STUDY AND REVISION GUIDE

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Information and Communication Technology

Second Edition

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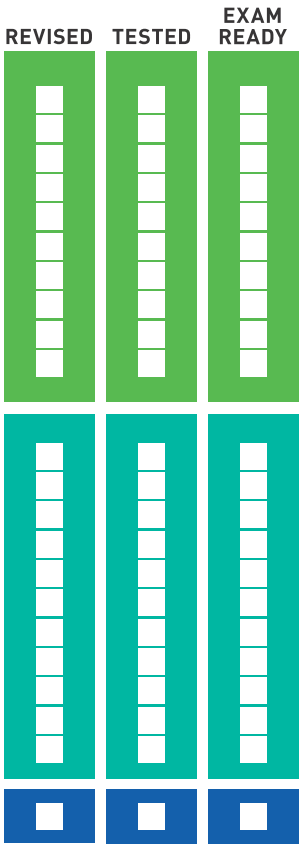
Contents



1 Types and components of computer systems

Key objectives

The objectives of this chapter are to revise:

- hardware and software:
  - types of hardware and software
  - analogue and digital data types
  - central processing unit/microprocessor
  - internal memory (RAM, ROM)
  - input and output devices
  - backing store
  - operating systems
- types of computer
- emerging technologies.

1.1 Hardware and software

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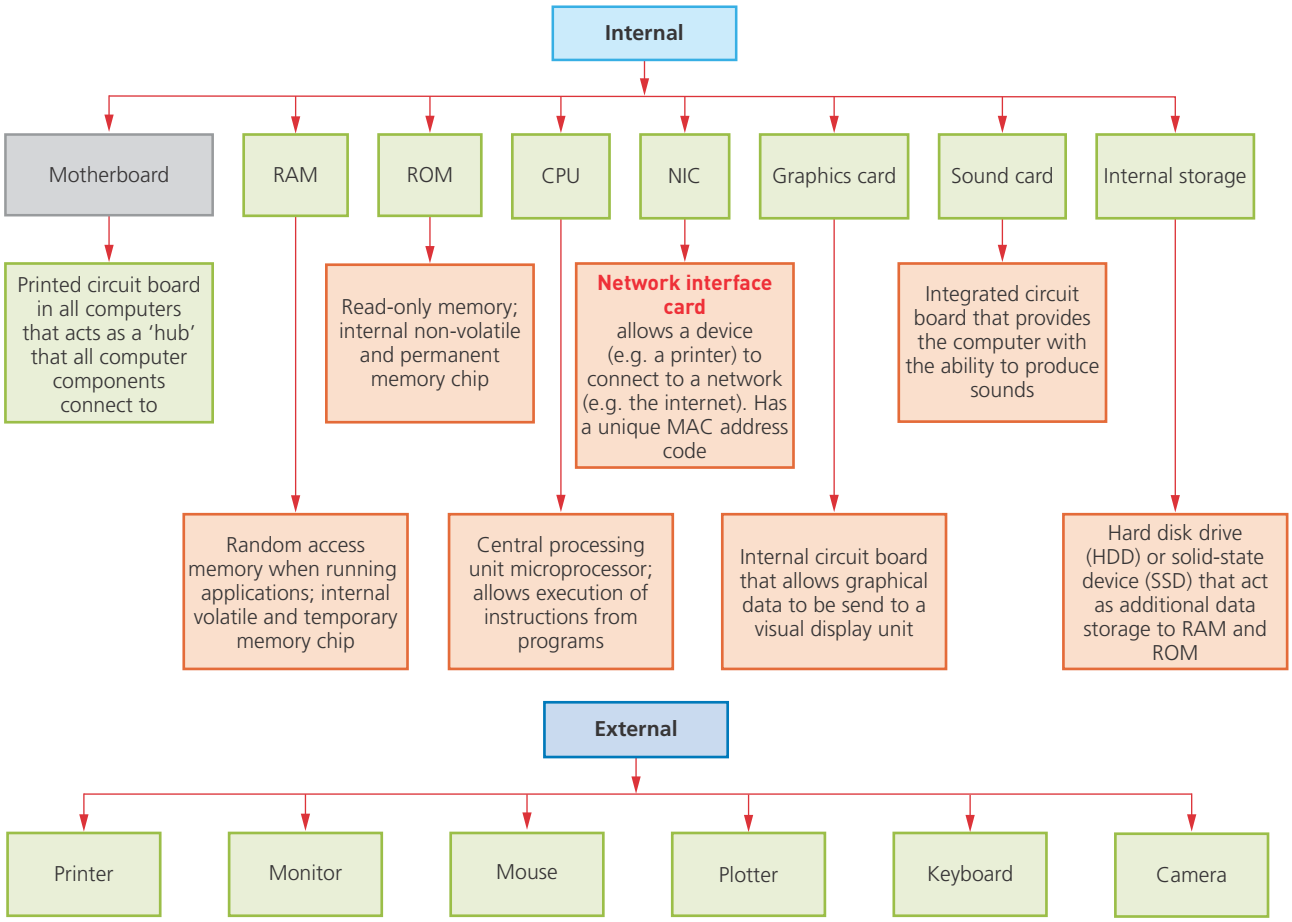
1.1.1 Types of hardware

