

UNIT 1

DIGITAL DEVICES

Assessment Objective 1

Demonstrate knowledge and understanding of Information and Communication Technology (ICT)

In this unit, you will learn about the features, purpose and use of a range of digital devices and the software that can be used with them. Understanding the rapid developments in the features and functionality of digital devices will help you to understand their current and possible future uses by individuals, organisations and society.

Assessment Objective 2

Apply knowledge, understanding and skills to produce ICT based solutions

Assessment Objective 3

Analyse, evaluate, make reasoned judgments and present conclusions

1 DIGITAL DEVICES

Digital devices are pieces of hardware that use computers or microcontrollers, and they are found everywhere in our digital world. They enhance and support how we live our lives every day. They can connect and work together to give us the data we need, when and where we need it.

Digital devices are always developing. This changes the way in which they are used by individuals, organisations and local, national and global societies.



LEARNING OBJECTIVES

- Be aware that mainframe computers are used for complex processing tasks and microprocessors are embedded in products such as washing machines
- Understand that laptop and desktop computers are types of personal computers. Some laptops are used as desktop replacements
- Know about types of mobile phones; smartphones and specialist phones and how they connect to the network (SIM)
- Know about tablet devices
- Be able to describe the purpose and use of other digital devices such as:
 - cameras and camcorders
 - games consoles
 - home entertainment systems
 - media players
- Know about navigation aids and how they are used
- Understand the terms 'multifunctional' (e.g. mobile phones that include a camera, have limited game playing functionality and GPS) and 'convergence' (e.g. functionality of smartphones and tablet devices becomes more similar) in the context of digital devices
- Understand features of digital devices: portability, performance, storage, user interface, connectivity, media support, energy consumption, expansion capability, security features
- Be able to discuss the features of identified digital devices
- Be able to identify digital devices and associated peripheral devices that meet particular needs, including accessibility
- Know about types of output peripheral such as monitor (screen size, resolution), printer (laser, inkjet, 3D), plotter, data projector, speaker, control device and when they would be used
- Know about types of input peripheral such as keyboard, mouse, tracker ball, joystick, graphics tablet, scanner, digital camera, webcam, microphone, touch screen, OMR reader, OCR reader, bar code scanner, biometric scanner, magnetic stripe reader, chip and pin, sensor and when they would be used
- Be able to differentiate between storage devices and the media used to store data
- Know the characteristics of hard disk drives (HDD), solid state drives (SSD), optical disk drives, flash memory drives
- Know that storage devices can be internal or external
- Know about types of storage media such as hard disks, optical disks (CD, DVD, Blu-ray), flash memory devices, magnetic tape
- Know that storage media can be recordable / write once (R) and rewritable (R/W)
- Understand the terms describing the capacity of storage such as bit, byte and multiples of these (kbytes, mbytes, gbytes, tbytes) (using 1KB = 1000 bytes)

SUBJECT VOCABULARY

mainframe computer a large, powerful computer that can do a lot of complicated jobs quickly and can be used by a lot of people at the same time

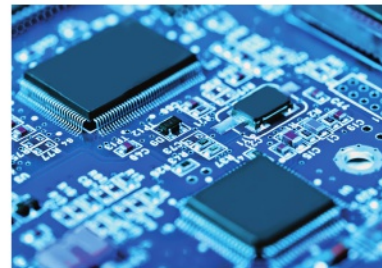
microprocessor the device that controls what a computer does; it takes data as input, does something with it and provides output

TYPES OF DIGITAL DEVICES

There are many types of digital devices. They range from very powerful **mainframe computers**, used by large organisations for complex processing tasks such as statistical analysis and bulk data processing, to **microprocessors** used to control washing machines, televisions and other household appliances. Examples of the devices you will consider include personal computers, digital cameras and home entertainment systems.



▲ Figure 1.1 A mainframe computer



▲ Figure 1.2 A microprocessor

SKILLS

CRITICAL THINKING
INTERPRETATION
COMMUNICATION

ACTIVITY

▼ DIGITAL DEVICES

- 1 Research the difference between a mainframe computer, a server and a supercomputer.
- 2 Create a list of the digital devices in your home that use microprocessors.

PERSONAL COMPUTERS

SUBJECT VOCABULARY

upgrade to make a computer better and able to do more things

peripheral device equipment that is connected to a computer and used with it

Personal computers (PCs) are common in homes and offices. They come in many different shapes and sizes, such as desktops and laptops.

DESKTOPS

Desktops have more space for components than laptops and often provide users with the option to **upgrade** them or add additional components. A desktop computer usually needs to have **peripheral devices** connected to it, such as a monitor, a printer, a mouse and a keyboard. For more information about peripheral devices, see pages 19, 20 and 32.



▲ Figure 1.3 A desktop computer

Some desktops are 'all-in-one'. This means that they combine the monitor with the PC hardware, as shown in Figure 1.4.



▲ Figure 1.4 An all-in-one computer

GENERAL VOCABULARY

portable easy to carry or move

LAPTOPS

Laptops include a keyboard, a screen, a track pad (see page 23) and a rechargeable battery. Having these features means that they can be taken away from the desk, which makes them an example of a **portable** device.



▲ Figure 1.5 A laptop computer

Some laptops are called 'desktop replacements'. These tend to be larger than other laptops, as well as having a bigger and better-quality screen and higher performance levels.

SUBJECT VOCABULARY

embedded computing computing hardware that is fixed into position and carries out a specialist task

physical computing interactive systems that can sense and respond to the world around them

SINGLE-BOARD COMPUTERS

Single-board computers (SBCs) are affordable computers used in education, **embedded computing** projects and **physical computing** projects. The Raspberry Pi Zero (see Figure 1.6) is an example of an SBC. The unit itself costs very little and uses a cheap microSD card as its storage.



▲ Figure 1.6 The Raspberry Pi Zero (top) and its microSD card (top left)

MOBILE PHONES

Mobile phones use a SIM card to connect to a mobile phone network. SIM stands for subscriber identity module, and a SIM card is used to identify the subscriber to a mobile phone network.

DID YOU KNOW?

Sri Lanka has more mobile phones than people. In 2015, for every 100 Sri Lankan citizens there were 113 mobile phones.



▲ Figure 1.7 The SIM card from a mobile phone

SUBJECT VOCABULARY

user the person who uses a computer system

SPECIALIST PHONES

Some mobile phones have specialist features to provide **users** with functions that meet particular user needs. For example, some phones have an emergency button that is linked to a list of emergency contacts. When this button is pressed, the phone will call each person on the list until someone answers.

SKILLS

CRITICAL THINKING
PERSONAL AND SOCIAL RESPONSIBILITY
COMMUNICATION
INTERPERSONAL SKILLS

ACTIVITY

▼ EMERGENCY BUTTON

Discuss which groups of people could need a phone with an emergency button. How would this phone meet their needs?

GENERAL VOCABULARY

accessibility a measure of how easy something is to use, especially by people with disabilities

Other phones meet users' **accessibility** needs. Examples include the Alto 2 'talking phone', shown in Figure 1.8, which is a specialist mobile phone for blind and partially sighted people. It meets its users' needs because every feature and function is spoken aloud. Other phones provide fewer, larger buttons and connections for hearing aids.

