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PREFACE

Absolute clarity! That's the aim.

This is everything you need to ace your exam and beam with pride. Each topic is laid out in a beautifully illustrated format that is clear, approachable and as concise and simple as possible.

We have included worked examination-style questions with answers for almost every topic. This helps you understand where marks are coming from and to see the theory at work for yourself in an examination situation. There is also a set of exam-style questions at the end of each section for you to practise writing answers for. You can check your answers against those given at the end of the book.

LEVELS OF LEARNING

Based on the degree to which you are able to truly understand a new topic, we recommend that you work in stages. Start by reading a short explanation of something, then try and recall what you've just read. This has limited effect if you stop there but it aids the next stage. Question everything. Write down your own summary and then complete and mark a related exam-style question. Cover up the answers if necessary but learn from them once you've seen them. Lastly, teach someone else. Explain the topic in a way that they can understand. Have a go at the different practice questions – they offer an insight into how and where marks are awarded.

MARK ALLOCATIONS

Green mark allocations[1] on answers to in-text questions through this guide help to indicate where marks are gained within the answers. A bracketed '1' e.g. [1] = one valid point worthy of a mark. There are often many more points to make than there are marks available so you have more opportunity to max out your answers than you may think.

ACKNOWLEDGEMENTS

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THE SCIENCE OF REVISION

Illustrations and words

Research has shown that revising with words and pictures doubles the quality of responses by students.[1] This is known as 'dual-coding' because it provides two ways of fetching the information from our brain. The improvement in responses is particularly apparent in students when asked to apply their knowledge to different problems. Recall, application and judgement are all specifically and carefully assessed in public examination questions.

Retrieval of information

Retrieval practice encourages students to come up with answers to questions.[2] The closer the question is to one you might see in a real examination, the better. Also, the closer the environment in which a student revises is to the 'examination environment', the better. Students who had a test 2-7 days away did 30% better using retrieval practice than students who simply read, or repeatedly reread material. Students who were expected to teach the content to someone else after their revision period did better still.[3] What was found to be most interesting in other studies is that students using retrieval methods and testing for revision were also more resilient to the introduction of stress.[4]

Ebbinghaus' forgetting curve and spaced learning

Ebbinghaus' 140-year-old study examined the rate in which we forget things over time. The findings still hold true. However, the act of forgetting things and relearning them is what cements things into the brain.[5] Spacing out revision is more effective than cramming – we know that, but students should also know that the space between revisiting material should vary depending on how far away the examination is. A cyclical approach is required. An examination 12 months away necessitates revisiting covered material about once a month. A test in 30 days should have topics revisited every 3 days – intervals of roughly a tenth of the time available.[6]

Summary

Students: the more tests and past questions you do, in an environment as close to examination conditions as possible, the better you are likely to perform on the day. If you prefer to listen to music while you revise, tunes without lyrics will be far less detrimental to your memory and retention. Silence is most effective.[5] If you choose to study with friends, choose carefully – effort is contagious.[7]

[1] Mayer, R. E., & Anderson, R. B. (1991). Animations need narrations: An experimental test of dual-coding hypothesis. *Journal of Education Psychology*, (83)4, 484–490.

[2] Roediger III, H. L., & Karpicke, J.D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science*, 17(3), 249–255.

[3] Nestojko, J., Bui, D., Kornell, N. & Bjork, E. (2014). Expecting to teach enhances learning and organisation of knowledge in free recall of text passages. *Memory and Cognition*, 42(7), 1038–1048.

[4] Smith, A. M., Floerke, V. A., & Thomas, A. K. (2016) Retrieval practice protects memory against acute stress. *Science*, 354(6315), 1046–1048.

[5] Perham, N., & Currie, H. (2014). Does listening to preferred music improve comprehension performance? *Applied Cognitive Psychology*, 28(2), 279–284.

[6] Cepeda, N. J., Vul, E., Rohrer, D., Wixted, J. T. & Pashler, H. (2008). Spacing effects in learning a temporal ridgeline of optimal retention. *Psychological Science*, 19(11), 1095–1102.

[7] Busch, B. & Watson, E. (2019), *The Science of Learning*, 1st ed. Routledge.

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TOPICS FOR PAPER 1

COMPUTER SYSTEMS

Information about Paper 1

Written exam: 1 hour and 45 minutes
75 marks
50% of IGCSE

Specification coverage

Data representation; data transmission; hardware; software; the Internet and its uses; automated and emerging technologies.

The content for this assessment will be drawn from subject content sections 1 to 6 of the specification.

Questions

This paper consists of short-answer and structured questions. All questions are compulsory. Calculators are not permitted.

1.1.1 1.3.1

BINARY REPRESENTATION

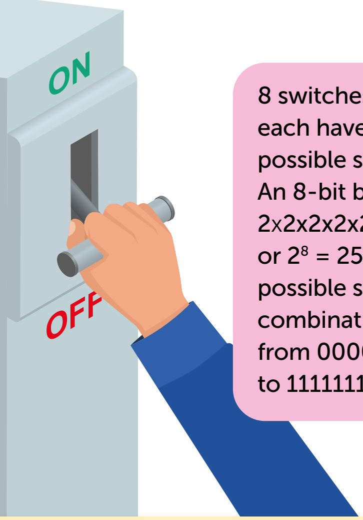
Bit	Nibble	Byte	Kibibyte	Mebibyte	Gibibyte	Tebibyte	Pebibyte	Exbibyte
(b)		(B)	(KiB)	(MiB)	(GiB)	(TiB)	(PiB)	(EiB)
0 or 1	4 bits	8 bits	1024 bytes	1024 KiB	1024 MiB	1024 GiB	1024 TiB	1024 PiB

A computer is made up of billions of **switches**, each with two states - an **off** position (represented by a 0) and an **on** position (represented by a 1). This is known as **binary**. All data therefore needs to be converted into binary before it can be processed by a computer. Data is processed using logic gates and stored in registers. See **pages 27 and 104** for more details.

With two or more switches, the number of combinations of 1s and 0s is doubled with each additional switch or **bit**.

Computers use binary to represent everything including numbers, text, sound, graphics and program instructions. The number of binary digits (or switches) used determines the number of states that can be represented.

Number of switches	Expression	Possible combinations of states
1	2^1	2
2	2^2	4
3	2^3	8
4	2^4	16
5	2^5	32
6	2^6	64
7	2^7	128
8	2^8	256



8 switches or bits each have two possible states. An 8-bit byte has 2x2x2x2x2x2x2x2 or 2^8 = 256 possible states, or combinations of bits, from 00000000 to 11111111.