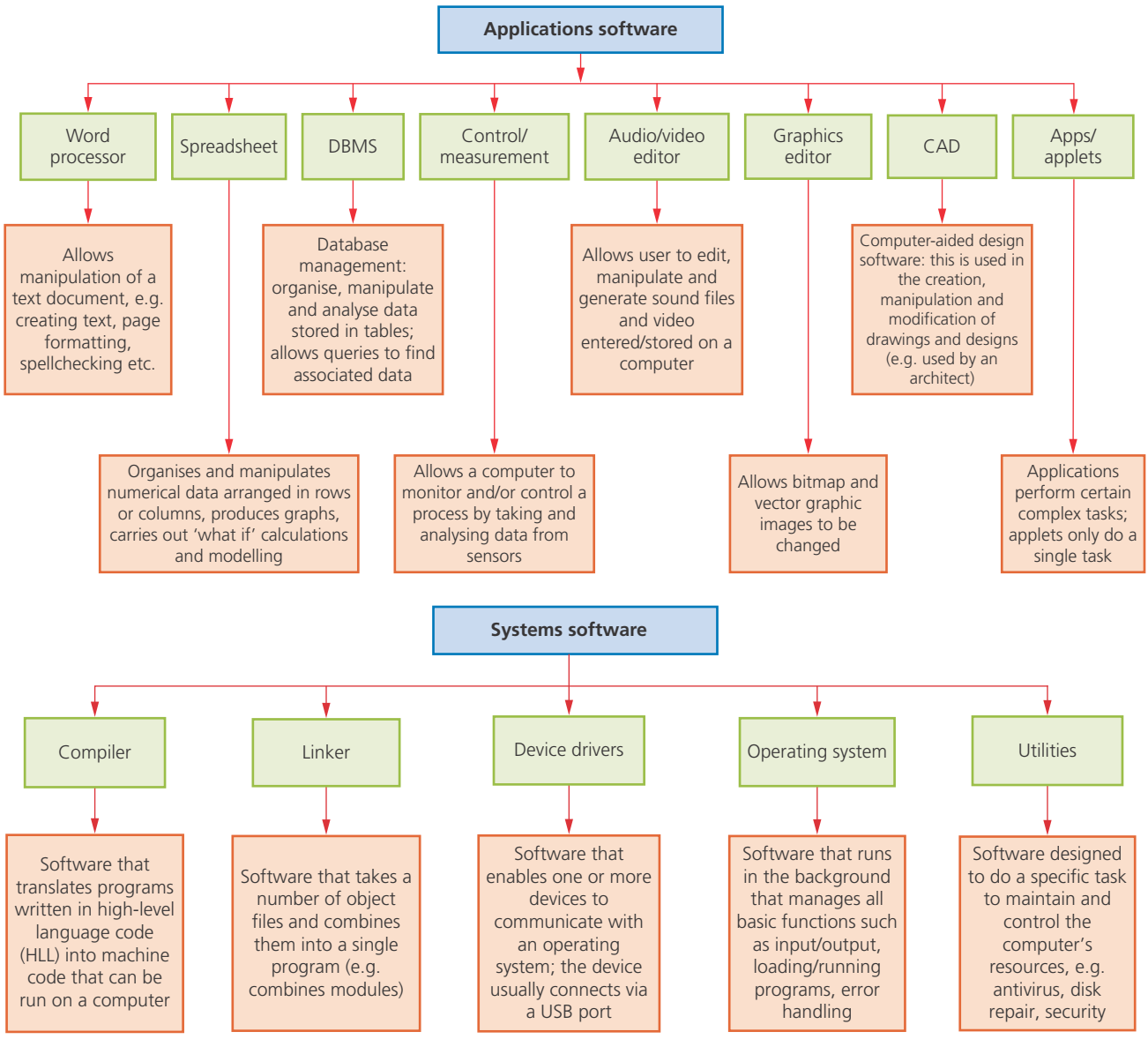
Hardware refers to the physical components that make up any typical computer system. These components can be internal or external to the computer.



1.1.2 Types of software

Software is a general term used for programs that control the computer system and process data; software can be applications software or system software.

Applications software provides the services that the user requires to solve a particular task. **System software** is designed to provide a platform on which all other software can run. Examples of both include:



1.1.3 Analogue and digital data

Computers can only understand data that is in a binary format (i.e. 0s and 1s only). This is referred to as **digital data** which is in contrast to **analogue data** found in the real world.

Analogue data is physical data that is continuous and not discrete in nature; it can have an infinite number of values. Digital data is written in binary format; the data is discrete and can only have specific values. The accuracy of digital data depends on how many bits are used to represent the data values. If analogue data needs to be sent to a computer, it must first be converted into digital data. If a computer needs to control a device (for example a motor), then the digital output must be converted into an analogue form. To convert data from analogue to digital requires an **analogue-to-digital converter** and to convert from digital to analogue requires a **digital-to-analogue converter**.

1.2 Main components of computer systems

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1.2.1 Central processing unit

The **central processing unit (CPU)** is a computer component that interprets and executes commands from computer hardware and software. It is usually part of the motherboard. The main components of the CPU are the control unit and arithmetic logic unit (ALU). It is often referred to as a **microprocessor**.

1.2.2 Internal memory and backing storage

Random access memory (RAM) is an internal memory chip where data is stored temporarily. The contents of RAM are lost when the computer is powered down. **Read-only memory (ROM)** is also an internal memory chip and stores data permanently; the data is retained even when the computer is powered down.

ROM also contains coding known as a **boot file**. This file tells the computer what to do when it first starts up. **Basic input-output system (BIOS)** is also part of this start-up procedure; here BIOS stores computer settings on a **complementary metal oxide semiconductor (CMOS)** chip.

This table summarises the differences between RAM and ROM:

RAM	ROM
Temporary memory so data can be changed	Permanent memory so data cannot be changed
Volatile memory – contents lost when power turned off	Non-volatile memory – contents retained even when power turned off
Can be written to and read from	Can only be read from
Stores data, files, part of operating system currently in use	Used to store BIOS and other start-up data
Can be increased in size to improve computer's performance	

1.2.3 Input and output devices

Input devices allow data to be entered into a computer either manually (e.g. using a keyboard) or automatically (e.g. direct data entry such as QR code readers).

Output devices allow the results of a computer's processing to be shown in a human-readable form (e.g. monitor or printer). Note that some devices can be both input and output (e.g. a touchscreen). Input and output devices are covered in more detail in Chapter 2.

1.2.4 Backing storage

Although main memory is RAM and ROM, data to be kept permanently (that can also be altered) is stored on a backing store. Backing stores are generally either **hard disk drives (HDD)** or **solid-state drives (SSD)**.

Backing storage (usually solid state in modern computers) is used to permanently store data; but it can also be changed, added to or removed by the computer or user. Backing storage can also be hard disk (magnetic) or Blu-ray disc (optical) and it can be either internal or external to the computer.

Data access is slower than for RAM or ROM but backing storage is usually considerably larger (2 TB or 4 TB is not unusual). The cost per byte of storage is also much less for backing storage devices.

Tip

RAM and ROM are directly addressable (i.e. can be read directly) by the CPU but backing storage is not. The data must be loaded into RAM first before it can be used by the computer.

1.3 Operating systems

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An **operating system (OS)** is a type of software that enables a computer system to function and allows the user to communicate with the computer by:

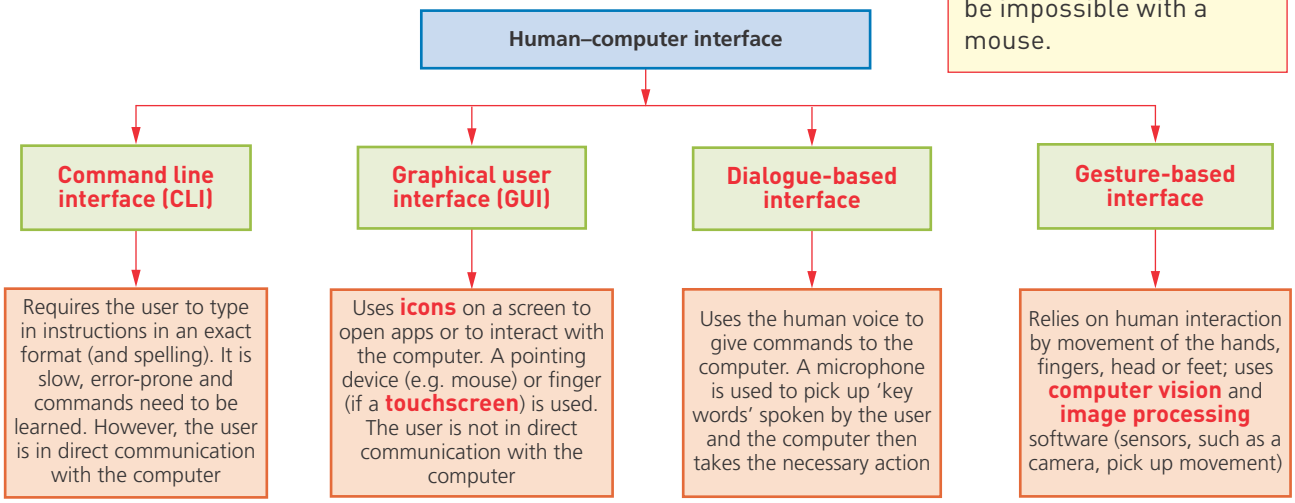
- controlling input/output devices and backing storage devices – this usually involves control of data flow
- supervising the loading, running and storage of applications (apps)
- dealing with errors as they occur
- maintaining security
- keeping a computer log of events
- allowing communication between computer and user.