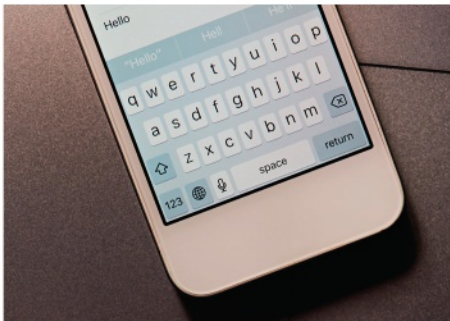
SUBJECT VOCABULARY

Wi-Fi (wireless fidelity) a way of connecting computers or other electronic machines to a network or the internet by using radio signals rather than wires

games console an electronic device that is used for playing computerised video games on a screen

application a program that allows a user to perform a task; applications are often called apps

virtual keyboard a keyboard displayed on and used via a touch screen



▲ Figure 1.10 A virtual keyboard



▲ Figure 1.8 The Alto 2 'talking phone' reads the names of contacts and text messages aloud to its user



▲ Figure 1.9 Some mobile phones use tactile keypads, which are more responsive than other keypads, and give the user a choice of on-screen text size and colours

SMARTPHONES

Smartphones are small computers with **Wi-Fi** and mobile phone connectivity to allow them to make phone calls and access the internet. They also include features of other devices such as cameras, media players and hand-held **games consoles**. They have a more advanced operating system than other mobile phones. **Applications** (or apps) can be downloaded onto the smartphone, which allow users to customise their smartphones with entertainment, educational and business features. Most smartphones use a touch screen to allow users to input information. A **virtual keyboard** is used to enter text, numbers and other characters.

Because they combine so many features, smartphones use more power than other types of mobile phone. This means that they have a shorter battery life and need to be charged more regularly than other mobile phones.

SKILLS

CRITICAL THINKING
INTERPRETATION
COMMUNICATION

ACTIVITY

▼ SMARTPHONES AND MOBILE PHONES

- 1 Research which smartphone features use the most power.
- 2 Make a list of activities for which a standard mobile phone would be more suitable than a smartphone.

SKILLS

CRITICAL THINKING
PERSONAL AND SOCIAL RESPONSIBILITY

ACTIVITY

▼ ACCESSIBILITY

The Royal National Institute of Blind People is a UK organisation that supports people with sight impairments. Do an internet search for the key terms 'RNIB mobile phone accessibility' to visit the RNIB's website, which will give you lots of information about the accessibility features of mobile phones and smartphones.

Watch the video on the RNIB's website about the accessibility features of major smartphones and make a list of the features mentioned. Which features did you already know about?

TABLETS

Tablet devices or tablets are bigger than smartphones, but have similar features. For example, a tablet device has a touch screen, apps and Wi-Fi connectivity to provide access to the internet. Some tablet devices have SIM card slots to allow internet connectivity using the mobile phone network, so that they can be online when they are not within range of a Wi-Fi signal.



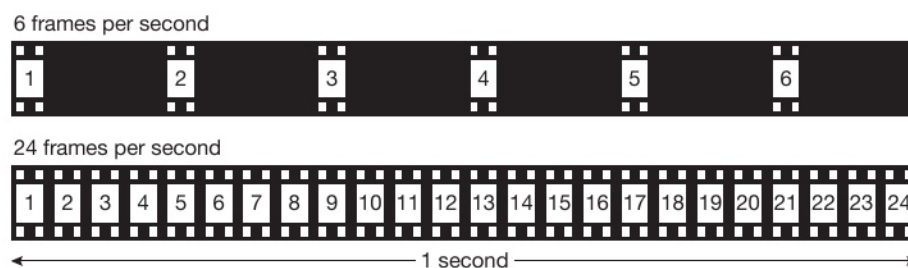
▲ Figure 1.11 A tablet device

CAMERAS AND CAMCORDERS

DID YOU KNOW?

Moving images (movies) are simply a sequence of images called 'frames'. Figure 1.12 shows how the frame rate affects the quality of a movie.

Digital cameras and camcorders use light sensors to capture images formed by light passing through the device's lens. Traditionally, cameras are used to capture still images and camcorders are used to capture moving images. However, most digital cameras can now film moving images and most camcorders can photograph still images.



▲ Figure 1.12 High frame rates produce smooth results, whereas low frame rates can produce results that appear to stutter or jump

GENERAL VOCABULARY

compensate to reduce or correct a negative effect

SUBJECT VOCABULARY

pixel a small dot that helps to make up an image

The quality of the image captured by the camera depends on the quality of the lens, the image processor and the resolution of the sensor.

- A good lens allows light to travel through it without introducing any defects. It also allows the user to choose how much light can travel through it, which affects the final image.
- A good image processor can **compensate** for poor lighting conditions.
- Digital images are made up of small dots called **pixels**. Better-quality sensors can capture more detail and produce images with a greater number of pixels. The sensor resolution of a camera is expressed as the number of pixels that can be captured, as shown in Table 1.1. Some cameras use more than one sensor, each dedicated to a different colour or wavelength of light.

SUBJECT VOCABULARY

resolution the number of pixels used by a screen to display an image
pixelated an effect that creates an unclear image consisting of large individual pixels that are visible to the human eye



▲ Figure 1.13 The area of the image with the leaf becomes **pixelated** when enlarged

▼ Table 1.1 Maximum display size at different **resolutions**

Resolution (number of pixels)	Maximum display size of image (in pixels, width × height) before pixelation occurs
1.3 megapixel (1.3 million pixels)	1280 × 960
2 megapixel	1600 × 1200
3 megapixel	2048 × 1536
4 megapixel	2272 × 1704
8 megapixel and above	2560 × 1920

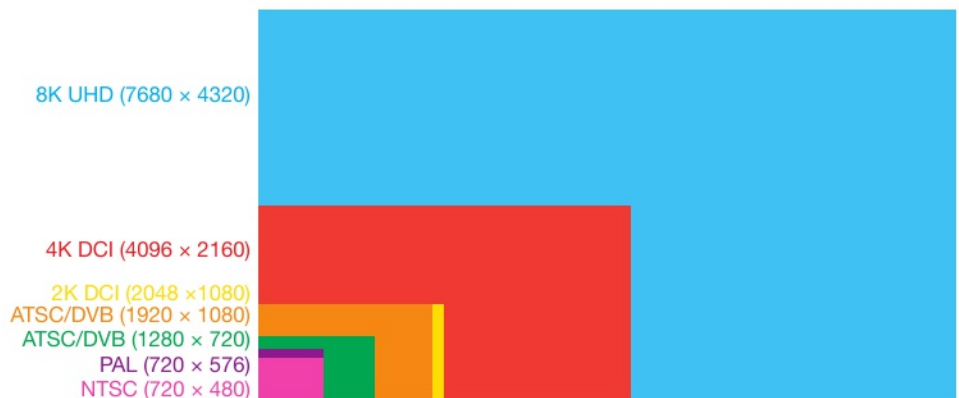
HOME ENTERTAINMENT SYSTEMS

TELEVISIONS

Televisions display still and moving images on a screen. The quality of the image is set by the number of pixels that are used to display the image. This is referred to as the screen's resolution. High definition (HD) television screens contain a larger number of pixels, which means that they have a higher resolution than standard definition televisions.