Calculate the following:

(a) Calculate the number of 650 MiB CDs required to store 2 GiB of images. Show your working. [2]

(b) Calculate in TiB the total capacity of a server with 4 × 2.5 TiB hard disk drives. [1]

(c) Calculate the total storage requirement for a database of 5,000 customer records each of 1.5 kiB each. Give your answer in MiB. Show your working. [2]

(d) Calculate the maximum number of states that can be represented in a binary pattern of 10 bits. [1]

(a) 2 GiB = 2 x 1024 = 2048 MiB. 2048 / 650 = 3.15[1] *(>3). Therefore 4 CDs will be required.*[1]

(b) 4 x 2.5 = 10 TiB.[1]

(c) 5000 × 1.5 kiB = 7500 kiB.[1] *= 7500 / 1024 = 7.32 MiB.*[1]

(d) 10 bits, each with 2 combinations = 2^{10} *= 1024.*[1]

2.1.1

DATA PACKETS

Just like some large shipments, data is broken down into smaller chunks called **packets**. Each is labelled, for example, packet 1 of 5 if it the first of five packets to be transmitted in the sequence.

Structure of a data packet

Each data packet contains:

Packet header

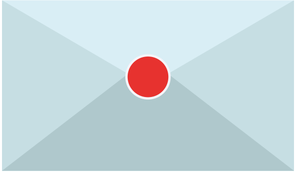
Packet 1 of 5
Leo Piccini
12 Sea Lane
Harbour Bay
Sender
Saffi Davids,
3 Atlantic Rd
Cape View

The **packet header** includes the **destination IP address**, the **packet number** and the **sender's address**.

Payload

The **payload** is the actual chunk of data being transmitted, e.g. 512 bytes.

Trailer

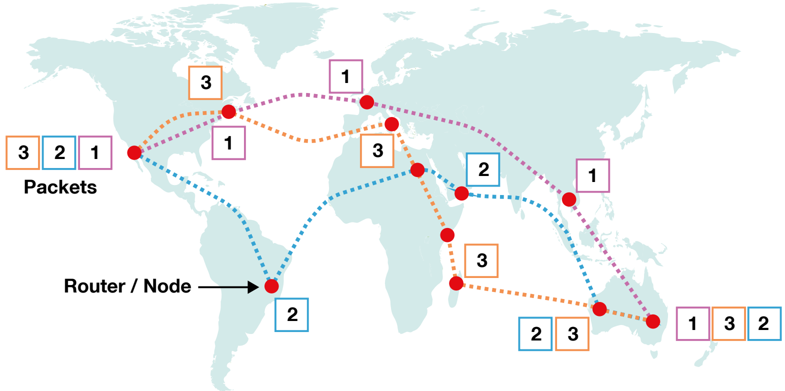


The **trailer** marks the **end** of the packet.

Packet switching

Packet switching controls the sending and receiving of packets across a network or the Internet.

1. Data is broken down into packets.
2. Each packet is given a sequence number and sent on its way.
3. Each packet may take a different route to the next depending on the quickest route at the time.
4. Routers control the route that a packet takes.
5. Packets may arrive out of order. Once the last packet has arrived, the sequence numbers are used to put them back into order. The data can then be reconstructed correctly.



EXAMINATION PRACTICE

1. When data is sent from one computer to another across the Internet, the data is split up into packets.

   (a) Tick (✓) **one** box to show which statement is true of packet switching. [1]

   A. ☐ Data is lost when it is broken into packets.

   B. ☐ Packets are sent by different routes depending on which is fastest at the time.

   C. ☐ Packets are sent in numerical order so they can be reassembled more quickly.

   D. ☐ Packets require one specific route to travel through from sender to receiver.

   (b) Give **four** items that would be included in each packet in addition to the data. [4]

2. Data may be transmitted using either serial or parallel transmission.

   (a) Explain the difference between these two forms of transmission. [2]

   (b) Give **two** advantages of serial transmission. [2]

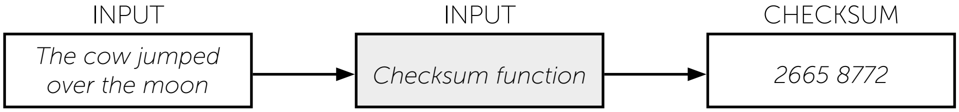
   (c) Rashid has a desktop computer with a printer connected to it using a short parallel cable.

   (i) Use a tick (✓) to identify the most suitable data transmission type for this application. [1]

Method	Tick (✓)
Simplex	
Half-duplex	
Duplex	

   (ii) Explain why your answer to part (c)(i) is the most suitable method of data transmission for sending data to the printer. [2]

3. The sentence "*The cow jumped over the moon*" is transmitted along with a checksum.



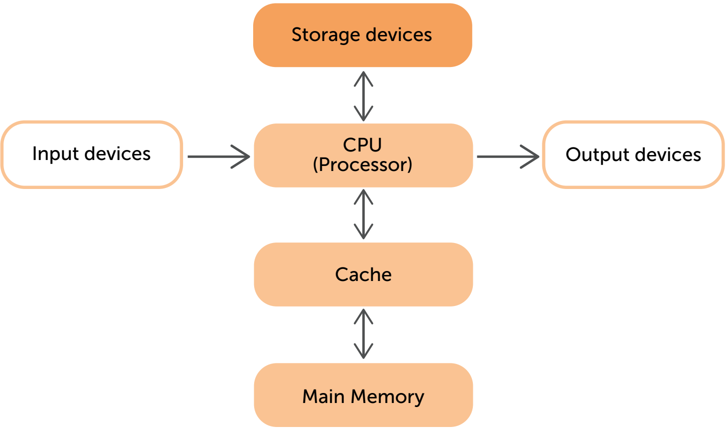
The checksum is recalculated at the receiving end as 3518 5003.