Tip

A GUI is often called a **windows icons menu and pointing (WIMP)** device environment and is used by PCs not equipped with touchscreens. Modern devices, such as notebooks, tablets and smartphones, all use touchscreens and these adopt a post-WIMP environment – this interface allows fingers to be used to carry out tasks such as pinching and rotating, which would be impossible with a mouse.

1.3.1 User interfaces

In this part of the computer, we will consider four types of human–computer interface (HCI):



Sample questions and responses

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a Describe the advantages and disadvantages of using dialogue-based and gesture-based interfaces **[6 marks]**

b Give an example of where each type of interface is used. **[2 marks]**

Tip

This is a 'describe' question so it is necessary to give all the main facts, features and/or characteristics of both types of interface. No comparison of the two types of interface has been asked for. In the second part of the question, it is important that the examples given reflect the list of advantages and disadvantages; they should not be contradictory. Six marks are awarded in the first part; you would be expected to give a minimum of six features. It would be advisable to give three features of each type of interface.

Sample high-level answer

a) Advantages of dialogue based-interfaces:
- when used in a vehicle, there is no need for a driver to take their hands off the steering wheel to increase sound volume in a stereo, for example
- in a home this is very useful for people with disabilities, since many tasks can be carried out by the spoken word only
- it is possible to use this as a security feature, since voice recognition could be used to identify a person.

Disadvantages of dialogue-based interfaces:
- the system is still not that reliable, with many commands not being recognised or needing to be repeated several times (especially if there is background noise)
- dialogue-based interfaces can be quite complex to set up
- the user needs to know which commands can be used.

Advantages of gesture-based interfaces:
- replaces mechanical input devices
- there is no physical contact required
- it is a very natural interface for a human operator; no training is needed to interface with the computer.

Disadvantages of gesture-based interfaces:
- it is possible for unintentional movement to be picked up
- it only works fairly near to the camera or sensor (maximum of 1.5 metres)
- it can be limiting what the gesture-based system will accept (e.g. it may take several attempts to find out exactly what finger movements are recognised).

b) Dialogue-based systems could be used in the home by people with disabilities to do tasks such as close the curtains, switch on the lights (etc.) by simple verbal commands. Gesture-based systems could be used in a vehicle to open/close windows and doors or to alter the heating/air conditioning settings.

Sample low-level answer

a) The advantage of a dialogue-based interface is it allows a person with disabilities to control the opening and closing of curtains without them having to leave their seat. The biggest disadvantage would be verbal commands to control devices could annoy other people in the house.
The advantage of gesture-based interfaces would be in a car where the passenger finds the music too loud; they could gesture to the driver to turn the sound down. This, of course, could distract the driver which is an obvious disadvantage.

b) Dialogue-based interfaces could be used in the house by a person with disabilities to control devices without leaving their seat. Gesture-based interfaces could be used in a car to let the driver know what needs to be altered.

Teacher's comments

The first answer is well-constructed and, if anything, gives too much information. This is fine provided the student doesn't write anything that contradicts any earlier answers. The answers are set out logically which will make it easy for the examiner to pick out salient points and it also logically follows the question.

The second answer is probably only worth about 2 marks in total. The reference to the person with disabilities is repeated in part (b), so credit would only be given once. A second mark could also be awarded for suggesting this type of interface would be useful in a car, even though the scenario given totally misses the point of gesture-based interfaces. The rest of the answer is very vague and not worth any additional marks.

Exam-style questions for you to try

1 Explain the following terms. In each case, give an example to help in your explanation.
   a Input device
   b Output device
   c Dialogue-based interface
   d Gesture-based interface [8]

2 In the following table, five statements about CLI and GUI have been made. In each case, tick (✓) the appropriate box to show whether the statement refers to a CLI or GUI interface.

Statement	CLI (✓)	GUI (✓)
The user is in direct communication with the computer		
All commands need to be typed in using the correct format		
Needs a complex OS and large memory requirement to operate		
Allows computer configuration settings to be *directly* changed		
Makes use of pointing devices (such as a mouse) or finger (if using a touchscreen)		

[5]

3 Seven statements are shown on the left and seven computer terms are shown on the right. By drawing lines, connect each statement to the correct term.

1. Non-volatile chip that is battery-powered and stores key BIOS data such as the date, time and system requirements	A. RAM
2. Used with touchscreens to allow actions such as pinching and rotating as well as app selection	B. ROM
3. Software used in the creation, manipulation, modification and analysis of drawings and designs	C. CMOS
4. Internal memory chip which can be read from and written to; stores files, data and part of the operating system currently in use	D. CPU
5. Picture or symbols used on screen to represent apps (or applets); when selected, the app will be launched; part of a WIMP system	E. CAD
6. Internal memory chip which stores data permanently; it is non-volatile in nature and is often used to store the computer BIOS	F. Post-WIMP
7. Interprets and executes commands from hardware and software; part of the motherboard; main components are CU and ALU	G. Icon

[7]

1.4 Types of computer

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1.4.1 Desktop computers

- **Desktops:** not portable but less expensive than other computer types and usually more powerful for the same cost. More stable internet connection since usually uses wired connectivity.

1.4.2 Mobile computers

There are four categories of mobile computers:

- **Laptop (or notebook):** lightweight, low power consumption, with no trailing wires, takes up less room than a desktop and is easy to work with multimedia systems since it is portable. Similar advantages to tablets but often bulkier (but this is changing with introduction of notebooks).
- **Smartphone:** very small and easy to carry round (always with you), can connect to cellular network and WiFi. Has a long battery life. Small screen size and virtual keyboards can make them difficult to use; relatively small memories and slower data transfer rates.
- **Tablet or phablet:** similar features to smartphones but much larger screen size (can be up to 33 cm); can be used with much larger keyboards built into cases. Slowly taking over from laptops as the preferred portable computing device since they often have similar or better performance.

Tips

In the sample question below, the term 'give' means it is acceptable to write a single sentence to highlight a typical use. In the second part, be brief when giving an example. However, remember your example must match with the use or it won't gain any marks. Note that each use, plus its example, is only worth one mark. This means it is very easy to lose the mark if either your use or the chosen example are too vague or don't match.