The resolution of a television in pixels is stated as horizontal pixels × vertical pixels. Often, television manufacturers do not specify the number of horizontal pixels and instead refer only to the number of vertical pixels. For example, a resolution of 1280 × 720 is often stated as 720p and 1920 × 1080 is stated as 1080p.

Ultra High Definition (UHD) television screens are sometimes referred to as 4K or 8K because they have a horizontal resolution of approximately 4,000 or 8,000 pixels. 8K screens make each pixel impossible to tell apart even when users are close to the screen.



▲ Figure 1.14 Comparison chart showing different screen resolutions

SKILLS CRITICAL THINKING
COMMUNICATION
SELF-DIRECTION
INTERPERSONAL SKILLS

SUBJECT VOCABULARY

stream play a file on your computer while it is being downloaded from the internet, rather than saving it as a file and then playing it

smart the ability of a device to use data from sensors to perform a programmed action independently; smart devices are often also able to connect to the internet

SUBJECT VOCABULARY

media player an electronic device that can store and play digital music and videos and show digital photographs

USB (Universal Serial Bus) a standard for wired connectivity that can also supply electric power

Bluetooth wireless connectivity that allows devices to connect over short distances

set-top box (STB) a device that sends video and audio received from a broadcaster to a television

ACTIVITY

▼ TYPES OF TELEVISION

- 1 Research the cost of HD, 4K and 8K televisions.
- 2 Research the types of content that is broadcast or available to buy in each resolution. How easy would it be to **stream** content in each resolution?
- 3 Estimate how far you sit from your television when watching television at home, then research how close to the screen a user must be in order to notice the quality of the three different resolutions.
- 4 Discuss whether it is worth paying the extra cost for 4K and 8K televisions in order to watch television. Do you think there is any point in creating 16K screens for home use?

For the production of sound, most televisions come with built-in speakers. However, these are often small and of limited quality because the screen is usually very thin. Most modern televisions can be connected to an external sound system to improve their sound quality.

Smart televisions use apps and can download and stream content from the internet.

SOUND SYSTEMS

Sound systems can produce loud, rich sound using high-quality speakers and amplifiers. Some speakers contain built-in amplifiers.

Sound systems can play music from CDs or from local storage. They can usually be connected to personal devices like smartphones, **media players** and tablet devices using wired connections like **USB** or wireless connections like **Bluetooth**. They can also be connected to a local network via Wi-Fi to play music that is stored on connected devices. Some sound systems can also connect to the internet to play music stored online.

PERSONAL VIDEO RECORDERS

A personal video recorder (PVR) is a device that records broadcasted content so that it can be watched at a later date.

Some devices fall into multiple categories. For example, some satellite television devices contain both a **set-top box (STB)** and a PVR.

BLU-RAY AND DVD PLAYERS

Blu-ray and DVD players connect to televisions in order to play films and other content that is stored on DVD or Blu-ray disks (see page 39 for more on Blu-ray media). Blu-ray players will usually play DVD disks, but DVD players will not play Blu-ray disks.

Blu-ray disks can store HD movies, which have higher-quality picture and sound. Newer 4K Ultra HD Blu-ray players can play 4K content on 4K televisions.



▲ Figure 1.15 A Blu-ray player

GAMES CONSOLES



▲ Figure 1.16 How many games consoles have you tried?

Games consoles are designed to enable users to play video games on a television screen. Games are provided on disks or as downloads from the internet. They use controllers, which are often wireless, to control the characters, vehicles and/or objects in the game.

SUBJECT VOCABULARY

avatar a figure that represents a person in a computer game or other virtual environment

Some consoles use motion sensors to allow the player to control the game with gestures and body movements. Other games use virtual reality controllers and headsets to immerse the player in a realistic gaming experience, where their own movements in the real world are replicated by an **avatar** in the virtual world of the game.



▲ Figure 1.17 Have you played any virtual reality games?

SKILLS

CRITICAL THINKING
PERSONAL AND SOCIAL RESPONSIBILITY
COMMUNICATION
INTERPERSONAL SKILLS

ACTIVITY

▼ VIDEO GAMES

Discuss the age ratings of popular games. Do you think these age ratings are appropriate? Do you think age ratings are necessary? Explain the reasons for your answer.

Modern games consoles are multifunctional (see page 15). They may have apps and connectivity that provide access to local networks and the internet as well as the option to play movies and music. Some consoles also have disk drives to play films and other content on DVD, Blu-ray or 4K Ultra HD Blu-ray media.



▲ Figure 1.18 Consoles can often do more than just play games

SUBJECT VOCABULARY

data values that represent information

Handheld versions of games consoles provide mobile gaming. Handheld consoles have a built-in screen and less storage than a full-size console. This means that the games that can be played on these devices often have reduced image and sound quality, reduced game complexity and limited storylines in order to reduce the amount of **data** that needs to be stored.

MEDIA PLAYERS

DID YOU KNOW?

Network attached storage (NAS) devices often have media streaming capabilities built in.

Media players provide video and audio content to a television. This content could be streamed directly from the internet or accessed from networked or local storage. Media players can be connected to a television directly or using a wired or wireless network. They are controlled using a remote control or, in some cases, a smartphone app. Some media players offer output in 4K.



▲ Figure 1.19 Have you used any other examples of media players?

SKILLS

CRITICAL THINKING
COMMUNICATION
INTERPERSONAL SKILLS

DID YOU KNOW?

A Raspberry Pi Zero single-board computer and free software can be used as a media player. This makes it a very affordable alternative to a television and media player, or a smart television.

SUBJECT VOCABULARY

flash memory a form of storage that stores data as electrical charges held in tiny electrical cells

ACTIVITY

▼ SMART TELEVISIONS

Smart televisions have the streaming and networking functions of a media player built in. Do you think that smart televisions are going to replace media players? Discuss your reasons for thinking that this may or may not happen.

Personal media players are compact, portable devices with local storage to hold media files for playback. They are useful when travelling or exercising due to their small size and long battery life. They often use solid state **flash memory** storage (see page 62), which is not affected by being moved or shaken.



▲ Figure 1.20 Personal media players are portable so they need to function while on the move

NAVIGATION AIDS

SUBJECT VOCABULARY

GPS the Global Positioning System that uses radio signals from satellites to show your exact position on the Earth on a special piece of equipment

DID YOU KNOW?

GPS satellites orbit more than 20km above Earth. They are accurate to within 5 metres.

Navigation aids (such as Sat-Nav) can calculate the best route between two or more locations and can provide updates to the route if it is not followed accurately. They are commonly used in cars, delivery vans and ships. They provide visual prompts and alerts to help drivers take the correct route, such as by taking a particular turning. Specialist devices with audio alerts and waterproof and shockproof cases are available for walkers, cyclists and runners.