Explain what action should be taken. [2]

COMPUTER ARCHITECTURE

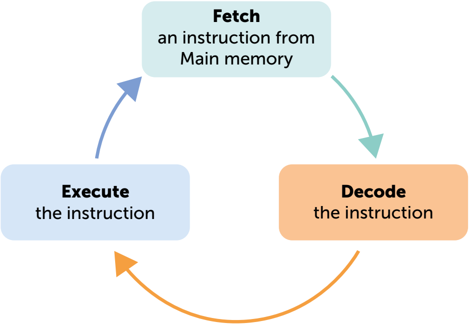
The purpose of the CPU

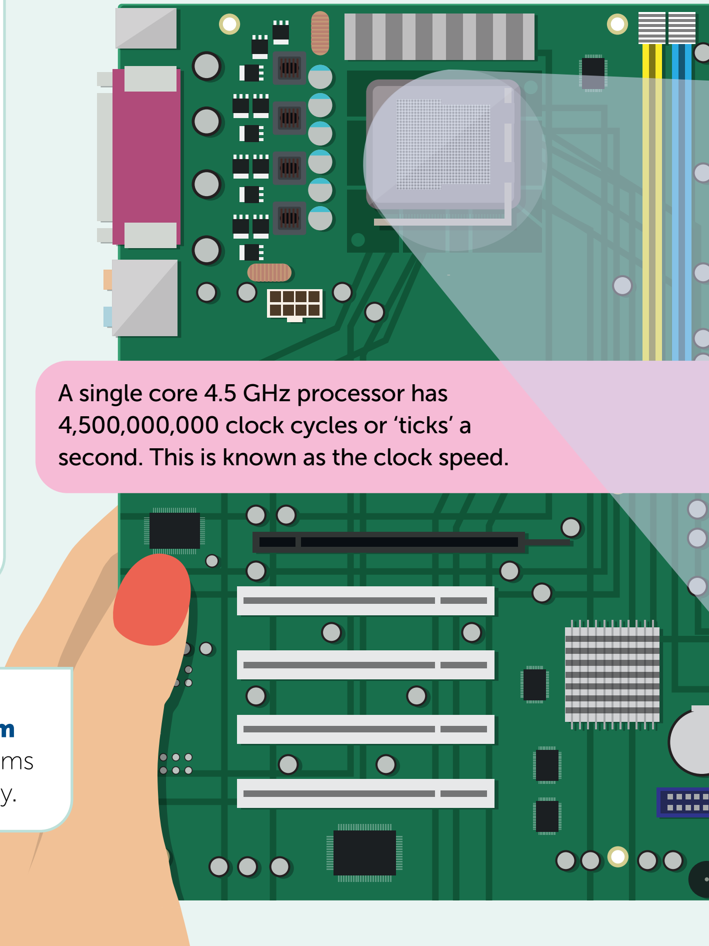
The purpose of the **Central Processing Unit** (**CPU**) is to continuously process instructions and data that are input by repeatedly carrying out the **fetch-execute cycle** in order to output a result. The CPU contains the **Arithmetic Logic Unit** and the **Control Unit**, in addition to several general-purpose and special-purpose **registers**.



The fetch-execute cycle

Every CPU instruction is fetched from memory. Once fetched, it is decoded by the Control Unit to find out what to do with it. Then the instruction is executed. Every operation carried out within the fetch-execute cycle is regulated by a 'tick' or cycle of the CPU clock.





A single core 4.5 GHz processor has 4,500,000,000 clock cycles or 'ticks' a second. This is known as the clock speed.

Von Neumann architecture

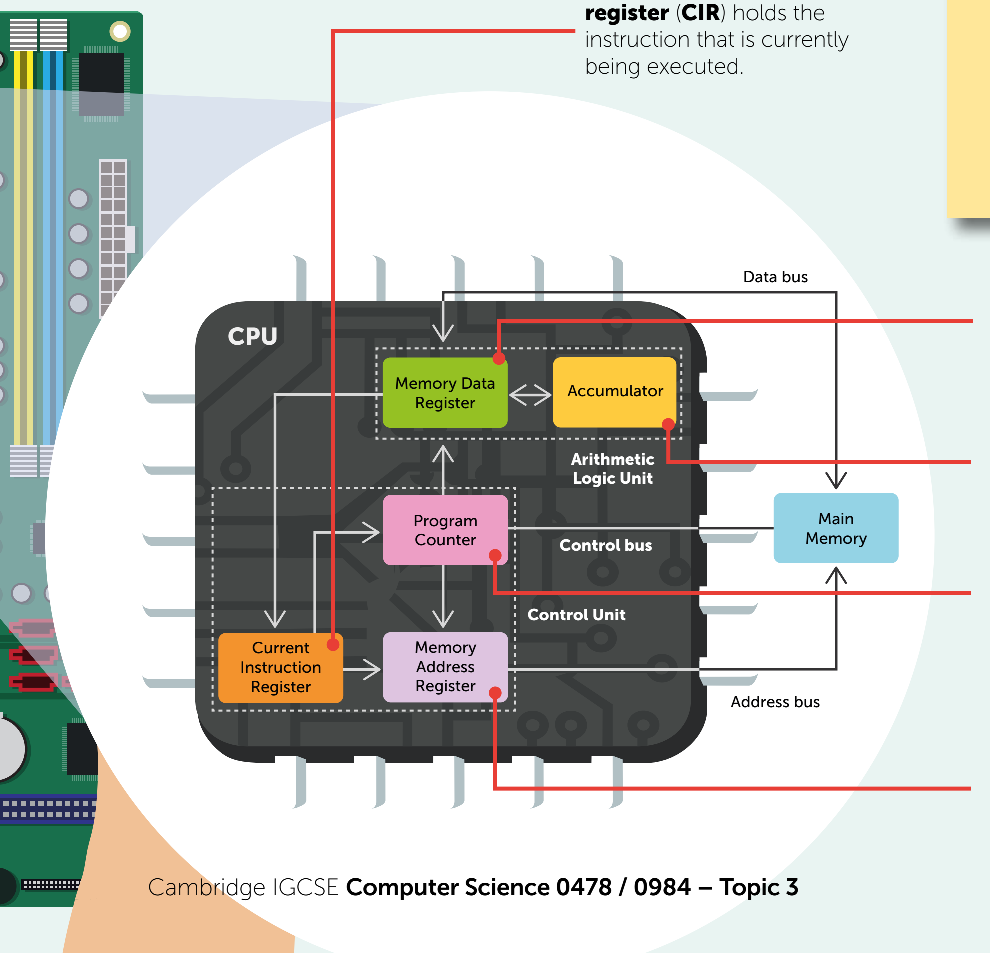
John von Neumann developed the **stored program computer**. In a von Neumann computer, the programs and the data they use are stored in the same memory.

CPU component	Function
ALU (Arithmetic Logic Unit)	Carries out mathematical and logical operations including AND, OR and NOT, and binary shifts. It compares values held in registers.
CU (Control Unit)	Coordinates all of the CPU's actions in the fetch-decode-execute cycle and decodes instructions. Sends and receives control signals to fetch and write data.
Clock	The clock regulates the speed and timing of all signals and computer functions.
Registers	Very small, very fast memory locations. Registers are built into the CPU chip to temporarily store memory addresses, instructions or data. They are used in the fetch-execute cycle for specific purposes.
Address, **data** and **control buses**	Buses are wires used to transfer data, instructions, memory addresses (of data and instructions), and control signals from one component to another.