Sample question and response

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Apart from making phone calls and text messaging, give five uses of the smartphone. For each use, give an example to illustrate your answer. **[5 marks]**

Sample high-level answer

- In the field of entertainment
  - for example, when streaming videos or music.
- As a camera
  - for example, taking 'on the spur of the moment' photos at an accident since your phone is always with you.
- Internet services
  - for example, using QR codes at an airport or bus station, which allow automatic website connections to tourist attractions, hotels or taxis.
- Telephone banking
  - for example, payment of goods or services at a supermarket or restaurant (no need to carry a credit/debit card with you).
- Remote control of devices
  - for example, devices that contain embedded processors (e.g. an oven) can be controlled by an app via the internet.

Sample low-level answer

Five uses of a smartphone would include:

- accessing the internet
- playing computer games
- using Facebook or Twitter
- playing music
- watching videos

Teacher's comments

The first answer is well-constructed. The student has separated uses from examples; this means they could potentially gain all the marks available for the question. Where only 1 mark is available for use *and* example, both are needed to gain the marks.

In the second answer, the student was unable to distinguish between the use of a smartphone and examples to illustrate the use. Consequently, they could potentially lose all 5 marks! It is possible to join up accessing the internet with playing music/videos and using Facebook giving a maximum of 2 marks. However, you should not use tradenames (Facebook) so this second mark would be at serious risk.

Exam-style questions for you to try

4 Give three advantages and three disadvantages of using smartphones rather than laptop computers. [6]

5 Explain the following terms. In each case, also give an example to help in your explanation.

a Phablet
b Accelerometer
c Fast battery drain
d App store [8]

6 Six statements about types of computer are shown in the following table. Tick (✓) the appropriate columns to indicate whether each statement is true or false.

Statement	True (✓)	False (✓)
Desktop computers are easier to upgrade/expand than laptops		
Laptop computers use a touchpad, as part of the keyboard, as a pointing device		
Phablets and tablets require the use of plug-in keyboards to allow them to be used to write emails		
Tablets don't allow the use of Voice over Internet Protocol (VoIP) or video calling		
The built-in cameras on smartphones and tablets can be used to read QR codes		
Desktop computers must use a wired internet connection; they cannot connect to WiFi		

[6]

1.5 Emerging technologies

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1.5.1 Impact of emerging technologies

Artificial intelligence (AI) is a machine or application which carries out a task that requires some degree of intelligence. There are a number of positive aspects of AI:

- improvements in safety
- improvements in quality
- faster development of products
- autonomous vehicles.

There are also a number of negative aspects of AI:

- can lead to job losses and de-skilling
- technology dependency
- suspicion that machines are 'taking over'.

Extended reality (XR) refers to the combination of real and virtual environments. The most common examples are **augmented reality (AR)** and **virtual reality (VR)**. The table summarises the differences between AR and VR:

Augmented reality	Virtual reality
The user experiences relationship between digital (virtual) and physical (real) worlds	Technology is able to take the user out of the real world into a virtual, digital environment
The user is not isolated from the real world and can still interact and see what is in front of them	The user is fully immersed in the simulated world
The user can experience the AR world through special goggles or via a smartphone/tablet	Users wear a VR headset which gives a 360° view of the virtual world
Virtual data and objects are overlaid	Can be used in medicine/surgery, construction, education and military applications

Sample question and response

REVISED

The manager of a car showroom has decided to use AR to allow their customers to gain the best possible experience when choosing a new car.

Explain what features of AR persuaded the manager to decide to use this technology in the car showroom. **[5 marks]**

Sample high-level answer

AR allows the user to experience the relationship between physical and digital worlds; sitting in the showroom the customer could be made to believe they were sitting behind the wheel of an actual car, thus gaining the full experience of being in the car.
Virtual information and objects would be overlaid onto real world situations, which would also lead the customer to believe they were actually sitting in the car.
The user can experience the AR world through special goggles; this allows an immersive experience but also permits the customer to still interact with the real world. The customer is still able to ask the car salesperson questions while 'sitting' in the virtual car.

Sample low-level answer

AR allows the customer to wear special goggles, which allows them to immerse themselves into the experience. They will be cut off from the real world, which allows them to fully enjoy the experience without outside noises and lighting disturbing them. The AR system allows them to drive the car without actually leaving the showroom

Tips

Since this is an 'explain' question, it is necessary to give as many facts as possible to support the chosen features. It is imperative that the features given match the car showroom scenario, and generic answers are not given in the hope of gaining some marks. Three features with full justification would gain full marks, or six features, with less supporting information, would also be acceptable.

Teacher's comments

The first answer is probably worth 4 or 5 marks since they have covered about five different points. Their answer has successfully distinguished AR from VR, which is very important in this question.

The second answer has not given sufficient evidence that the student really knows the difference between AR and VR. They have mixed up the two technologies in their answer. They would gain credit for the use of special goggles and a reference to immersive experience.

Exam-style questions for you to try

7 Six statements about AR and VR are shown on the right. Draw lines to connect each feature to the AR or VR technology.

	A. Takes the user out of the real-world environment into a simulated digital environment
VR	B. Virtual objects and information are overlaid onto real world situations
	C. Allows the user to experience the relationship between real and physical worlds at the same time
	D. Users wear a headset which allows 360° view of simulated world (this 'fools' the brain to believe the situation is real)
AR	E. The user is fully immersed in a simulated digital world
	F. The user is not isolated from the real world and is still able to interact and see what is happening in the real world

[6]

2 Input and output devices

Key objectives

The objectives of this chapter are to revise:

- the characteristics, uses, advantages and disadvantages of:
  - input devices
  - direct data entry devices
  - output devices.

2.1 Input devices

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An input device is hardware that allows a user to interact with a computer and also allows the computer to collect data. The following table lists a number of input devices together with some of their uses as well as their advantages and disadvantages:

Input device	Uses of input device	Advantages	Disadvantages
Keyboard	• Entering data manually into a computer • Typing in commands to a computer (e.g. PrtScrn, Ctrl+P and so on)	• Well-known method • Easy method of entering data into a computer • Easier to carry out verification checks on data entered	• Difficult to use for people with certain physical disabilities • Slow entry method compared to direct data entry • Can lead to ailments such as **RSI**
Numeric keypad	• At **ATMs** to key in PIN to obtain money • At **POS** terminals in case the barcode on an item fails to scan properly • When using chip and PIN devices to make a card payment	• Faster input method than a standard keyboard when entering numeric data • Easy-to-use input device since it involves fewer keys	• Keys can be small, making input difficult for some people • Order of numbers on keypads is often not intuitive
Pointing device: **mouse**	• Controls the position of an on-screen pointer to allow selections, open/close files and so on	• Faster method to choose on-screen options compared to a keyboard • Only requires a small amount of desk space	• Difficult to use by people with certain disabilities • Can lead to injuries such as RSI • Some surfaces don't work well with mechanical mice (mouse slips on the surface)
Pointing device: **touchpad**	• Similar to mouse but uses a flat panel below the keyboard on a laptop computer	• Same advantages as a mouse • Since it is integrated into a laptop, there is no need to carry a mouse around with you	• Not everyone finds touchpads easy to control and certain actions can be difficult (such as drag and drop)
Pointing device: **trackerball**	• Used in control rooms where desk space is at a premium (and has more accurate control than a mouse) • Used in luxury cars to select functions such as operating the Global Positioning System, allowing use of smartphone and so on	• More accurate positioning of pointer on screen than a mouse • More robust and doesn't need any special surface to work properly • Requires less desk space than a mouse • Less prone than a mouse at causing RSI	• More expensive to buy than a mouse • May require training to use properly since it is a less well-known type of pointing device

