** which exactly match the text/images of the page to be printed.
6	The **drum is then coated with positively charged TONER** (powdered ink); since the toner is positively charged, it **only sticks to the negatively charged parts** of the drum.
7	A **negatively charged sheet of paper is then rolled** over the drum.
8	The **toner on the drum now sticks to the paper** to produce an exact copy of the page sent to the printer.
9	To prevent the paper sticking to the drum, the **electric charge on the paper is removed after one rotation** of the drum.
10	The paper finally **goes through a fuser which is a set of heated rollers**; the heat **melts the ink so that it fixes permanently** to the paper.
11	At the very end, a **discharge lamp removes all the electric charge** from the drum making it ready to print the next page.

3) 3D printers:



3D Printers

- They are primarily used in **computer-aided design (CAD) applications.**
- They can produce **working 3-dimensional solid objects.**

i) Working:

- The solid object is **built up layer by layer** using materials such as **powdered resin, powdered metal, plastic, paper or ceramic powder**.
- They use **additive manufacturing**.
- Additive manufacturing is a process that **adds successive layers of material to create an object** (e.g. building up the object layer by layer).

ii) The more traditional method is:

- **Subtractive manufacturing**.
- It involves **removing sections or portions of a material by machining or cutting it away** to make it into any shape we want, for making the object.
- Similarly, **CNC machining removes metal to form an object**; hence it uses subtractive manufacturing method.

iii) An example to show the difference between additive and subtractive manufacturing:

- If we have to make a statue using 3D printing, **additive method would involve building it up layer by layer using powdered stone** until the final object is formed.
- The **subtractive method would involve carving the statue out of solid stone** (e.g. removing the stone not required) until the final item is produced.

Be very clear that additive manufacturing (building up layer by layer) is called 3D printing. Subtractive manufacturing is not 3D printing or any method of 3D printing

iv) There are two technologies of 3D printing:

1) Direct 3D printing:

- It uses **inkjet technology**.
- A **print head can move from left to right** as in a normal printer.
- A **print head can also move up and down** to build up the layers of an object.

2) Binder 3D printing:

- It is **similar to direct 3D printing**.
- However, this method **uses two passes for each of the layers**.
- The **first pass sprays dry powder**.
- The **second pass sprays a binder** (type of glue) to form a solid layer.

However, the newer technologies are using lasers and UV light.

v) The following are the steps involved in 3D printing:

A design is made using **computer-aided design (CAD) software.**

↓

The finalized drawing is **imported into some special software** that prepares it in a format which is understood by the 3D printer.

↓

The **3D printer is set up** to allow the solid object to be made.

↓

The solid **object is built up layer by layer** (often only 0.1 mm thick); this can take several hours, depending on the thickness of the layers, the material used and the size of the final object.

↓

The **object is removed from the printer and is then prepared**; for example, some use a jelly-like support which needs to be washed away by immersion in water, some require the removal of excess plastic powder and others require the cutting away of unused material; in many cases, the object has to be left to 'cure' for a few hours.

vi) Uses of 3D printing:

1. A **physical model** can be made **from a blueprint**.
2. It is used to **make prosthetic limbs** that exactly fit the recipient.
3. It is used to **make items that allow precision reconstructive surgery**.
4. It is used in **aerospace**; wings and other parts are made due to precision and lightweight.
5. It is used for **making suspension parts for a vintage car** that are no longer in production.