A microprocessor is a type of integrated circuit on a single chip that processes instructions.

Identify **two** events that happen during the fetch-decode-execute cycle. [2]

The address of the next instruction to be executed is held in the PC.[1] The CPU fetches the instruction and data from memory/RAM[1] and stores them in its registers[1]. The PC is incremented[1]. The Control Unit decodes the instruction[1] and the instruction is executed[1].



The **current instruction register** (**CIR**) holds the instruction that is currently being executed.

MDR holds data or a program instruction when it is fetched from memory or data that is waiting to be written to memory.

The **accumulator** (**ACC**) is a register in which results of operations carried out in the **ALU** are stored.

PC is a register which holds the **memory address** of the next instruction to be processed.

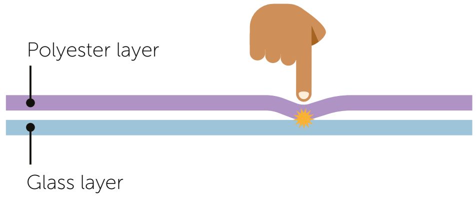
MAR holds the address (location in memory) of the current instruction or piece of data to be fetched or stored.

TOUCH SCREENS

A touch screen is both an **input device** and an **output device**.

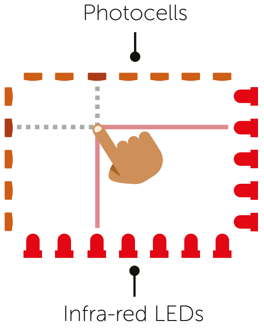
Resistive screens

Resistive touchscreens are made up of a layer of conductive polyester and a layer of conductive glass. The two layers are separated by an insulating membrane. When the screen is gently pressed by a finger, the two conducting layers make contact and complete a circuit. The position where the screen is touched is calculated by a microprocessor. Resistive screens are often used with some ATM screens and medical equipment as users commonly wear gloves.



Infra-red screens

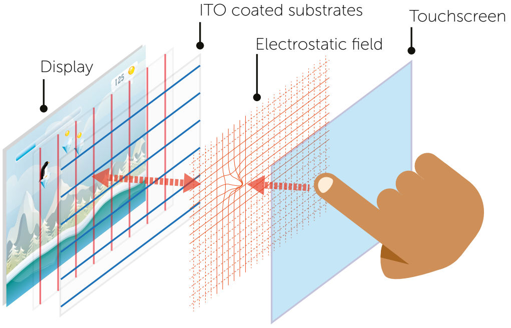
LEDs shine infra-red light across the screen from the top and sides. The infra-red rays form a grid across the screen. When the screen is touched by a finger, the infra-red beam is interrupted, and a microprocessor calculates the coordinates of where the screen was touched.



Infra-red screens are commonly used at staff tills in fast food outlets.

Capacitive screens

Capacitive touchscreens are made up of glass layers. The bottom surface of the upper layer and top surface of the bottom layer are coated in perpendicular lines of transparent conductive material forming a grid. The screen behaves like a capacitor, storing electrical energy. When the screen is touched by a finger, there is a change in the electric field at that position. The position where the field changes is calculated by a microprocessor Unlike resistive screens, capacitive screens can be touched in more than one place at a time.



Capacitive touchscreens are commonly used with smartphones.
Explain why you cannot control the screen when wearing gloves. [2]

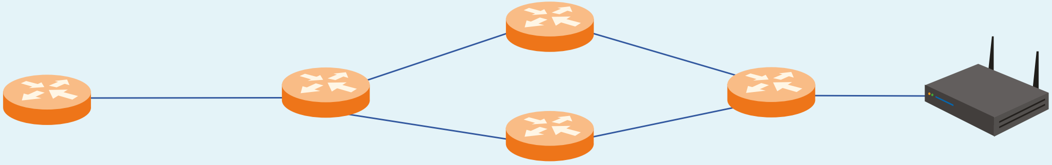
Gloves provide an insulative layer[1], *preventing the electric field from being changed and sensed by the screen.*[1]

INTERNET PROTOCOL (IP) ADDRESSES

An **IP address** is a unique **public address** for the **router** or gateway of a network. **Private addresses** are not unique and the IP address of a portable device such as a laptop will change when it is moved, for example between towns. A router can assign IP addresses.

Routers

Routers use IP addresses to direct data packets from one router to another between start and end points on a network. They sit between **local networks** and the **Internet** to join them together with a public IP address for the Internet and a private IP address for the local network. Any local data is passed on to the Internet by the router. Any inbound data from the Internet is received and directed internally to a specific device.



Static and dynamic addresses

The IP address for your whole network is assigned by your **Internet Service Provider**. All computers within a network have IP addresses **assigned** by your own internal network router. **Static** addresses do not change. **Dynamic** addresses do change and are assigned from a list of available addresses at the time they are required. This is because the IPv4 system does not have enough static addresses for everyone.

IPv4 and IPv6 addresses

An **IPv4** address is commonly four numbers (that are each stored using 8 bits) each separated by a full stop.

Your home router is likely to have a private IP address such as 192.168.0.1. This system however is running out of possible addresses owing to the huge rise in networked devices. To solve this problem, a new system called **IPv6** has been developed. This uses a 128-bit address which is usually represented in hexadecimal. This will provide enough address permutations to cater for all devices on the planet.

IPv4 addresses have four groups of digits e.g.: 212.58.244.66

IPv6 addresses have eight groups of digits e.g.: 2001:0000:4136:e378:8000:63bf:3fff:fdd2

Give **three** characteristics of an IP address. [3]

An IP address can be either static or dynamic,[1] *public or private.*[1] *IP addresses are unique within the network they are used.*[1] *Values are separated by full stops or colons.*[1] *Each value is between 0-255 or 0-FFF.*[1]

APPLICATION AND SYSTEM SOFTWARE

Application software runs on the operating system and provides the services that the user requires, for example, a word processing package, stock control software or an in-car navigation system.

System software programs are those that are needed to enable the computer to function, including the operating system, utilities, library routines and programming language translators.

Major operating systems include **Windows**®, **Linux**®, **MacOS**®, **Apple iOS**® and Google's **Android**®. An **Operating System** (**OS**) is a group of programs that is essential for managing the computer's resources. It handles several crucial tasks:

OS

Managing multitasking:

The OS coordinates the CPU to **schedule processes**. All processes currently in memory waiting to be executed are held in a circular queue. The CPU allocates each process a **time slice** and switches to the next process very quickly, making it seem as though they run at the same time. This is known as **multi-tasking**.

Each process has exclusive use of the CPU during its allocated time slice. Several time slices may be required to complete a process, so an unfinished process must await its next turn at the back of the queue once its time slice expires.