Input device	Uses of input device	Advantages	Disadvantages
Remote control	• Used to control functions on televisions, Blu-ray players, hi-fi equipment and so on	• Can operate from a reasonable distance unlike, for example, a wired mouse • Easy-to-use interface	• Easy to lose the device • Batteries need replacing on a regular basis (an environmental issue) • The remote's infrared signal can be blocked and may not work well if not in direct line of device
Pointing devices: **joystick** and **driving wheel**	• Both are used as input devices to many gaming consoles or **simulators** (e.g. flight simulator or car driving simulator) to mimic actual controls	• More realistic interface than a mouse in many games and **simulations** • Easier and more accurate than a mouse or keyboard to control on-screen movements	• Movement can be too sensitive, making the input device difficult to use in certain applications • Doesn't allow any feedback during a simulation
Touchscreen	• Self-service tills (e.g. at a petrol station) • ATMs to enter PIN, amount of money required and so on • Public information kiosks (e.g. at an airport) • Mobile phones and tablets • Computer-based training	• Fast data entry and easy-to-use interface • It is easy to expand screen size as necessary with no need to change software or entry method • Easier to keep clean since the surface is glass (keypads and keyboards are more difficult to keep clean)	• Limited number of possible choices available • Screens can get very dirty quickly and can cause issues at fast food menu screens, for example, if not cleaned on a regular basis • Screens can get scratched, causing them to malfunction
Scanner	• Scanning in paper documents and photos to be saved in electronic format on a computer • Archiving of valuable old manuscripts • Used to scan in barcodes at a POS using laser or LED scanners	• Converts written text into electronic format, allowing the text to be manipulated by OCR software and used in other documents (using a word processor) • Allows damaged photos and manuscripts to be recovered • When used to read barcodes, the scanner becomes a DDE device (see 2.2)	• Quality of photos and text depends on the scanner resolution • Scanning (particularly colour image scanning) can be a very slow process • If the barcode being scanned is damaged, the scanner can't successfully read it and a backup input method is needed
Digital camera	• Taking photographs or videos • A data capture device (e.g. reading of QR codes or a reversing aid in a vehicle) • In dentistry to photograph teeth for later dental work • Creation of virtual tours around buildings, industrial plants and so on	• Can take many photos compared to a traditional camera (unwanted photos are easy to delete) • No need to develop photos (saving money and also gain immediate feedback about photo just taken) • Easy to store photos on another device or in the cloud	• Need to be computer-literate to use digital cameras effectively • Some artistry is lost since brightness, sharpness, exposure (etc.) can all be altered by software later on • Compression of images when being stored can lead to some loss of quality
Microphone	• Input speech/sound to be used in presentations, special effects, music sampling and so on • As a sensor to pick up sounds (e.g. in an intruder alert system, detection of liquid dripping from pipes) • In video conferencing • Input device for people with disabilities	• Fast input method and useful for people with certain disabilities • Allows the possibility of manipulating sounds in real time • Can be used in voice activation systems improving safety (e.g. verbal commands in a car to operate key functions without the driver taking their hands off the steering wheel)	• Sound files can take up a large amount of memory unless they are compressed • Using verbal input can be inaccurate (e.g. 'how to wreck a nice beach' could be mistaken for 'how to recognise speech', which would be a problem if a microphone was used to input data into a word processor) • In voice activation, you must remember keywords or certain functions of the system can be activated by mistake

Input device	Uses of input device	Advantages	Disadvantages
Analogue sensors	• Measure physical data from the environment and send it to a computer • Many sensors exist: – temperature (greenhouse environment) – pressure (intruder alert system) – light (control of street lighting) – sound (intruder alert system) – humidity (monitor the atmosphere in a chip manufacturing process) – pH (monitor acidity levels in a chemical process)	• Readings taken are more accurate than manual methods • Readings taken continuously (no vital readings would be missed) • Possible to take readings in places hazardous to humans or when severe weather causes risks to human life • Data gathering is automatic so it can be automatically sent to a computer	• Faulty readings can lead to spurious results, which can be dangerous (e.g. sensors used in monitoring/controlling functions in an aeroplane) • Most sensors are analogue, which means they require conversion to digital using an **ADC**
Light pen	• Selecting objects on a CRT screen • Used with **CAD**/CAM software on a CRT screen	• Have greater accuracy than touchscreens • Very small devices (useful where space is an issue) • Very easy input device to use	• Problems of 'lag' when moving the pen on screen (especially if the screen is not clean) • Currently only work with CRT screens • Very dated technology

Sample questions and responses

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Name a suitable input device for each of the following applications. Give an advantage and a disadvantage of your chosen device in each case. A different device needs to be chosen for each application:

a) street lighting in a town where the lights are turned on automatically when it turns dark and are switched off again when it becomes light.

b) a 'smart house' where the opening/closing of windows, turning lights on/off and operating other devices (such as a television) is done by voice command.

c) simulation of an aircraft cockpit which needs to be as realistic as possible.

d) selection and control of icons (e.g. representing pumps) on a large screen in the control room of an oil refinery plant. **[12 marks]**

Sample high-level answer

a) ***Device:*** *light sensor*
Advantage: *allows for automatic control of the street lights, therefore there is no need to manually switch them on/off; allows 24-hour control irrespective of the time of day or the weather.*
Disadvantage: *unless set up properly, lights would come on and off during heavy cloud cover during the day causing constant on/off; light sensors are analogue devices requiring the use of an additional ADC to convert input to digital; sensors also need regular maintenance to operate correctly.*

b) ***Device:*** *microphone*
Advantage: *a person with disabilities can easily control the operation of devices in the home from their seat without the need to physically open/close windows and so on.*
Disadvantage: *can be expensive to set up initially; a dependence on technology is always a big risk, for example what happens if the system breaks down?*

Tip

The question only asks for a named device; do not give any unnecessary descriptions. For advantages and disadvantages, ensure your answers refer to the scenario given and don't use generic examples. Think about your answer carefully to ensure you don't choose the same device for two applications; for example, choosing sensors for applications (a) and (b) would lose you all the marks for part (c).

c) **Device:** joystick
Advantage: gives a fairly realistic control of an aircraft interface; it is an easy input device to operate.
Disadvantage: movement of a joystick can be too sensitive, reducing the realism or leading to unwanted results; an expensive interface would be needed for actual realism since the joystick doesn't feed back in a simulation.

d) **Device:** trackerball
Advantage: space is at a premium in a control room (for safety reasons, desks need to be uncluttered), therefore a trackerball is a better option than, say, a mouse or a keyboard; they are a very robust device and can handle rough treatment by the operators; they have more accurate control of the on-screen process parameters.
Disadvantage: often requires training to gain maximum benefit of the device since operators would only be used to using a mouse or touchscreen before.