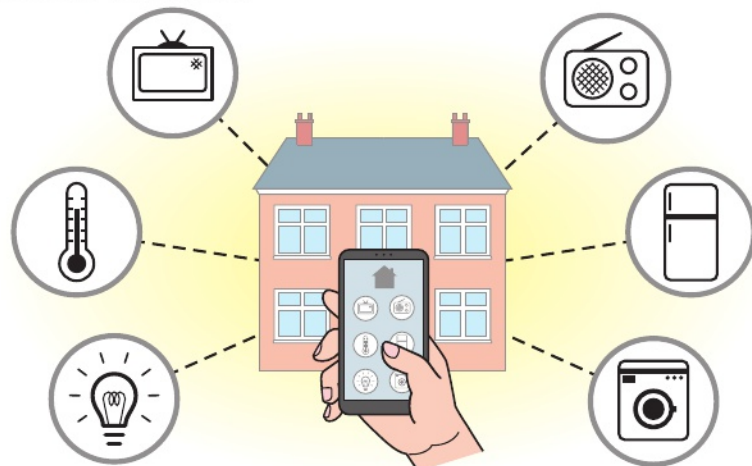
Navigation aids use information from **GPS** satellites to determine the exact location of the device on Earth. Navigation aids also use orientation sensors to know which way the device is currently pointing, and the device will display the user's position and orientation on a map. Maps are either stored permanently on the device or downloaded from the internet when they are needed.

GPS does not need internet connectivity in order to work. However, navigation aids need internet connectivity in order to update map data.

Smartphones are now replacing specialist in-car navigation aids. There are many navigation apps for smartphones which have a range of features.

HOME AUTOMATION DEVICES AND SMART ASSISTANTS

One type of emerging technology is a group of devices that can be used to create smart homes. For example, home automation devices can connect a range of digital devices which sense and control functions in the home, such as temperature and lighting. These functions can be controlled from apps on smartphones or the internet.



▲ Figure 1.21 Home automation devices can connect digital devices to control functions in the home

MULTIFUNCTIONAL DEVICES AND CONVERGENCE

SUBJECT VOCABULARY

multifunctional device a device that can perform a range of different functions

SKILLS SELF-DIRECTION

SUBJECT VOCABULARY

convergence when the designs of devices change so that they become similar to one another

A smartphone is a type of mobile phone, which means that its primary function is to make phone calls. It can also be used to take photographs or to function as a navigation aid, fitness tracker, music player or handheld games console. Because a smartphone can perform such a range of different functions, it is classed as a **multifunctional device**.

ACTIVITY

▼ MULTIFUNCTIONAL DEVICES

Identify another example of a multifunctional device. What is its primary function? What else can it do?

As they develop, devices like smartphones often adopt technologies and features from other types of device. This is called **convergence**.

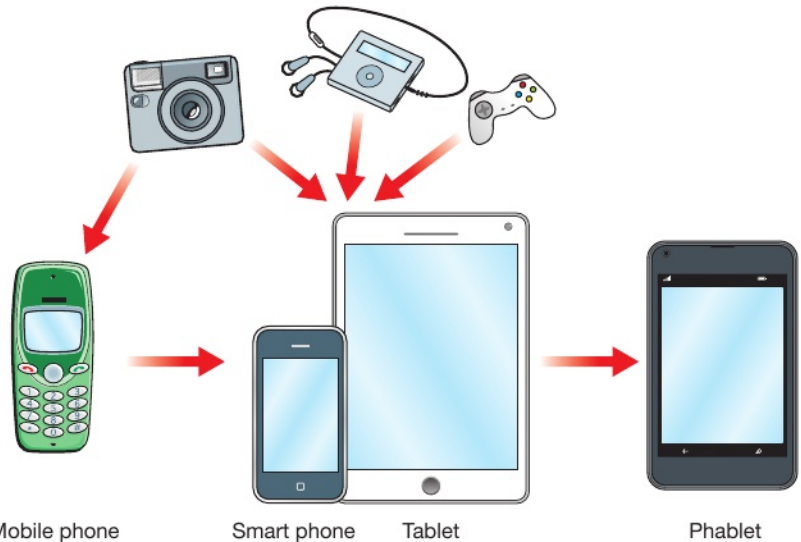


▲ **Figure 1.22** Some laptops now have touch screens that can flip 360 degrees, allowing them to operate as tablet devices



▲ **Figure 1.23** Some tablet devices come with attachable keyboards, allowing them to operate as laptop computers

Convergence blurs the distinction between different types of device. For example, smartphones and tablet devices are very similar. They are different in that a smartphone has mobile phone network connectivity and is smaller than a tablet device. However, newer smartphones are getting bigger to look more like tablets (and are known as ‘phablets’), while tablet devices can now connect to mobile phone networks. Similarly, most smartphones have digital cameras, while some digital cameras have Wi-Fi and mobile phone network connectivity.



▲ **Figure 1.24** As devices develop, their features often converge

SKILLS SELF-DIRECTION

ACTIVITY

▼ CONVERGING DEVICES

Research the differences and similarities between smartphones, tablet devices and touch screen laptops.

SUBJECT VOCABULARY

connectivity a device's ability to connect to networks and other devices

FEATURES OF DIGITAL DEVICES

The digital devices that you use have a number of features, such as portability, performance and **connectivity**. Different devices will have different features.

PORTABILITY

For a device to be portable, it needs to be easy to carry and move around. This means that the portability of a device is directly related to its size and weight. For some devices, such as a television or a desktop computer, portability is unlikely to be a priority.

PERFORMANCE

SUBJECT VOCABULARY

processor one or more Central Processing Units (CPUs) that carry out software instructions
RAM Random Access Memory, which is the memory in a computer system that is used for running software
virtual memory storage used by the processor once the space in RAM has run out

A high-performance device performs its job or tasks quickly. The speed at which a device performs is determined by the speed at which it can carry out instructions from its software. Software instructions are carried out by the **processor**, which means that a faster processor will increase performance (see page 62).

Instructions are loaded into the processor from **RAM**, which means that faster RAM will also allow instructions to be loaded into the processor more quickly. RAM holds all software instructions to be carried out, so more RAM will allow the system to have more programs running at the same time. In addition, because instructions are loaded into RAM from storage, such as a hard disk (see page 39), faster storage will enable faster loading of instructions to RAM.

When the space in RAM runs out, storage is used as an overflow, and this is known as **virtual memory** (see page 60). This means that fast storage means faster access to instructions in virtual memory.

The software itself can also be written in an efficient way that makes the most of the processor's capabilities. Inefficient software can slow down the whole system and therefore has an impact on a device's performance.

STORAGE

SUBJECT VOCABULARY

file a collection of data that represents a document, image, database or similar
program a set of instructions that are carried out by the processor

Files and **programs** are stored in storage. More available storage allows users to store more files and programs. Storage speed also affects performance, as you saw in the previous section.