Managing peripherals and drivers:

Peripheral devices connected externally to the CPU include **printers**, **keyboards** and **monitors**. Users must communicate with devices via the OS. "Out of paper" messages for example, must come via the OS. A **driver** is software used to provide an interface for a hardware device.

Managing files:

The OS allows users to create, delete, move, save and copy files, or allocate them to folders. It can search for files, restore deleted files, free up space for new files and prevent conflicts when two users attempt to modify the same file at once. **Access rights** to individual files may also be managed.

Managing user accounts:

Different users will each be provided with an account with their own **user name** and **password management**. Each account can be granted different levels of access depending on their needs and levels of security. The OS can also monitor **login activity** and log out users after set periods of inactivity.

Handling interrupts:

An **interrupt** is a signal from a software program or hardware device to the CPU. A **software interrupt** occurs when an application program terminates or requests certain services from the OS. A software interrupt also occurs with a program error such when a **division by zero** occurs, or when two processes try to access the same memory location.

A **hardware interrupt** may occur, for example, when an I/O operation is complete or when a new USB device is plugged in and detected.

A hardware interrupt also occurs when a key is pressed on the keyboard or the mouse is moved.

Interrupts are also triggered regularly by the timer, to indicate that it is the turn of the next process to have processor time. It is because a processor can be interrupted that **multi-tasking** can take place.

Software called the **Interrupt Service Routine** (**ISR**) determines how to handle each interrupt.

Providing an interface:

The OS provides a means of interacting with the computer, often through buttons, keyboards, touchscreens or mice. An interface may be purely text using a **command line interface**, or it may be a **Graphical User Interface** (**GUI**) / **WIMP interface**.

WIMP stands for Windows, Icons, Menus, Pointer.

Providing a platform for running applications:

When a new application is installed on your computer, the OS will manage this process. The OS will also allocate memory space for the application and control the application's access to data or devices. User access to programs is also managed.

Managing memory:

Files and programs need to be in memory for the CPU to perform tasks which use them. The OS moves programs and files between memory and storage (e.g. hard drive) if virtual memory is required.

Providing system security:

The OS controls user access to prevent users from accessing files or folders they should not have access to. **Security updates** from software manufacturers are also downloaded to help fix bugs and improve security against malware. Files on the hard disk may also be encrypted.

The bootloader

When a computer is turned off, the operating system and all programs and data in use are lost from RAM. The OS remains in non-volatile storage, e.g. hard disk. The **bootloader** (also known as the **bootstrap loader**) is a small piece of software (**firmware**) that is responsible for starting up (booting) a computer. The firmware is held in ROM (Read Only Memory) and automatically starts up when the computer is switched on. It loads the operating system into main memory (RAM).

Explain why the bootloader instructions are stored in ROM and not in RAM. [1]

The contents of ROM are not lost when the computer is turned off.[1]

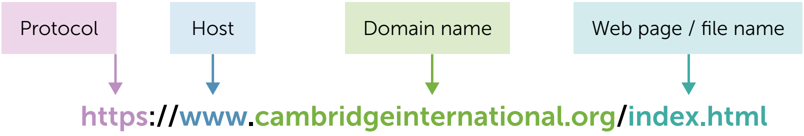
THE INTERNET AND THE WORLD WIDE WEB

The **Internet** is a global **infrastructure** of interconnected networks. The **World Wide Web** is all the web pages that are accessible via the Internet.

Uniform Resource Locator (URL)

Web pages are held on computers connected to the Internet. The World Wide Web (WWW) uses the Internet as a service to communicate the information held on these pages. Every web page has its own unique text-based address, known as the **Uniform Resource Locator (URL)**.

These pages are accessed using a program called a **web browser** such as Google Chrome™, Microsoft® Edge or Apple® Safari. A typical web page address is shown below:



http and https protocols

A **protocol** is a set of rules for communication between devices. It covers standards for physical connections, cabling, mode of transmission, data format and error detection. It allows equipment from different suppliers, all following the standard communication protocol, to work together.

HTTP

HTTP (HyperText Transfer Protocol) is the standard protocol used to communicate across the Web. When you visit a site which has an address starting with **http**, any data you enter into the site, such as your name, address or bank details, is sent in plaintext and is susceptible to hacking.

HTTPS

HTTPS (HyperText Transfer Protocol Secure) is a secure protocol, meaning that any data transmitted between the website and your browser is encrypted and cannot be understood by anyone intercepting it. The web server you are connecting to is also **authenticated** to ensure the site is genuine.

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Functions of a browser

In addition to rendering and displaying web pages, the functions of a web browser include:

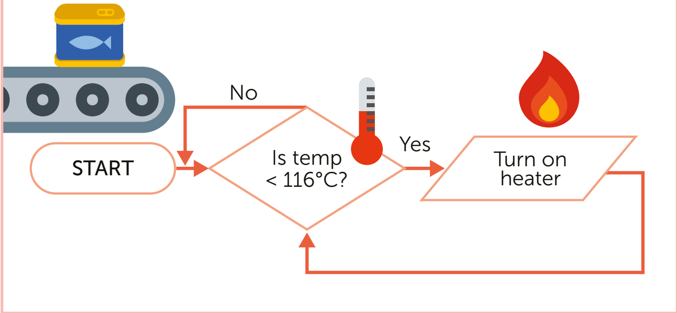
- Storing bookmarks and favourites
- Recording user history
- Allowing use of multiple tabs
- Storing cookies
- Providing navigation tools
- Providing an address bar

AUTOMATED SYSTEMS

An **automated system** usually comprises **sensors** to **take measurements** of their environment, **microprocessors** to process the information and make decisions based on the readings, and **actuators** to make a **physical change** to the environment such as a motor opening a door, shutting a valve or turning on an alarm.

Industry

The canned food industry relies on bringing the contents of tins to a certain temperature under pressure before they are then cooled, and the food inside is deemed safe to eat. The temperature of the cans is measured on the production line and a response is made if the temperature falls below a pre-set minimum.



An automated process means that far greater accuracy of measurements can be achieved. Even a 99.9% accuracy level on a production line with 100,000 cans per day means that 100 cans will contain potentially harmful bacteria. Automated systems are more expensive to install, but they do not require salaries and can work 24/7, significantly increasing productivity.

Agriculture

Humidity, pH and moisture sensors in agriculture ensure that the crops are grown and stored in the optimum conditions. Microprocessors will process any readings from the sensors and cause actuators to turn on sprinkler systems or open vents, or turn on heaters, for example.