4) 2D and 3D cutters:

- A two-dimensional (2D) and three-dimensional (3D) cutter is a **high powdered laser that cuts materials** such as **thin metals or wood**.

i) Working:

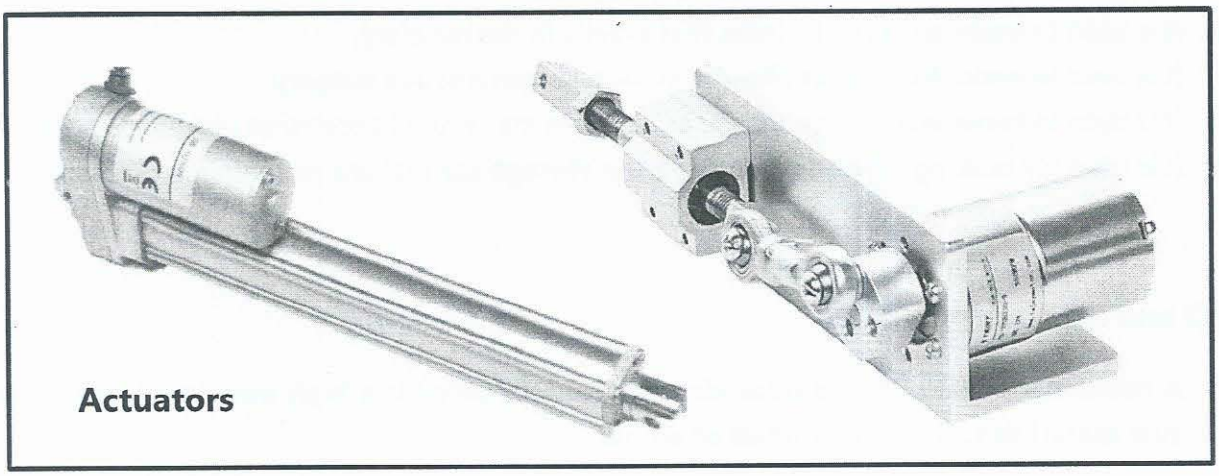
- Both 2D and 3D cutters work almost in a similar way.
- 2D cutter is a **high powered laser that uses the x-y plane.**
- 3D cutter is a **high powered laser that uses the x-y-z plane.**
- 3D cutters can cut the following materials:

1) glass
2) wood
3) crystal
4) metal
5) polymer

ii) Advantages:

1. Very **complex designs can be cut** since the **cutters are controlled by computers and very sophisticated software.**
2. A **3D cutter can cut beyond the surface of the material** and **produce very intricate designs.**

5) Actuator:



Actuators

- It is an **electromechanical device.**
- It is a component of a machine that is **responsible for powering and moving a motor in machinery**, such as a robot arm in a factory.
- It is **responsible for moving and controlling a mechanism or system**, for example by opening a valve.
- An actuator **requires a control signal and a source of energy.**

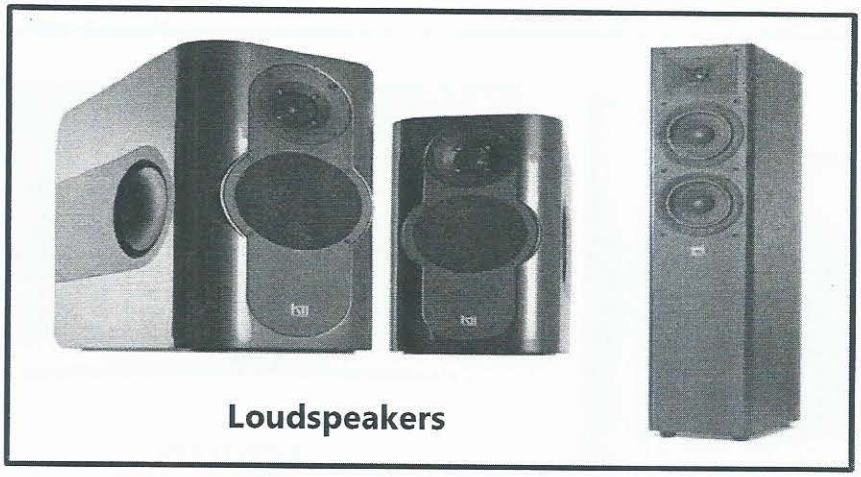
i) Uses:

1. It is mainly used in many **control applications involving sensors and devices such as ADC and DAC.**

ii) Examples of actuators:

1. Electric motor.
2. Comb drive.
3. Digital micro mirror device.
4. Hydraulic cylinder.
5. Screw jack.

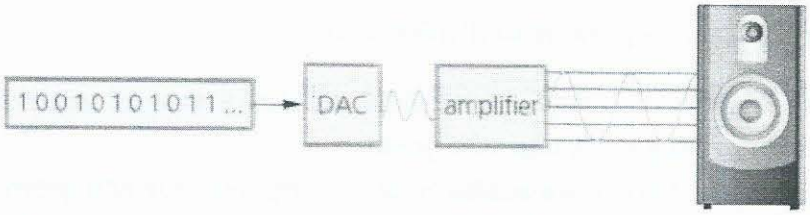
6) Loudspeakers/headphones:



Loudspeakers

i) Working:

- A **sound is produced** from a computer **by passing the digital data through a digital-to-analogue converter (DAC).**
- DAC translates the **digital output into analogue voltages**.
- It is then **passed through an amplifier** so the sound emerges from a loudspeaker.
- The sound is **produced by voltage differences vibrating a cone in the speaker housing at different frequencies and amplitudes**:



ii) The sampling rate:

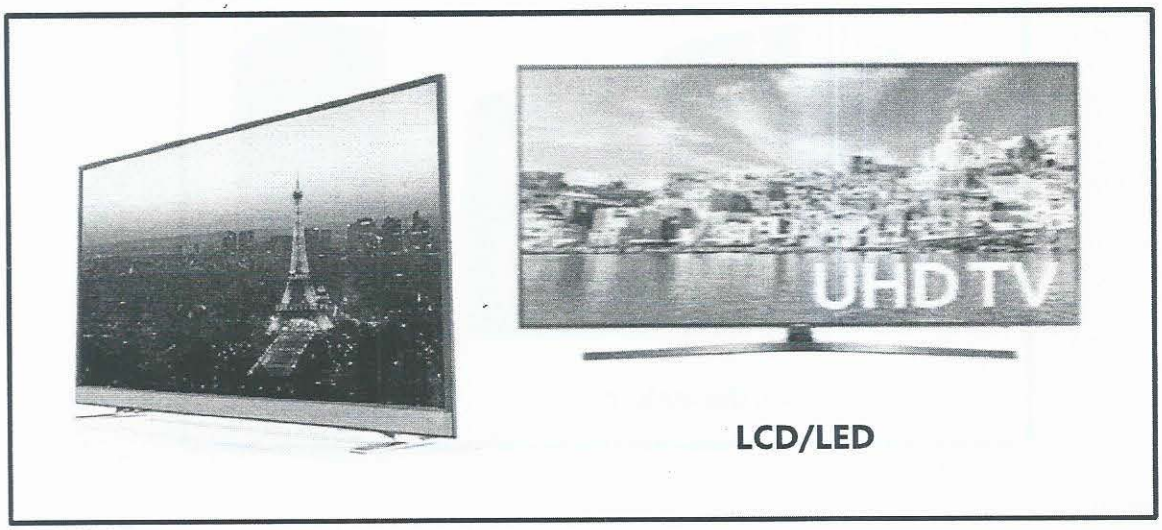
- The **rate at which the DAC can translate the digital output into analogue voltages** is known as sampling rate.
- The **standard sampling rate is 44 100** samples per second.

Q1. A CD is being produced to contain a number of music tracks. Each piece of music is sampled 44 100 times a second. Each sample is 16 bits. The music is in stereo. Find out how many bytes are sampled per second.

Since the music is in stereo, we will multiply the values with 2

1. The sampling rate x 16 bits x 2 (stereo) = 44 100 x 16 x 2 = **1 411 200 bits per second.**
2. 1 411 200 bits / 8 = **176 400 bytes per second sampling.**

7a) Liquid Crystal Display/Diode (LCD):



LCD/LED

- It is a **flat panel display** that **uses the light modulating properties of liquid crystals**.
- The screen is made up of **liquid crystal diodes**.
- These tiny **diodes are grouped together in blocks of red, green and blue pixels** (those systems that use groups of four include a yellow diode and it makes the colors more vivid).
- The screen **uses layers of different types of liquids**.

i) Describe how an LCD screen operates to display data.