USER INTERFACE

SUBJECT VOCABULARY

user interface the system that allows a user to interact with a device

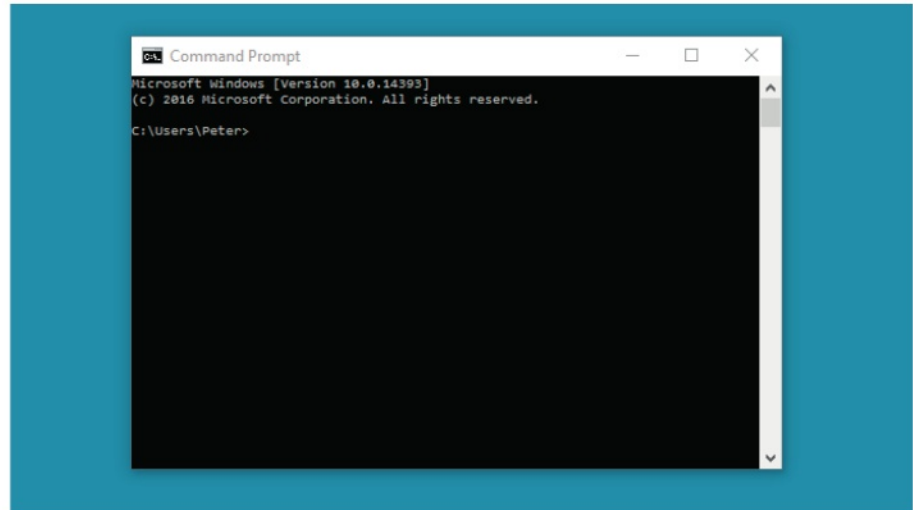
Users give commands to a device through the **user interface**. There are several different types of user interface.

COMMAND LINE INTERFACE (CLI)

When using a command line interface, users enter text instructions and the computer system provides results or feedback as text. This type of interface

is often found on older systems or for devices with limited storage because it requires little memory.

Commands have to be typed precisely because the interface only recognises certain commands. There is usually a help menu for users that lists and explains the acceptable commands.



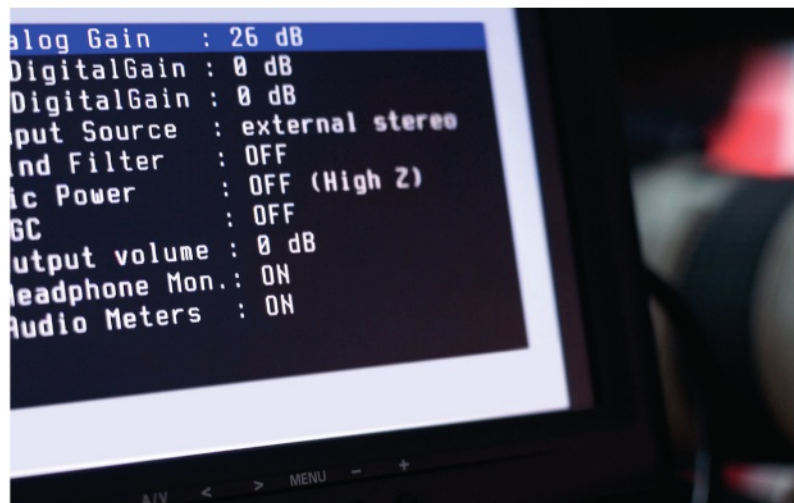
▲ Figure 1.25 A command line interface

MENU-DRIVEN INTERFACE

This type of interface displays a list of options as a menu. Selecting one of these options will either trigger a command or display another menu with further options to choose from.

Menu-driven interfaces are easier to use than command line interfaces, but can take more time as you have to go through the menu structure each time you want to carry out a command, rather than typing the command directly into the system.

This type of interface is used in many devices including ATMs (cash machines in banking), televisions and older mobile phones.



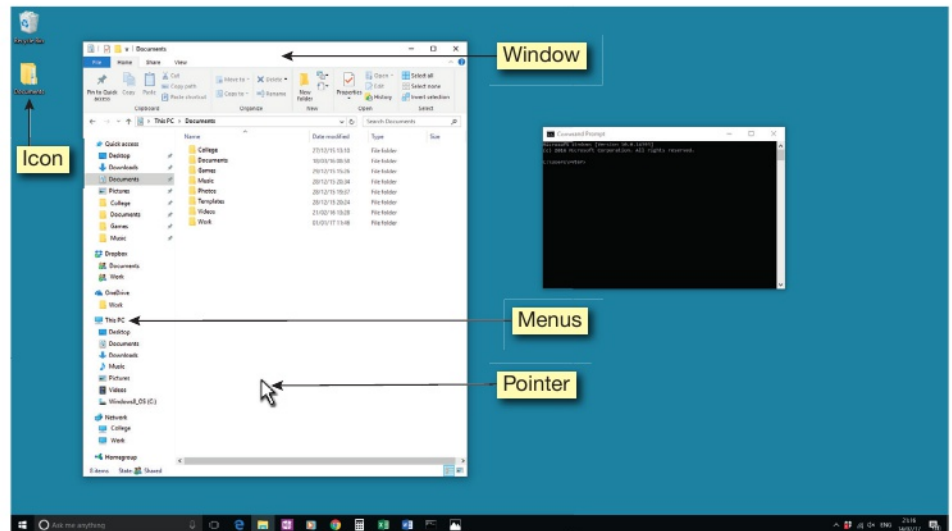
▲ Figure 1.26 A menu-driven interface for a monitor

GRAPHICAL USER INTERFACE (GUI)

A graphical user interface is controlled by a pointer on the screen and uses a screen made up of windows, icons and menus.

- Windows are areas of the screen that are dedicated to applications or operating system tasks.
- Icons are small images that represent an application. They can be selected with the pointer to open the application.
- Menus provide options for tasks relating to the operating system or open application.

This is the easiest type of interface to use, but it takes up more memory and storage than a command line or menu-driven interface.



▲ Figure 1.27 A graphical user interface uses windows, icons, menus and pointers (WIMP)

VOICE INTERFACE

A voice interface allows the user to give spoken commands to a device. The device has voice recognition software which matches the spoken words against a library of words to find a match. To save storage on the device, the library of words is often stored online, so these devices usually require internet access.

The disadvantage of using a voice interface is that sometimes the software cannot find a match or returns an incorrect match, which produces unwanted results. For this reason, voice interfaces sometimes check the instruction with the user before searching for a match. Some voice interfaces use the results of this confirmation to 'learn' the voice of their user and improve future matches.



▲ Figure 1.28 Voice interfaces compare the spoken commands to a library of matched words

The advantage of voice interfaces is that hands-free operation is possible. This means that they are often used in vehicles in order to improve road safety.



▲ Figure 1.29 Some voice interface devices can control home entertainment systems, appliances and systems such as lighting and heating

GESTURE INTERFACE

This type of interface allows the user to control the device by swiping their finger or fingers across the screen, or by pinching their fingers together to zoom in or out. This type of interface is commonly found on devices with touch screens.

CONNECTIVITY

SUBJECT VOCABULARY

back up to make a copy of information stored on a computer in case the original is lost or damaged

Devices can share data by connecting to each other using wired or wireless connectivity. Connectivity can be used to update software, **back up** files or play media from one device on another. Different connectivity types provide different speeds of data transfer and levels of convenience. Wired connectivity is usually faster and more reliable, but introduces additional cost, mess, inconvenience and safety risks such as tripping, especially for young children.