Transport

Proximity sensors in self-driving cars can automatically apply the brakes if a car gets too close to another in front. Aircraft are equipped with thousands of sensors and actuators to adjust the wing flaps, throttle, rudder etc., as part of the autopilot and safety systems.

A scientific laboratory is conducting tests on 50,000 test tubes containing different concentrations of a new vaccine. They are considering using an automated system to conduct the tests.

Describe **two** disadvantages of installing an automated system in a laboratory. [4]

The initial investment costs of equipment may be very high[1] *and more space may be needed.*[1] *Equipment may involve increased maintenance and replacement costs.*[1] *Increased generation of noise, heat and vibrations.*[1] *Increased risk of downtime.*[1] *May involve job disruption, changing skill needs, rising inequality.*[1]

TOPICS FOR PAPER 2

ALGORITHMS, PROGRAMMING AND LOGIC

Information about Paper 2

Written exam: 1 hour and 45 minutes
75 marks
50% of IGCSE

Specification coverage

Algorithm design and problem-solving;
programming concepts; databases; Boolean logic.

The content for this assessment will be drawn from subject content sections 7 to 10 of the specification.

Questions

This paper consists of short-answer and structured questions, and a scenario-based question. All questions are compulsory. Calculators are not permitted.

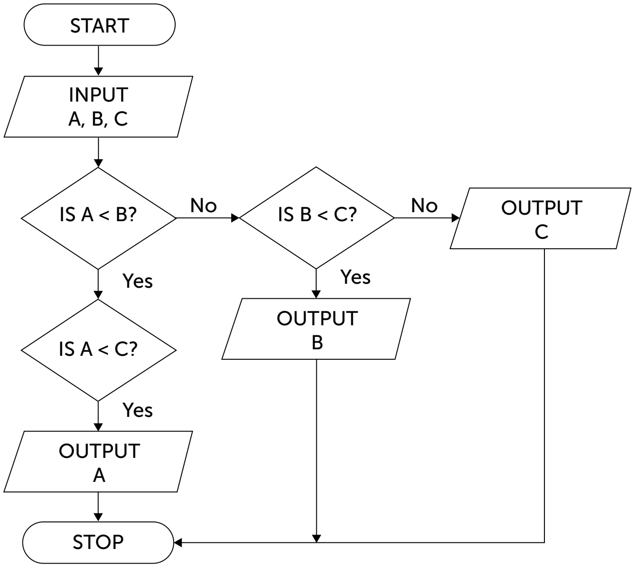
EXPLAIN THE PURPOSE OF A GIVEN ALGORITHM

Every problem to be solved using a computer involves input, processing and output.

Input, process, output

Many problems involve reading data from or writing data to a permanent storage device.

- The **input** may be typed by someone at a keyboard, or it may be a reading from a sensor such as a moisture, pressure or temperature sensor, or some other form of input.
- The data then has to be **processed** in some way – for example by sorting a list, performing calculations or using temperature readings to predict ice on the roads.
- **Output** is the end result after processing. This could be, for example, a printed report, a valve opened or closed, graphics displayed on a screen or data stored on a storage device.



(a) Explain the purpose of the algorithm shown on the left. [1]

(b) Write the algorithm using pseudocode instead of a flowchart. [4]

(a) The purpose is to output the smallest of three numbers input by the user.[1]

(b) In pseudocode:

```
INPUT A
INPUT B
INPUT C[1]
IF A < B
  THEN
    IF A < C
      THEN
        OUTPUT A
    ENDIF[1]
  ELSE
    IF B < C
      THEN[1]
        OUTPUT B
      ELSE
        OUTPUT C
    ENDIF[1]
ENDIF[1]
```

This algorithm uses a **nested selection** structure.

The IF statement has an IF statement nested inside it. In this example, the ELSE statement also has a nested IF statement.

BUBBLE SORT

A bubble sort works by repeatedly going through the list to be sorted, swapping adjacent elements if they are in the wrong order.

To sort a list of n items, a maximum of n – 1 passes is required. (The items may be alphabetical or numeric.)

Example

A list of 5 numbers 7, 3, 5, 9, 4 is to be sorted. Show the state of the list after each pass.

List	7	3	5	9	4	
Pass 1	3	7	5	9	4	
	3	5	7	9	4	
	3	5	7	9	4	
	3	5	7	4	9	Examine 5 items

After the first pass through the list, the largest number has ‘bubbled’ to the end of the list. In the second pass, we only need to compare the first four items.

Pass 2	3	5	7	4	9	
	3	5	7	4	9	
	3	5	4	7	9	Examine 4 items
Pass 3	3	5	4	7	9	
	3	4	5	7	9	Examine 3 items
Pass 4	3	4	5	7	9	Examine 2 items

The list is now sorted.

1. The list of animals hamster, rabbit, dog, cat, goldfish, is to be sorted in alphabetical order using a bubble sort.

   Show the state of the list after:

   (a) Pass 1 [1]

   (b) Pass 2 [1]

(a) hamster, dog, cat, goldfish, rabbit[1]

(b) dog, cat, goldfish, hamster, rabbit[1]

The bubble sort algorithm is not efficient for large lists. Note that in some cases, the algorithm may have sorted the list before performing the full number of passes. If no swaps are made during a particular pass, then the list must already be sorted.

This condition could be tested and the sorted list output without performing any more passes.

EXAMINATION PRACTICE

1. A pseudocode algorithm is given below.

```
01  AList ← [3,6,7,9,13,15,16,19,20,24,26,29,36]
02  Found ← False
03  N ← 1
04  INPUT X
05  WHILE Found = FALSE AND N <= LENGTH(AList) DO
06    OUTPUT aList[N]
07    IF AList[N] = X
08      THEN
09        Found ← TRUE
10      ELSE
11        N ← N + 1
12    ENDIF
13  ENDWHILE
14  IF Found = TRUE
15    THEN
16      OUTPUT X, N
17    ELSE
18      OUTPUT "Invalid number"
19  ENDIF
```

(a) At line 05, what is the value of LENGTH(AList)? [1]

(b) The user enters 9 at line 04. What is printed at line 06 the first 3 times the WHILE...ENDWHILE loop is performed? [1]

(c) State what will be printed at line 16 if the user enters the number 9. [1]

(d) Explain the purpose of this algorithm. [2]

2. An algorithm for a bubble sort is given below.

```
01  Names ← ["Edna ", "Adam ", "Victor ", "Charlie ", "Jack ", "Ken", "Maria"]
02  N ← LENGTH(Names)
03  Comparisons = N - 1
04  SwapMade ← TRUE
05  WHILE Comparisons > 0 AND SwapMade = TRUE DO
06    SwapMade ← False
07    FOR Index ← 1 TO Comparisons
08      IF Names[Index] > Names[Index + 1]
09        THEN
10            <swap the names>
11
12
13            SwapMade ← TRUE
14      ENDIF
15    NEXT Index
16    Comparisons ← Comparisons - 1
17  ENDWHILE
18  OUTPUT Names
```

DATABASES

A **database** is a way of holding data in an organised way so that searching for data items meeting certain criteria is quick and easy.