- The display of a LCD screen is **made up of pixels** that are **arranged together as a matrix**.
- Each **pixel has three filters** red, blue and green.
- The **different shades of color are achieved by mixing** red, blue and green.
- The **screen is backlit using some form of technology such as CCFL or LED.**
- The **light is shone through the liquid crystals** and they can be **made to turn solid or transparent (on or off)** by changing their shape.

ii) Backlighting of LCD:

- **LCD doesn't emit any light**, some form of **back-lit technology needs to be used**.
- Modern LCD monitors are **back lit using light emitting diode (LED) technology** which gives the image better contrast and brightness.
- When LEDs are used, a **matrix of tiny LEDs is used behind the LCD screen**.
- Before the use of LEDs, LCD monitors used a **cold cathode fluorescent lamp (CCFL) as the backlighting method.**
- Essentially, **CCFL uses two fluorescent tubes behind the LCD screen** which supplies the light source.

b) Light Emitting Diode (LED):

- It is a **flat panel display** that **uses an array of light-emitting diodes as pixels.**

i) Advantages of using LEDs compared with older CCFL technology:

1. LEDs **reach their maximum brightness almost immediately** (there is no need to 'warm up' before reaching full efficiency).
2. LEDs **give a whiter light which sharpens the image and make the colors appear more vivid**; CCFL had a slightly yellowish tint.
3. LEDs **produce a brighter light** which improves the colour definition.
4. The monitors using LED technology are **much thinner** than monitors using CCFL technology.
5. LEDs **last almost indefinitely** which makes the technology **more reliable** and means a more consistent product.
6. LEDs **consume very little power** which means they **produce less heat as well as using less energy.**

c) Organic Light Emitting Diode (OLED):

Future LED technology is making use of **organic light emitting diodes (OLEDS).**

- These use **organic materials** (made up of carbon compounds) to **create semi-conductors which are very flexible.**
- **Organic films are sandwiched** between **charged metallic cathode** and a **glass anode.**
- When an **electric field is supplied to the electrodes, they give off light.**
- This means that **no form of backlighting** is required.
- It also removes the need to use LCD technology, since **OLED is a self-contained system.**

i) Advantages of using OLED compared with existing LEDs and LCDs include:

1. The plastic, organic layers of an OLED are **thinner, lighter and more flexible** than the crystal structures used in LEDs or LCDs.
2. The light-emitting layers of an OLED are **lighter and these layers can be made from plastic rather than the glass** used in LED and LCD screens.
3. OLEDs **give a brighter light** than LEDs.
4. OLEDs **do not require backlighting** like LCD screens as they generate their own light.
5. They use **much less power** than LCD screens as **no backlighting is required** (this is very useful in battery-operated devices such as mobile phones).
6. OLEDs are **essentially plastics and so they can be made into large, thin sheets** (this means they could be used on large advertising boards in airports, subways, and so on).
7. OLEDs have a **very large field of view, about 170 degrees**, which makes them ideal for use in television sets and for advertising screens.

d) Uses of these technologies:

They are used in:

1. television screens
2. computer monitors
3. portable systems with touchscreens
4. smartphones
5. tablets
6. handheld game consoles

Exam Style Questions:

Q1. Modern LCD monitors and television use LED back-lit technology.

Give two advantages of using this new technology compared to the older cold cathode fluorescent lamp (CCFL) method. (2)

- LED's do not need to warm up and reach maximum brightness immediately.
- LED gives a whiter tint which makes colors appear more vivid.
- LED provides a higher resolution display.
- LED allows for much thinner monitors with lighter weights.
- LED is a more reliable technology and longer lasting.
- LED uses much less power and it is more efficient.