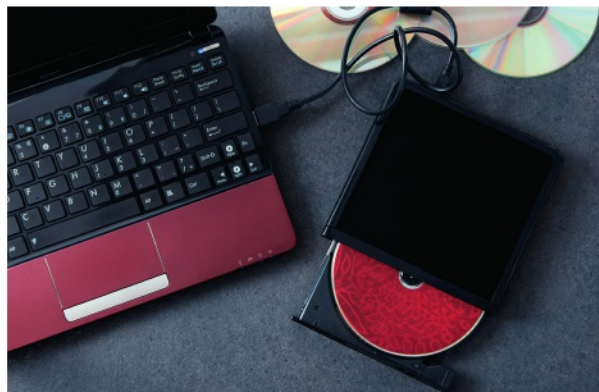
You will learn more about connectivity types in *Unit 2 Connectivity* (pages 71–76).

MEDIA SUPPORT

SUBJECT VOCABULARY

media items such as memory cards and CD-ROMs that make information available to people and devices

Different devices can read data from and write data to different types of **media**. Examples of media include SD and microSD flash memory cards, and DVD. If devices do not have built-in (native) media, adapters can usually be connected to provide connectivity to an external device into which the media can be inserted.



▲ Figure 1.30 Some laptops are too thin to incorporate an optical disk drive, so an adapter is required to connect an external drive

ENERGY CONSUMPTION

Digital devices require electricity to work. One benefit of lower energy consumption in mobile devices is a longer battery life. Due to the rising cost of energy and pressure from customers and governments to be more environmentally responsible, manufacturers are creating digital devices that consume less energy. The aim of this is to save their customers money and demonstrate social responsibility, such as by reducing environmental damage.

You will learn more about sustainability in *Unit 3 Operating online* (page 153)

DID YOU KNOW?

Computers can generate a lot of heat. This means that a large proportion of the energy consumed in data centres is used to cool the computers.

SKILLS

SELF-DIRECTION
PERSONAL AND SOCIAL RESPONSIBILITY

ACTIVITY

▼ TECHNOLOGY AND THE ENVIRONMENT

Visit environment.google in order to research the steps that Google™ has taken to make its activities more environmentally responsible. You could also watch Google's video, *Story of Send*.

EXPANSION CAPABILITY

Some PCs allow users to install additional components. Some smartphones and tablet devices have expansion slots to allow them to make use of flash memory cards (see page 19). Systems can also be expanded using ports such as USB ports. These allow the user to connect extra devices called peripheral devices (pages 21–41).

SECURITY FEATURES

The data stored on digital devices may be private, valuable or both. This means that devices need to have security features to keep their users' data safe.

SOFTWARE SECURITY

To prevent unauthorised access to data, digital devices have a range of software security features to ensure that the person trying to use the device is allowed to do so.

The operating systems of many devices can be set so that, when the device is turned on, the user must enter a password or personal identification number (PIN) before the device can be used. Another common security setting **locks** the device's screen or keyboard if it has not been used for a specified period of time, after which the password or PIN will be required to unlock it again. Some devices are set so that, if an incorrect password or PIN is entered, the user must wait a set amount of time before trying again. Such systems may even **wipe** the data after only a few failed attempts. This prevents criminals from freely guessing thousands of combinations in order to break into the device or system.

The longer and more complex a password is, the better it is. Pattern PINs are used by some smartphone operating systems, and they allow the user to set a swipe pattern between a group of points. A four-digit pattern PIN is more secure than a four-digit PIN, because it has 389,112 possible combinations, whereas the four-digit PIN has 10,000 possible combinations.

SUBJECT VOCABULARY

lock to make a device inactive so that it requires a password or PIN to reactivate it

wipe to delete data from a device or drive

DID YOU KNOW?

A four-digit PIN only has 10,000 possible combinations (0000–9999). A six-digit PIN is much more secure, with 1 million possible combinations.



▲ Figure 1.32 Entry screen for a pattern PIN

KEY POINT

Do you think your password or PIN is secure enough? If not, you should change it now.

SKILLS

CRITICAL THINKING
INTELLECTUAL INTEREST AND CURIOSITY



▲ Figure 1.33 A Kensington security lock in use



▲ Figure 1.31 A smartphone's lock screen

Some devices use biometric scanners, such as Apple® Touch ID®¹, to provide authorised users access to data on that device (see page 27 for more about biometric scanners).

You will learn more about passwords, PINs and other ways to secure data in *Unit 3 Operating online* (page 100).

PHYSICAL SECURITY

Physical security to prevent theft is also important. Many devices use security slots which can have locks attached to secure them to furniture. Some attach to specialist slots. Others connect to a port on the device with special screws used to secure the locks in place. Figure 1.33 shows an example of a security lock.

ACTIVITY

▼ DRONES AND SECURITY

- 1 Search for and watch these three videos online:
 - TU Delft – Ambulance Drone'
 - Drone Racing: First Person View (FPV) Lateline
 - Amazon® Prime Air's First Custom Delivery

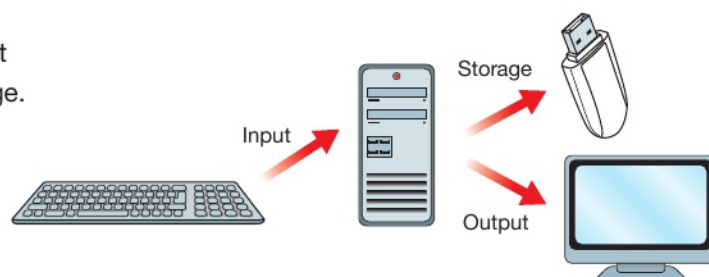
How do the features of these drones allow them to perform their function?

- 2 Search for 'Eagles drones Dutch Police' and read an online news article about how police are responding to the negative use of these devices.

TYPES OF PERIPHERAL DEVICES

Peripheral devices are devices that can be connected to a computer, such as a PC or tablet device. Peripherals can be connected inside or outside a computer and can be grouped into three types (see Figure 1.34):

- input
- output
- storage.



▲ Figure 1.34 Data is input from devices such as keyboards and processed by a computer, and the results can then be sent to output devices such as screens

¹ TOUCH ID® IS A TRADEMARK OF APPLE INC., REGISTERED IN THE U.S. AND OTHER COUNTRIES

SKILLS

EXECUTIVE FUNCTION
CREATIVITY
COMMUNICATION
COLLABORATION
RESPONSIBILITY

ACTIVITY

▼ THE CHARACTERISTICS OF PERIPHERAL DEVICES

Create posters that include the characteristics and uses of a range of peripheral devices. You could split the work between members of your class so that some of you investigate input peripherals, some investigate output peripherals and some investigate storage peripherals.

INPUT

Input peripherals are devices that send data to the computer. They allow the user to control the computer or store data captured from sources outside the system.

KEYBOARDS

Keyboards use buttons known as keys, which users press to input text or to interact with software. Keyboards send data to the computer either using a wired or wireless connection. Different types of keyboards are used for different operating systems, languages and functions, as shown in Figure 1.35.