Sample low-level answer

a) **Device:** light sensor
Advantage: inexpensive item with low maintenance.
Disadvantage: may break down in use.

b) **Device:** sound sensor
Advantage: a person with disabilities doesn't need to move.
Disadvantage: can pick up other sounds and not work properly.

c) **Device:** steering wheel
Advantage: can control an aircraft as in real life.
Disadvantage: aeroplanes don't use steering wheels.

d) **Device:** touchscreen
Advantage: easy-to-use interface.
Disadvantage: screen becomes dirty.

Teacher's comments

The first answer would probably gain the full 12 marks as each device has been correctly identified and the advantages and disadvantages refer to the actual application and are not generic.

The second answer would only gain about 5 marks. Devices (a), (c) and (d) would just about gain 3 marks; the second device is far too vague and is also a repeat of sensors as an input device. Part (b) advantage and part (d) disadvantage would also gain 2 marks since they are just enough – the answers are weak but not wrong. The rest of the advantages and disadvantages are either incorrect or much too vague to gain any marks.

Exam-style questions for you to try

1 A water purification plant needs to check acidity levels and oxygen levels in the water. This process is controlled from large LCD screens in a control room.
A list of possible input devices is given in the table below. Select which input devices would be suitable for this pollution monitoring plant and its control room.

Input device	Tick (✓) if suitable device
Microphone	
pH sensor	
Keypad	
Oxygen gas sensor	
Touchscreen	
Joystick	
Remote control	
Light pen	
Trackerball	

[4]

2 Describe applications for each of the following input devices. Justify your choice of device in each case:
a Driving wheel
b Microphone
c Touchscreen
d Digital camera
[8]

2.2 Direct data entry devices

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Direct data entry (DDE) devices are used to input data into a computer without the need for very much, if any, human interaction. For example, barcode readers are DDE devices and the only human intervention is to point a reader/scanner at the barcode. The data collection and transfer to a computer is done automatically. The following table lists a number of DDE devices together with a description and some of their uses as well as their advantages and disadvantages:

DDE device	Description of device	Uses	Advantages	Disadvantages
Magnetic stripe reader	Reads information on **magnetic stripes** on the back of a card, for example a debit or credit card, which holds data such as account number, sort code, expiry date and start date. It does *not* hold the PIN	• On credit/debit cards for use at ATMs or POS terminals • Security cards to allow entry to a building, hotel room and so on	• Faster data entry than using a keyboard or keypad • Error-free (no typing) • Information is more secure: the data isn't held in human-readable format • Physically robust system	• If the magnetic stripe is damaged, the information cannot be read • Reader needs to be in close contact with card • Data may not be human-readable but certain devices can read and clone data on the magnetic stripe
Contactless debit card readers	A read-only RFID chip is embedded in the card, containing data such as PIN, account number, sort code, expiry date and so on A radio frequency reader can read the chip from a few centimetres away	• Debit cards – allow customers to pay for items (up to a certain amount) without the need to enter a PIN	• Faster transaction as no need to enter a PIN • Uses 128-bit encryption • No need for a customer to remember their PIN • Retailers now don't have access to customers' credit card/debit card information	• It is possible to monitor contactless transactions if someone near you is using an RFID reading device • The maximum transaction is limited to a small value
Chip and PIN reader	The credit/debit card is inserted into the device and the embedded chip is read. A PIN is then entered that should match the PIN stored on the chip before the transaction can take place	• To make payments at garages, restaurants, travel agents and so on • The card reader uses an internet link (usually WiFi) to contact the card-issuing bank when making a transaction	• More secure than contactless payments (needs a PIN) • The limit on spending is much higher than for contactless methods	• If the PIN is accessed by a third party, the chip and PIN system is very insecure (cards can be cloned using devices attached to ATMs) • The lack of an upper limit can cause problems if a stolen card is used before it is reported stolen

DDE device	Description of device	Uses	Advantages	Disadvantages
Radio Frequency Identification (RFID) readers	Use radio waves to read and capture information stored on a **tag**. The tag is made up of a microchip and an antenna. (Note: passive tags use the reader's radio wave energy to relay back information)	• Livestock tracking on a farm • Retail (unlike barcodes, there is no need to scan – the tag is automatically read from a distance) • Security (RFID tags attached to goods allow supermarkets to check if articles are being removed from the store without payment) • Admission passes, for example at a theme park to gain access to rides and events • Libraries (to track books out on loan)	• Tags can be read from a reasonable distance • Very fast read rate (it takes less than 100 milliseconds to respond) • Allows bi-directional data transfer (data can be sent in both directions) • Allows bulk detection/reading to occur (several tags can be read at the same time) • Unlike barcodes, it is difficult to copy or alter the data stored on RFID tags	• Tag collisions can occur (where data from two or more tags overlap) • Radio waves can be blocked or jammed which means the data can't be read • It is possible to hack into transmitted data and read or change it • The system is more complex and more expensive than barcode readers
Optical mark recognition (OMR)	Can read marks written in ink or pencil on a pre-printed form either by joining dots  or filling in a lozenge 	• Reading questionnaire responses • Automatic marking of multi-choice exam papers • Automatic counting of voting choices in an election	• Fast method of data input (documents can be loaded into a hopper and read automatically) • More accurate than entering the data using a keyboard (removes risk of typing errors) • Faster to fill in a form than if using OCR	• Needs expensive and complex forms • Forms need to be carefully designed to capture required data (OMR limits the amount of data that can be captured) • Problems occur if the form is not filled in correctly (often instructions on how to fill out the form need to be given)
Optical character recognition (OCR)	Converts text on hard copy documents into an electronic format. The data can then be processed and used, for example in a word processor	• Processing of passports and ID cards at an airport security desk • Converting handwritten text into a computer-usable format • Automatic number plate recognition to identify cars when entering, for example, car parks • Digitisation of valuable, ancient documents and books	• Much faster data entry than manually keying in data using a keyboard • More accurate and less error-prone than manual data entry methods • If used in questionnaires, allows customer to expand on answers (unlike OMR where a customer is limited to answering a set questions)	• The system can't always read certain handwriting styles • Scanning of documents isn't always 100% accurate • A complex and expensive system