Q2. Modern Liquid Crystal Display (LCD) monitors use Light-Emitting Diode (LED) backlit technology.

Give four benefits of using LED technology. (4)

- It reaches maximum brightness quickly.
- The colors are vivid and brighter.
- It provides with a good colour definition.
- It allows for screens to be made thinner.
- It is more reliable as LED's are long lasting.
- It consumes very little power/energy.

8) Light Projectors:

Projectors

There are two common types of light projector:

1. Digital light projectors (DLP)
2. LCD projectors

Projectors are used to **project computer output onto larger screens, walls or even onto interactive whiteboards**. They are often **used in presentations** and in **multimedia applications**.

1) Digital Light Projector (DLP):

- It uses a **bright white light source and micro mirrors on a chip** to produce an image to be shone onto a wall or screen through lens.

i) Working:

- It uses a **millions of micro mirrors on a small DLP chip** and the **number of mirrors along with their arrangement on the chip determines the resolution** of the digital image.
- When the **micro mirrors tilt towards the light source, they are on** and when they **tilt away from the light source, they are off** which creates a light or dark pixel of projection screen.
- It **can switch on or off several thousand times a second** creating various grey shades (typically 1024 grey shades).
- A **bright white light source** (e.g. from a xenon bulb) **passes through a colour filter** on its way to the DLP chip.
- The **white light is split into red, green and blue** while the on and off states of each micro mirror are linked with colors from the filter to produce the coloured image.

ii) Features:

- The DLP projector can **create over 16 million different colors**.

iii) Advantages:

1. It produces a **smoother video**.
2. It has a **higher contrast**.
3. It is **smaller, lighter and easily portable**.
4. The **pixels are less visible**.

iv) Disadvantages:

1. It has **more moving parts** and therefore **produces more heat**.
2. It **produces audible sounds** while running.
3. It **produces poorer reds and yellows color** when running at full power.
4. The **picture quality is poorer** than LCD projectors.

2) LCD Projector:

- It is an **older technology** than DLP.
- It **uses a high intensity beam of light** shone through three layers of changing pixels.

i) Working:

- A **powerful beam of white light is generated from a bulb or LED** inside the projector body.
- This **beam of light is then sent to a group of chromatic-coated mirrors** which **reflect the light back at different wavelengths** corresponding to red, green and blue light components.
- These **three different coloured light components pass through three LCD screens** and a red, green and blue version of the grey image emerges.
- These **images are then combined using a special prism** to produce a full colour image which consists of millions of colors.
- Finally the **image passes through the projector lens onto a screen**.

ii) Advantages:

1. It **produces richer color dynamics in ambient light**.
2. It **consumes less power** and therefore **produces less heat.**
3. It **runs quieter**.
4. It **produces a sharper image** which has a better quality than DLP projectors.

iii) Disadvantages:

1. It has **more visible pixels**.
2. It has a **poorer contrast**.
3. It is **bulkier and not very convenient for portability**.

General Questions:

Q1. What is meant by automatic data capture?

- It means **saving and collecting data with no actual need for human interaction**.

Q2. Name the devices used for automatic data capture.

1. Barcode reader/scanner.
2. Document scanner.
3. Magnetic stripe reader.
4. Smart card reader.
5. Finger print reader.
6. Retina scanner.
7. Microphone.
8. Digital (video) camera.
9. OCR.
10. OMR.
11. RFID reader (radio frequency identification – used in electronic tagging).

Q3. Give different types of device that allow human beings to interface with computer systems.

1. Keyboard (type in the responses).
2. Touch screen (select options from on screen menus).
3. Mouse/trackerball/touchpad (click on options from a menu).
4. Microphone (speak options).
5. Data gloves/goggles.
6. Camera.

Exam Style Questions:

Q1. A remote controlled model car contains RAM. ROM and a solid state drive. The car receives radio signals from its remote control. It can only receive radio signals of a certain frequency. The manufacturer sets this frequency and the owner cannot change it. The owner of the model car can input their own sequence of movements from an interface underneath the car.