▲ Figure 1.35 Different layouts are provided for different operating systems or language requirements

SUBJECT VOCABULARY

shortcut a combination of key presses used to access common software commands quickly

Combinations of key presses allow the user to access common software commands called **shortcuts**. Some people learn to touch-type, which is a method of typing without needing to look at the keys. This increases the speed at which these people can input data.



▲ Figure 1.36 This is an example of a keyboard used with specialist video software; the keys are **mapped** to specialist commands

SUBJECT VOCABULARY

mapped linked

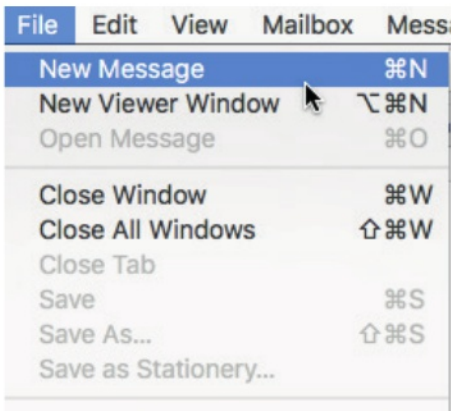
SKILLS PROBLEM SOLVING

DID YOU KNOW?

The layout of keys on a standard QWERTY keyboard comes from the layout of keys on a typewriter. The most commonly used letters were spread out, to reduce the number of times the metal typewriter hammers hit each other.

SUBJECT VOCABULARY

pointer an on-screen indicator used to select displayed objects



▲ Figure 1.37 An arrow is often used as the pointer

ACTIVITY

▼ KEYBOARD SHORTCUTS

Choose a piece of software and look up three keyboard shortcuts that you could use to complete common tasks more quickly.

POINTING DEVICES

A **pointer** is used on a screen to select displayed objects. There are several types of device that allow you to control a pointer.

- **Mouse:** A mouse uses an optical sensor to recognise the movement of the device. Its sensitivity can be affected by the surface upon which it is placed. Some mice use roller balls to control the movement of the pointer.



▲ Figure 1.38 Have you used a roller ball before?

- **Tracker ball:** A tracker ball is rolled to move the pointer. It does not have buttons to press.



▲ Figure 1.39 Tracker balls are often used in installations like the kiosk shown here

- **Track pad:** The track pad surface senses finger movements, touches and presses.



▲ Figure 1.40 Track pads are often built into laptop computers to save space

SUBJECT VOCABULARY

sprites on-screen graphics in a computer game, used to represent characters, vehicles and objects

- **Joystick:** Joysticks are commonly used on games controllers to move **sprites** around the game.



▲ Figure 1.41 Have you used a joystick like this one?

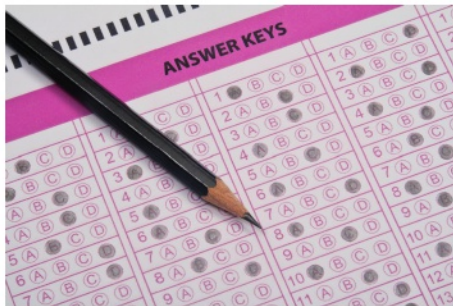
SUBJECT VOCABULARY

stylus a pen-shaped device

- **Graphics tablet:** A graphics tablet is a flat pad that is used with a **stylus**. Users use the stylus to draw or write on the graphics tablet. These devices are often used by digital artists and designers.



▲ Figure 1.42 Graphics tablets are often used by digital artists and designers



▲ Figure 1.43 An OMR multiple choice response sheet

GENERAL VOCABULARY

characters printed or written letters and symbols

SCANNER (INCLUDING OCR AND OMR)

Scanners use light sensors to record physical documents as images, which are then saved as files to the computer.

Software allows scanners to read **characters** on the document and store the result in a text file. This is known as Optical Character Recognition (OCR).

Optical Mark Recognition (OMR) software can also be used with scanners to detect simple marks on a document. A common use for OMR is for recognising and recording responses to multiple choice tests.

SUBJECT VOCABULARY

barcode a pattern of lines and gaps that can be read by a device

BARCODE SCANNER

A **barcode** is a pattern of lines and gaps that can be read by barcode scanners, which detect the width of lines and gaps in a barcode. Barcodes are often used on parcels, so that they can be tracked, and on items for sale in shops. The barcode represents letters and numbers which are used to identify the item.

There are two types of barcode:

- linear
- matrix.

▶ Figure 1.44 Linear barcode used to identify a parcel



DID YOU KNOW?

There are apps for smartphones and tablet devices that use the device's camera to read barcodes and QR codes. There are also websites that allow users to create barcodes and QR codes.

Matrix codes are also known as QR codes. They are newer than linear barcodes and have some advantages over linear barcodes, such as:

- they can hold much more information than linear barcodes
- they can be scanned from any angle.

In South Korea, a supermarket company wanted to open a new shop, but there was no space left on the high street. Instead, the company created a 'virtual store' by putting posters of their supermarket shelves in a subway station, as shown in Figure 1.45. Every item pictured on the shelves had its own QR code that shoppers could scan. This allowed people to shop while they were travelling to work in the morning, knowing that their shopping would be delivered to their home that evening.



▲ Figure 1.45 A Virtual Subway Store in South Korea

SKILLS

EXECUTIVE FUNCTION
RESPONSIBILITY
CO-OPERATION

SUBJECT VOCABULARY

plain text text that is not specially formatted

ACTIVITY**▼ MATRIX CODES**

Visit a website to create a QR code for a **plain text** message. Ask a friend to scan it to reveal the message you have left for them.

WEBCAM

Webcams are specialised cameras. They are generally lower quality than camcorders, and may have built-in microphones to capture sound. They can be used as security cameras and can stream images or video to the internet.

SKILLS

CRITICAL THINKING
INTELLECTUAL INTEREST AND CURIOSITY

ACTIVITY**▼ USING WEBCAMS**

Webcam footage can be used for a variety of purposes. For example, if you do an internet search for 'Bondi Beach webcam', you will be able to see live footage from Bondi Beach in Australia, which can be used to check the conditions for surfing at the beach.

Find out about any webcams in your local country or local area. What are they being used for? Who would be interested in the footage?

SUBJECT VOCABULARY

diaphragm a thin round object, especially in a telephone or loudspeaker, that is moved by sound or that moves when it produces sound

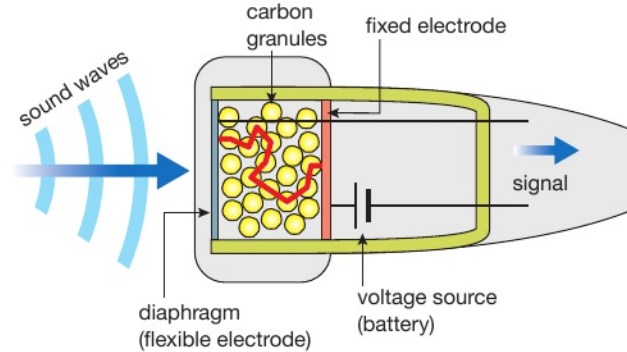
analogue representing information with continuously variable electrical signals that digital signals approximate

sound card a device built into or added into a computer to allow it to playback and record audio

VoIP Voice over Internet Protocol, which is the technology that allows people to use broadband internet connections to speak to other people, rather than using a conventional telephone

MICROPHONE

A microphone is used to capture sound. It uses a **diaphragm** which moves when air hits it. This movement produces an **analogue** electrical signal. A microphone converts the electrical signal to a digital signal with its **sound card**, which acts as an analogue-to-digital converter.