DDE device	Description of device	Uses	Advantages	Disadvantages
Barcode readers	Reads **barcode** labels on items  Barcodes are read by a laser or LED scanner/reader which scans the thickness of the dark and light lines and converts the data into a digital format	• In supermarkets on products, enabling automatic product information, pricing and automatic re-ordering of items; they also allow for itemised billing • In libraries to track books out on loan • Safety records of equipment, for example in an office (e.g. recording the last time an electrical safety check was carried out)	• Faster checkouts and fewer errors than typing in prices using a keypad • Allows for automatic stock control in many applications, such as in a supermarket, allowing for 'just-in-time' stocking of items • A well-tried and trusted technology	• Not totally foolproof, barcodes can be altered or swapped by someone • Barcodes are more easily damaged than RFID tags or magnetic stripe cards • If damaged or torn, barcodes may not be successfully scanned
Quick response (QR) code readers	QR codes are made up of a matrix of dark squares on light backgrounds  QR codes are able to store large amounts of information/data; the codes can be read by the camera built into a smartphone or tablet	• In advertising, the QR code can contain phone numbers, physical addresses, website addresses and so on • Can contain weblinks that are automatically activated when the codes are scanned in • Can store WiFi authentication details (e.g. passwords and type of encryption being used) • In **augmented reality** (e.g. in a car showroom) • Can establish **virtual online stores** (the QR code is scanned by the customer's phone and the goods are automatically delivered to their home)	• QR codes can store much more information/data than barcodes • Fewer errors than using barcodes, since QR codes allow the use of built-in error-checking procedures • Easier to read than barcodes, they don't need expensive scanners and can be read by a smartphone/tablet camera • QR codes can be encrypted which makes them more secure than barcodes	• There is more than one QR code format • QR codes can be used to store malicious codes (known as **attagging**). When the QR code is scanned, the user is sent to a bogus website or even unwittingly downloads malware

Sample question and response

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VISIT WHITEPOOL

Visit our local attractions. Need help? Call 0800 1111 11000

The local bus station and railway station at a popular holiday resort use posters containing QR codes that give arrivals important information about amenities and attractions in the local area.

Describe how a holidaymaker can use their smartphone to find out information about local attractions in the area using this poster.

[5 marks]

Sample high-level answer

- the holidaymaker points their smartphone at the QR code on the poster(s)
- an app on their smartphone processes the image taken by the camera
- browser software on the smartphone automatically reads the data about the holiday resort generated by the app
- the user will then see either information about local attractions and possible phone numbers or they will be sent a link to a website where they will find useful information about various attractions at the holiday resort
- the user will also be able to buy tickets online to allow them to visit theatres, museums and so on without the need to queue
- entry passes will be sent to the holidaymaker's smartphone (probably in the form of a barcode or QR code).

Sample low-level answer

The holidaymaker would use their smartphone and photograph the QR code. The QR code may contain weblinks, which take the user to the holiday resort's website. The user would type in this website on their phone and get the information they want. They could also use their smartphone to call the number on the poster at the bus station or railway station.

Exam-style questions for you to try

3 Which five computer terms and devices are being described below?
- **a** A matrix of filled-in dark squares on a light background; the matrix is read by the built-in camera in a smartphone or tablet.
- **b** A device that can read marks written in pen or pencil; the pen or pencil marks must be made in predetermined positions.
- **c** A device that converts a photograph or document into a computer-readable format.
- **d** A device used to control the operation of other electronic devices using infrared signals.
- **e** Direct data entry device that uses radio waves to read and capture information stored on an electronic tag. **[5]**

4 **a** Explain how barcodes could be used in a library to track books that are out on loan. **[4]**

b Another library uses RFID tags to track books on loan. Describe the relative advantages and disadvantages of using RFID tags compared to the method you described in part (a). **[4]**

5 Seven applications are given below. Tick (✓) the appropriate column to indicate the best DDE device for each of the applications.

Application	OCR	OMR	QR reader
Reading the number plate on a vehicle entering a pay car park			
Reading and counting the voting slips in an election			
Reading the data on a passport at an airport security desk			
Used in augmented reality at a car showroom to give the customer an immersive experience			
Reading embedded website addresses written in a matrix code on an advertising poster			
Digitisation of ancient books and manuscripts			
Marking multi-choice exam questions automatically			

[7]

Tips

As a 'describe' question, a full description of the process of how the smartphone and QR code would be used by the holidaymaker is expected. The answer should be as detailed as possible and make references to the given scenario rather than giving generic responses. Five marks will be awarded so you need to make at least five valid points for a strong answer.

Teacher's comments

The first answer would probably gain full marks, but they may be marked down for use of bullet points since this is a description (and usually requires sentences). They would, however, still gain at least 4 of the 5 marks since their answer is very thorough.

The second answer is very brief and only worth 1 or 2 marks: 1 mark for mention of the use of a camera (in a smartphone) to record the QR code and 1 mark (probably) for phoning the holiday 'hot line' since a phone number was given on the poster which means the student is technically correct. The rest of the answer was worth no marks.

2.3 Output devices

REVISED

The following table lists a number of output devices together with some of their uses as well as their advantages and disadvantages:

Output device	Uses of output device	Advantages	Disadvantages
monitor: **cathode ray tube (CRT)**	• In specialist areas, in applications such as CAD where a light pen is used to draw and select items on a large CRT screen	• They have a very large viewing angle • CRT monitors allow the use of light pens	• CRT monitors are heavy when compared to modern LCD screens • They tend to run very hot posing a fire risk • They consume considerably more power than LCD screens • CRT screens can flicker, causing headaches and eye problems
monitor: • liquid crystal display (LCD screens are made up of tiny liquid crystals backlit using LEDs) • light emitting diode (made up of a matrix of tiny LEDs)	• LCD: – The main output device for computers, tablets, laptops and smartphones – Where touchscreen technology is required, LCD screens are used • LED: – Generally used in large outdoor displays	• LCD: – Very efficient, low power consumption – Very lightweight and very thin screens – Don't suffer from image burn-in – Don't suffer from a flickering image – Very sharp image resolution – Very low electromagnetic screens compared to CRT • LED: – No motion lag/ghosting – No need for backlighting since LEDs produce their own light – Low power consumption – LEDs have a very long life – Screens can be any size	• LCD: – Colour and contrast from various viewing angles can be inconsistent – Suffer from some motion blur/image ghosting – Possible to have weak pixels that can show as either black (all fully off) or white (all fully on) dots on the screen – Need backlighting (LCDs don't produce their own light) – this can lead to variable illumination • LED: – More expensive than LCDs – Can suffer from colour shift (e.g. white can become yellowed) due to age and temperature – Contrast ratios are not consistent
Touchscreen (acting both as input and output device)	• Smartphones and tablets • ATMs (supplying cash and other bank facilities) • Ticket collection machines (at railway/bus stations, theatres, cinemas, etc.) • Information kiosks (at museums, airports, galleries, etc.)	• Faster data entry than a keyboard/keypad • Easy method to use and less error-prone since no typing is involved • Easy to keep screen clean (unlike keyboards) since the surface is glass • They allow multi-touch functions (such as zoom in/out, rotation, etc.) • No physical switches or buttons allowing interfaces to be more creative/intuitive	• Screens can become scratched and dirty, leading to poor performance or malfunction • As there is no 'mechanical interface', it is sometimes difficult to know if a user's action has registered. (Note: latest systems have 'haptic' feedback e.g. buzzing – but this is outside the syllabus)