The owner needs to be able to enter their own sequence of movements for the model car.

(i) Name a suitable input device. [1]

- Touch screen or key pad (NOT keyboard).

(ii) Give a reason for your choice. [1]

- It has an easy to use interface.
- It has limited number of options.
- It has small space/space is limited.
- The other devices such as mouse, keyboard, trackerball etc. are not suitable.

Q2. A business wants to use a biometric security system to control entry to the office.

The system will use a biometric device and a microprocessor.

Explain how the biometric security system will make use of the biometric device and the microprocessor to control entry to the office. [6]

- A suitable biometric device, such as a fingerprint scanner/retina/eye/iris scanner/face recognition/voice recognition/palm scanner will be used.
- The sensor in biometric device will capture and take data/readings of user.
- The data/readings are converted from analogue to digital using ADC.
- The data/reading is sent to the microprocessor.
- The data/readings are compared to pre-set or stored values/data.
- If data/readings match with stored value, then the user can enter.
- If data/readings do not match with stored value, then the user is declined entry or user is asked to try again.
- An alert may be sent to security or an alarm may sound in case the user tries to access the office unauthorized.
- The process is a continuous loop.

Q3. Input and output devices are often connected to a personal computer.

(a) Identify three input devices that can be connected to a personal computer. [3]

- Any three input devices studied in the whole chapter can be written here.

(b) Identify three output devices that can be connected to a personal computer. [3]

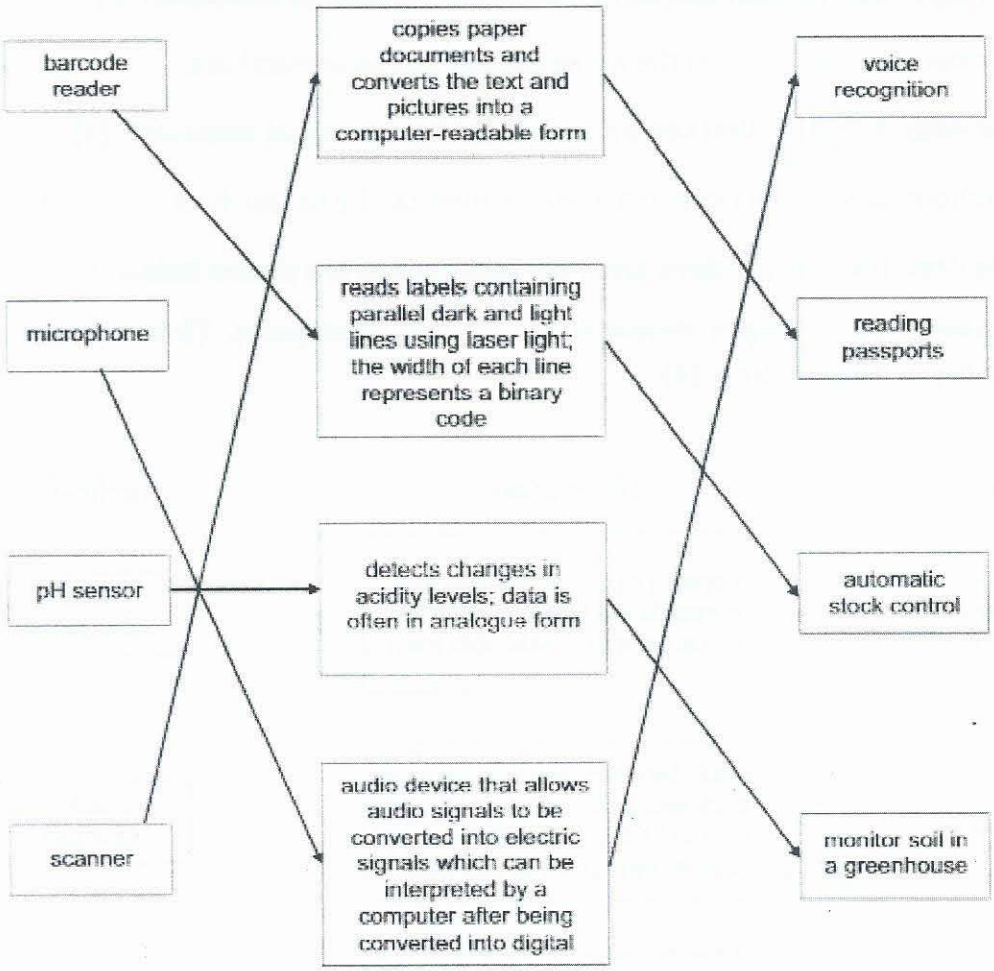
- Any three output devices studied in the whole chapter can be written here.