Tables, records and fields

A database consists of one or more **tables**. Each table consists of many **records** (rows) each having an identical record structure. Each **field** (column) in a record has a defined field type such as **text/alphanumeric**, **character**, **Boolean**, **integer**, **real** or **date/time**.

Each table will have a **primary key** field that uniquely identifies each record in the table. In this table, the primary key is **ID**.

Volcano

ID	Name	Country	LastErupted	TimesErupted	ElevationMetres
1	Taal	Philippines	2020	7	311
2	White Island	New Zealand	2019	39	321
3	Shiveluch	Russia	2019	21	3283
4	Anak Krakatoa	Indonesia	2018	21	813
5	Eyjafjallajökull	Iceland	2010	2	2119
6	Etna	Italy	2021	57	3326
7	Stromboli	Italy	2019	1500	924
8	Puyehue-Cordón Caulle	Chile	2011	8	2236

The table **Volcano** above, records volcanic eruptions and the number of times each one has erupted in recent times.

(a) State how many records are featured in the **Volcano** table. [1]

(b) State how many fields are in the **Volcano** table. [1]

(c) Suggest suitable data types for the data in the **Country**, **LastErupted** and **ElevationMetres** columns. [3]

(a) 8[1]

(b) 6[1]

(c) text[1]*, integer*[1]*, integer*[1].

STRUCTURED QUERY LANGUAGE (SQL)

Records in a database format can be searched using **Structured Query Language** (**SQL**).

The format of an SQL statement

SELECT... list the field(s) you want displayed here
FROM... list the table or tables the data will come from here
WHERE... list search criteria here
ORDER BY... optional criteria to sort in ascending (ASC) or descending (DESC) order.

Using the **Volcano** table, the SQL statement below will return a **Results** table showing all eruptions since 2019, in alphabetical order of name.

SELECT Name, lastErupted, TimesErupted
FROM Volcano
WHERE LastErupted >= 2019
ORDER BY name **ASC**

Name	LastErupted	TimesErupted
Etna	2021	57
Shiveluch	2019	21
Stromboli	2019	1500
Taal	2020	7
White Island	2019	39

You can also use Boolean operators AND and OR in search criteria.

Example

Find all volcanoes with an elevation of less than 500 metres which have erupted since 2019. Display the results in descending order of the date they last erupted, i.e. the volcano which erupted most recently should appear first in the list.

SELECT Name, Country, LastErupted, ElevationMetres

FROM Volcano

WHERE LastErupted >= 2019 **AND** ElevationMetres < 500

ORDER BY LastErupted **DESC**

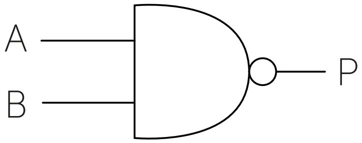
RESULTS table

Name	Country	LastErupted	ElevationMetres
Taal	Philippines	2020	311
White Island	New Zealand	2019	321

NAND, NOR AND XOR (EOR) GATES

NAND gate

The NAND gate is a combination of the AND and NOT gates, which inverts the output of the AND gate. Having a single type of NAND gate that can perform two separate functions can help to reduce development costs if a NAND gate is cheaper than separate AND and NOT gates.

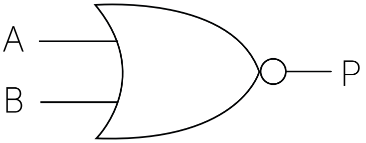


P = NOT (A AND B)

A	B	P = A NAND B
0	0	1
0	1	1
1	0	1
1	1	0

NOR gate

The NOR gate returns true only when both inputs are false.

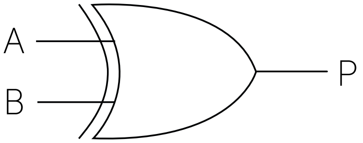


P = NOT (A OR B)

A	B	P = A NOR B
0	0	1
0	1	0
1	0	0
1	1	0

XOR (EOR) gate

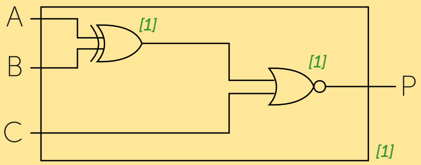
The exclusive OR gate returns true if one input is true, but not both.



P = A XOR B

A	B	P = A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

Draw a logic circuit for this logic expression: P = (A XOR B) NAND C [3]



EXAMINATION PRACTICE ANSWERS

Topic 1

1. 4.5 × 1024 = 4,608 bytes. [1]

2. 'C' is three characters before 'F', so deduct 3 from the value for 'F'. 100 0011. [2]

3. (a) (i) A signed integer would be most appropriate as this accommodates for negative values. [1]
   (ii) An 8-bit signed integer has the minimum and maximum values of -128 to 127 which would be enough to store the highest and lowest recorded temperatures and more. [2]
   (b) D. 1111 1010 [1]

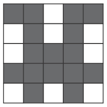
4. (a) (i) 0111 1111 [1] (ii) 127 [1]
   (b) 58 and 90. [2]
   (c) 1001 0100 [1]
   (d) Overflow has occurred, changing the sign bit. This gives an incorrect negative result of 10010100 which is -108. [2]
   (e) –13 [1]

5. (a) 9 [1]
   (b) 0000 0100 = 4 in denary. Each shift right divides by 2. Loss of precision occurs when the last digit dropped is odd. [3]

6. (a) 0000 0101. [1]
   (b) 0101 0000. [1]
   (c) The leftmost bits of the original bit pattern are unchanged and the rightmost four bits are set to zero. [1]

7. (a) 17 257 [2] (b) 00000011 01101010 [2]

8. (a) [2]



   (b) Lossy compression (e.g. JPG) would provide the smallest file size whilst maintaining a good quality image. Whilst some data is removed during the compression process, the image would still be recognisable. The smaller file size would mean it was able to download and display on a browser more quickly. Alternative compression methods such as PNG or GIF are acceptable with an explanation. [4]
   (c) 25 pixels × 24 bits / 8 = 75 bytes. [1]
   (d) (i) Green: 0010 1110, Blue: 1010 0110. [2]
   (ii) Hexadecimal is easier to remember than a string of binary values, so humans make fewer errors when writing it down or using it in code. Hexadecimal is a shortened notation of binary so uses fewer characters. [2]