Output device	Uses of output device	Advantages	Disadvantages
Multimedia projectors (take computer output and enlarge it to be projected onto a screen or white wall)	• Training presentations (large screen makes it easy for a large number of people to take part) • Advertising, for example at a shopping mall • Home cinema systems (projecting image from DVD/Blu-ray, television, mobile phone and so on)	• Enables many people to see a presentation • Avoids the need for several networked computers since a computer output can be seen on one large screen • Space saving – projectors can be mounted on the ceiling, for example	• Images can be a bit fuzzy and colours faded or incorrect shade • Expensive items to purchase and maintain • Setting up projectors can be difficult • A darkened room is usually needed • Need a separate audio system (which can add to the costs and complexity of setting up)
Laser printer (uses a rotating drum, dry ink (toner) cartridges and electrostatic printing)	• Where low noise required (e.g. in an office) • When fast, high-quality, high-resolution printing is needed (e.g. a large print run)	• Faster printing than an inkjet printer for large print runs • Quality of the printing is high and these printers can handle small fonts and fine lines better than an inkjet • Toner cartridges last for a long time • The paper trays have much greater capacity than inkjet printers	• Can be expensive to run (especially colour printers) since the toner cartridges and maintenance are expensive • Produce ozone gas and volatile toner particles (which can be harmful to people in an office, for example) • Unlike inkjet printers, they can't handle a variety of printing materials (any material that is heat sensitive can't be used) • Larger and heavier than inkjet printers
Inkjet printer: (use **thermal bubble** or **piezoelectric** technology; use four or five small wet ink cartridges and stepper motors to feed the paper)	• Where a low-volume print run is needed (e.g. a one-off photograph) • Good for high-quality colour printing (e.g. they have a photo quality option which enhances photos) • Useful when an 'unusual' printing medium is used (e.g. printing logos on T-shirts (cloth))	• Low start-up costs • Can handle many types of paper (e.g. cardboard) and other materials (e.g. as plastics, cloth, photo paper, etc.) • Cheaper to buy than laser printers • The ink cartridges can be refilled • Smaller footprint and lighter than a laser printer • Don't produce ozone gas or ink particulates	• Inkjet ink is very expensive • Not suited for long print runs since they have very small paper trays and the ink cartridges don't last long • The paper fastness of the ink isn't good; for example, a highlighter pen can't be used on the printed sheets since the ink will 'dissolve' • Need regular head cleaning to prevent the head clogging up with ink (a process which uses a lot of ink) • Not as durable as laser printers
Dot matrix printer (a type of impact printer that uses an inked ribbon (like an old typewriter) and a printhead containing an array of pins)	• Useful in places where the atmosphere is damp or dusty (e.g. a factory floor) • Can be used in places where their noise is not an issue (e.g. in a workshop) • Useful if the print run requires multi-part stationery (i.e. carbon copies) or continuous stationery – for example, when producing thousands of wage slips during a night run	• Can be used in an environment that would be harmful to a laser or inkjet printer • Carbon copies (multi-part) can be made (very useful when producing wage slips where the impact head prints on the inside of a folded paper and not on the outside, thus keeping information confidential) • Very cheap to run and maintain • Very good for long print runs since they can use continuous stationery (which can be 2000 continuous perforated sheets)	• Very noisy in operation • Expensive to buy initially • Very slow at printing • Very limited colour printing options (some 4-coloured ribbons exist, but the colour range is very limited) • Printing is generally of very poor quality • The technology is very outdated; the printers are only suitable where laser or inkjet are not suitable

Output device	Uses of output device	Advantages	Disadvantages
(graph) **plotters** (use pens to draw lines on very large sheets of paper or plastic)	• Producing architectural drawings and product blueprints • Producing engineering drawings • Drawing animation characters for the film industry	• Very high-quality drawings • Can produce large monochrome and colour drawings to a high accuracy • Can print on a variety of materials (e.g. aluminium, cardboard, plastic, cloth, steel, wood) as well as paper • Not expensive to run	• Very slow printing • Expensive equipment to purchase initially (although running costs are relatively low) • Need a very large physical footprint
3D printer (uses **additive printing** technology where a solid object is built up in very thin layers (typically <0.1 mm thick) – makes use of adapted inkjet or laser printer technology)	• Making prosthetic limbs, which are unique to each person • Making bespoke items to allow for reconstructive surgery based on exact scans of the patient's anatomy • Making precision parts for industry (e.g. in aerospace) • Fashion and art; allows for new creative ideas • Making parts for items no longer in production (e.g. vintage cars)	• Easier to produce prototypes that work (it is also much quicker and less expensive than making a real part) • Although expensive, it is still cheaper than making a product in the conventional way • Many medical benefits, such as producing artificial organs and so on • It is good for the environment: keeping items working for longer by making bespoke parts reduces the 'throw away' mentality	• Counterfeit items are easier to produce using 3D printing • Can lead to illegal activity (e.g. production of dangerous items based on blueprints found online) • Printing is a slow process • Potential for job losses as 3D printing can replace certain skills • Use of 3D printers is very expensive
Speakers or **loudspeakers** (convert electric signals to sound)	• Sound in multimedia presentations • Act as an interface with devices for people with certain disabilities (e.g. people with visual impairment) • Playback of music files • Audible warnings in systems being computer-controlled (e.g. nuclear power station safety systems)	• Sounds add an extra dimension to a presentation making it more interesting and informative • Useful when helping people with disabilities where a microphone/speaker combination affords a workable interface with devices • A well-tried technology	• Speaker output can be very annoying in the office environment • Expensive if high quality sound is required
Actuators (used in control applications)	• Control motors, pumps, switches and so on • Allow a computer to control physical devices by using a **DAC** interface	• Allow automatic control of many devices • Relatively inexpensive technology	• Require the use of a DAC interface if digital devices are sending signals to actuators • An additional device in the system that could go wrong

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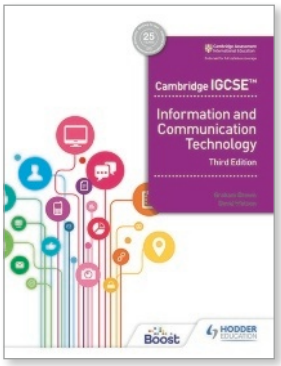

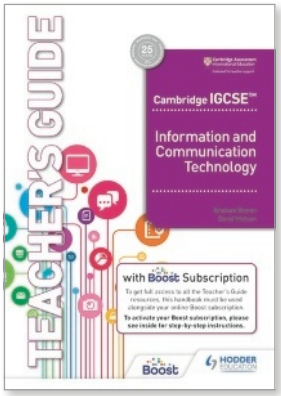

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ISBN 978-1-3983-1852-6

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