Q4. Four input devices, four descriptions and four applications are shown below.

Draw a line to connect each input device to its correct description. Then connect each description to its correct application. [6]

Input device	Description	Application
barcode reader	copies paper documents and converts the text and pictures into a computer-readable form	voice recognition
microphone	reads labels containing parallel dark and light lines using laser light or LEDs; the width of each line represents a binary code	reading passports
pH sensor	detects changes in acidity levels; data is often in analogue form	automatic stock control
scanner	device that allows audio signals to be converted into electric signals; these can be interpreted by a computer after being converted into digital form	monitor soil in a greenhouse

Answer:

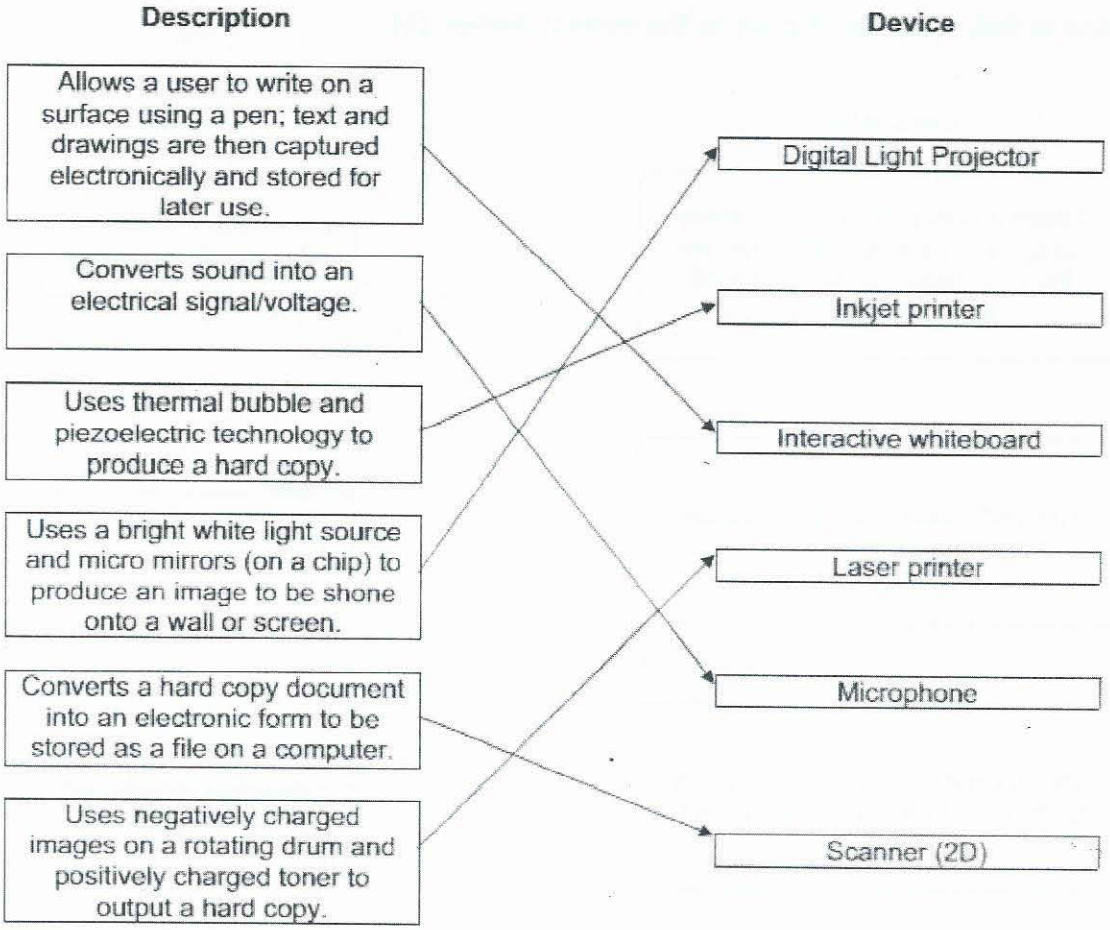

barcode reader
microphone
pH sensor
scanner
copies paper documents and converts the text and pictures into a computer-readable form
reads labels containing parallel dark and light lines using laser light; the width of each line represents a binary code
detects changes in acidity levels; data is often in analogue form
audio device that allows audio signals to be converted into electric signals which can be interpreted by a computer after being converted into digital
voice recognition
reading passports
automatic stock control
monitor soil in a greenhouse

Q5. Six descriptions and six devices are shown below.

Draw a line to link each description to the correct device. [5]

Description	Device
Allows a user to write on a surface using a pen; text and drawings are then captured electronically and stored for later use.	Digital Light Projector
Converts sound into an electrical signal/voltage.	Inkjet printer
Uses thermal bubble and piezoelectric technology to produce a hard copy.	Interactive whiteboard
Uses a bright white light source and micro mirrors (on a chip) to produce an image to be shone onto a wall or screen.	Laser printer
Converts a hard copy document into an electronic form to be stored as a file on a computer.	Microphone