9. (a) Sample resolution means the number of bits allocated to each recorded sample. Sample rate is the frequency with which samples are taken. [2]
   (b) The greater the number of bits, the more accurately the wave height of each sample can be recorded.
   This increases the overall quality of the recording as it will create a closer representation of the original sound. [2]
   (c) Increased duration will increase the file size as it will involve a greater number of samples. [1]

Topic 2

1. (a) B. Packets are sent across different routes depending on which is fastest at the time. [1]
   (b) Destination IP address [1], packet number [1], sender's IP address [1], sequence number [1], trailer [1] marking the end of the packet. [4]

2. (a) Serial transmission: bits are sent one at a time along a single cable.[1]
   Parallel transmission: several data bits are sent simultaneously.[1] [2]
   (b) More reliable over long distances.[1] Smaller, simpler and cheaper connections.[1] [2]
   (c) (i) Half-duplex [1]. [1]
   (ii) Half-duplex allows the full bandwidth of the cable to be used to send data to the printer [1], but then allows the printer to communicate errors back to the computer, such as an 'out of paper' error [1]. [2]

3. The checksum shows that there has been an error in transmission, so the file should re-transmitted. [2]

INDEX

EXAMINATION TIPS

With your examination practice, apply a boundary approximation using the following tables. These tables are calculated using an average of past years' boundaries for the 0478 (A*-G) and 0984 (9-1) IGCSE course.

Both courses are identical in content but vary in the way they are graded. Be aware that boundaries vary annually.

0478 (A*-G)	A*	A	B	C	D	E	F	G
Boundary	80%	67%	54%	41%	34%	28%	21%	15%

0984 (9-1)	9	8	7	6	5	4	3	2	1
Boundary	81%	73%	65%	56%	48%	40%	30%	23%	15%

1. Read each question carefully. Some students give answers to questions they think or hope are being asked rather than the actual question. Avoid simply rewriting a question in your answers or repeating examples that are already given in the question.
2. Be sure to write your answers in the spaces provided. Answers given outside of this space may be missed in the scanning and marking process.
3. Understand the requirements of command words at the back of the specification. If *'Describe'* or *'Explain'* questions are given you need to expand your answers. To help you justify your responses, aim to include connective words such as BECAUSE... or SO... in every answer **because** this forces you to justify your point, **so** you get additional marks. See how well it works! *'Explain'* questions such as *'Explain why this is the most appropriate...'* do not require just a list of benefits. Instead you should identify the benefits and then expand each one, applying them to the scenario or context.
4. No marks are awarded for using brand names of software packages or hardware, e.g. "MS Word", "Excel", "iPhone", "Android" or "Windows". Use generic terms where you can, e.g. word processor or smartphone.
5. Full answers should be given to questions – not just key words. Make your answers match the context of the question.
6. Generic answers are not sufficient. E.g. If a question asks for a description of the function of a router, an answer 'it connects devices together' is not sufficient. Instead, answers should describe how routers are used to receive packets from computers, read the destination address of each and then forward each packet to its destination. *Faster, bigger* and *cheaper* are not very useful responses unless you justify your points.
7. Algorithm questions require an actual algorithm, not a repetition of the question. If a question explicitly asks for an algorithm to be written in pseudocode, then it will not gain marks if it is written as a flowchart. Equally, a question that asks for an algorithm to be written as a flowchart will not gain marks if answered with pseudocode.
8. Learn and make use of the standard flowchart symbols when drawing or constructing charts.
9. Be careful when outputting strings and variables: the string must be in quotes, e.g. `OUTPUT "Hello", name`
10. Be careful with quotes around strings. E.g. `choice ← A` (which assigns a variable `A` to `choice`) is very different from `choice ← "A"` (which assigns a value `"A"` to `choice`).
11. The first element of an array has an index of 1 in IGCSE pseudocode, e.g. Day[1]. In most programming languages, e.g. Python, the index of the first array element is 0.
12. A common error in IF statements is writing `IF name = "Sam" OR "sam"`. This should be:

    ```
    if name = "Sam" OR name = "sam"
    ```

Good luck!

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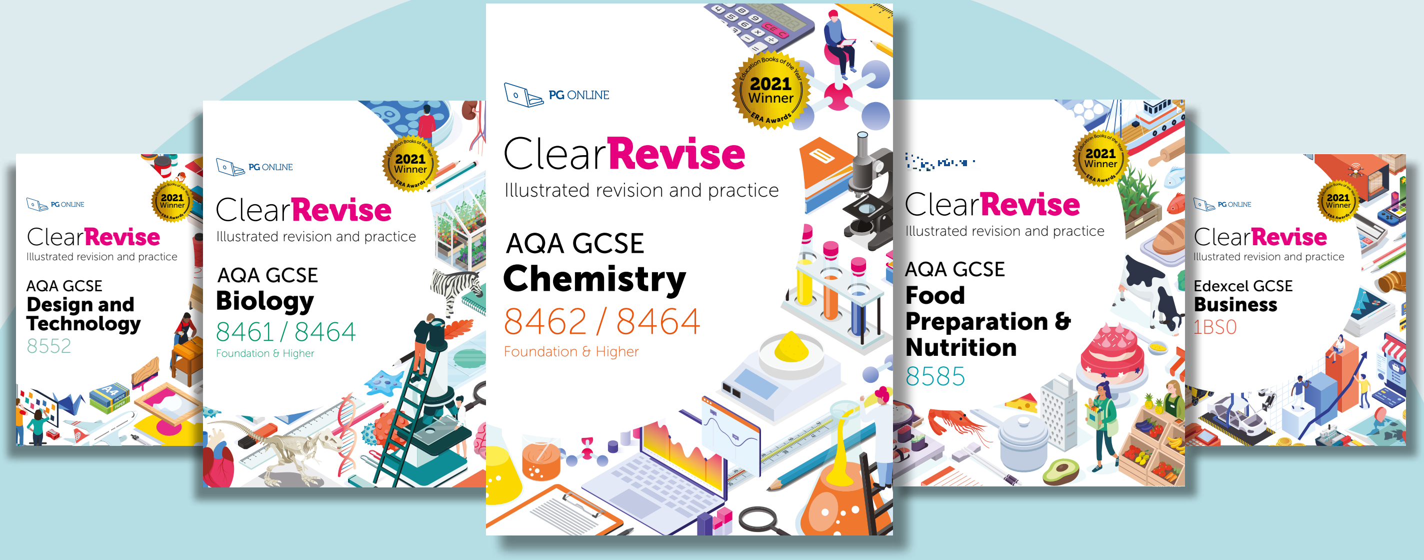

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