Uses negatively charged images on a rotating drum and positively charged toner to output a hard copy.	Scanner (2D)

Answer:


Description
Device
Allows a user to write on a surface using a pen; text and drawings are then captured electronically and stored for later use.
Converts sound into an electrical signal/voltage.
Uses thermal bubble and piezoelectric technology to produce a hard copy.
Uses a bright white light source and micro mirrors (on a chip) to produce an image to be shone onto a wall or screen.
Converts a hard copy document into an electronic form to be stored as a file on a computer.
Uses negatively charged images on a rotating drum and positively charged toner to output a hard copy.
Digital Light Projector
Inkjet printer
Interactive whiteboard
Laser printer
Microphone
Scanner (2D)

May/June 2020 (12) Questions:

Q1. **Six** statements are given about touch screen technology.

Tick (✓) to show if the statement applies to **Capacitive** or **Resistive** touch screen technology.

Statement	Capacitive (✓)	Resistive (✓)
Needs pressure to be applied to create a circuit		
May not register a touch if the user is wearing gloves		
More commonly used in smartphones		
More responsive to a touch		
Needs an electrical field to be changed to register a touch		
Cheaper to manufacture		

[6]

Answer:

Statement	Capacitive (✓)	Resistive (✓)
Needs pressure to be applied to create a circuit		✓
May not register a touch if the user is wearing gloves	✓	
More commonly used in smartphones	✓	
More responsive to a touch	✓	
Needs an electrical field to be changed to register a touch	✓	
Cheaper to manufacture		✓

Q2. **(b)** State **two** benefits and **one** drawback of Leonard using a laser printer, instead of an inkjet printer, to print the letters.

Benefit 1 .....

.....

Benefit 2 .....

.....

Drawback .....

.....

[3]

Answer:

(b) **Two** marks for benefits, **one** mark for drawback

Benefits:

- Faster speed of printing
- Can print duplex / on both sides
- Many letters can be printed from one toner cartridge
- Can print in high volumes

Drawback

- Toner cartridge more expensive to buy
- More time to warm-up
- Larger footprint