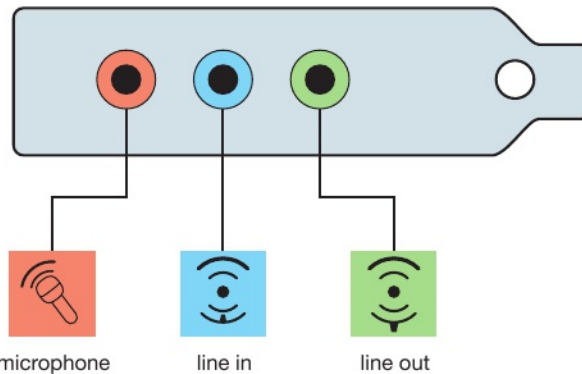


▲ Figure 1.46 Sound waves hitting a microphone and being converted to an electrical signal

Small, low-quality microphones are often built into computers and are used for voice recognition, recording speech or allowing **VoIP** calls using software such as Skype®. Higher quality microphones are often used by recording artists and can be connected to a sound card's audio input port.



▲ Figure 1.48 This headset contains a microphone and headphone speakers



▲ Figure 1.47 A microphone can be plugged into a port on the sound card

DID YOU KNOW?

Microphones are often used in order to make devices and technology accessible to people with disabilities, as they provide access for people who are unable to input data using a mouse and keyboard.

HINT

Microphones can often be included in other devices, such as the headset in Figure 1.48. The headset itself is not a type of peripheral device, but a piece of equipment for combining a microphone and headphone speakers. Try to provide specific examples of peripheral devices when answering questions in the exam.

TOUCH SCREEN

Touch screens are used in many devices, including smartphones, tablet devices, laptops and desktop computers. There are two types of touch screen:

- resistive
- capacitive.

HINT

Do not confuse accessibility (increasing people's ability to access devices and technologies) with usability (making devices more efficient and satisfying to use).

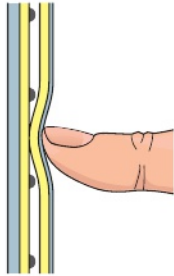
GENERAL VOCABULARY

capacitive able to hold an electrical charge

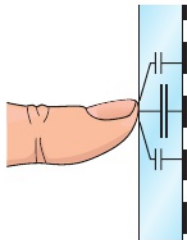
conductive able to conduct electricity

When a user presses on a **resistive** screen, the pressure causes two layers underneath the screen to touch and make a connection. Resistive touch screens are more durable than capacitive touch screens, but are harder to read because more layers reflect more light. In addition, they can only recognise one touch at a time, so they are not suitable for multi-touch applications.

Under the glass of a **capacitive** screen, there is a layer of **capacitive** material. When a user touches the screen, a small amount of charge flows away from their finger because humans are **conductive**. The change in electrical charge is measured precisely: the closer the finger is to the charged areas, the more current flows away. This allows the computer to calculate the precise location at which the screen was touched. Capacitive touch screens are often used in smartphones.



▲ Figure 1.49 A resistive touch screen



▲ Figure 1.50 A capacitive touch screen



▲ Figure 1.51 A fingerprint scanner detects unique patterns in your fingerprints

BIOMETRIC SCANNER

If you have watched a spy film, you may have seen a biometric scanner being used. Biometric scanners work by measuring part of the unique physical characteristics of a user, often multiple times, until a suitable average result is produced. This average result is then stored and future samples are compared against it in order to check whether the person being scanned is the authorised user. This allows the information to be updated so that the saved sample is perfected.

Four examples of biometric scanners are as follows.

- **Fingerprint recognition:** These scanners read the patterns of arches, loops and whorls in a human fingerprint. Fingerprints are unique to each individual person, which makes them a useful method of identification, but fingerprints can be obscured, damaged or changed, such as by injury or disease.



Arch



Loop



Whorl

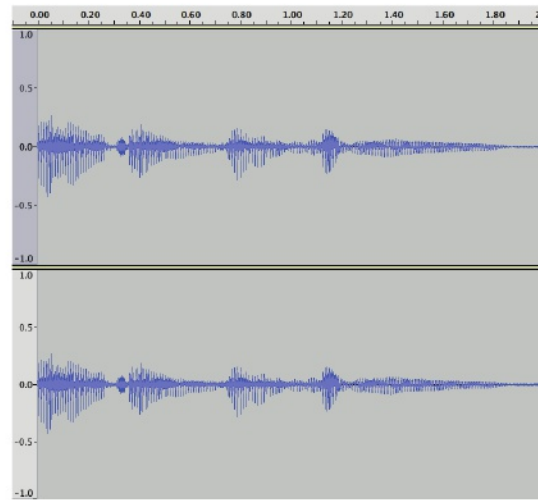
▲ Figure 1.52 Examples of different types of fingerprint patterns

- **Facial recognition:** These scanners identify the structure of a human face in order to identify an individual.



▲ Figure 1.53 Surveillance scanners are also used by some government agencies to recognise number plates, models and colours of vehicles

- **Voice recognition:** These scanners require a microphone to capture the voice. They then compare the voice print against a saved original and check to see whether the two prints match. (See page 26 for more information about microphones.)



▲ Figure 1.54 Voice recognition software compares a voice print with a stored original and checks for a match

GENERAL VOCABULARY

iris the round, coloured part of an eye

- **Iris recognition:** Like fingerprints, the human iris has a unique pattern, though an iris scan is approximately 120 times more detailed than a fingerprint. This means that iris recognition is 120 times more reliable when identifying people.



▲ Figure 1.55 Some passports now contain a chip that holds biometric data about the passport holder that is compared with the results of biometric scans carried out at airports

▼ Table 1.2 Advantages and disadvantages of using biometric scanners

ADVANTAGES	DISADVANTAGES
Easier for users than passwords because biometric data cannot be forgotten	Cause privacy and security concerns because detailed personal information is stored electronically
More difficult to trick or confuse biometric scanners than some other methods	Possible to trick or confuse them
Can speed up transactions	Expensive to make and buy
Are not restricted by language barriers	Make some people feel uncomfortable

SKILLS

CRITICAL THINKING
 COMMUNICATION
 INTERPRETATION
 ADAPTIVE LEARNING
 EXECUTIVE FUNCTION
 PERSONAL AND SOCIAL RESPONSIBILITY
 INITIATIVE
 COMMUNICATION
 COLLABORATION
 CO-OPERATION
 INTERPERSONAL SKILLS
 RESPONSIBILITY



▲ Figure 1.56 Magnetic strip reader being used to unlock a door

SKILLS

PERSONAL AND SOCIAL
 RESPONSIBILITY
 INTERPERSONAL SKILLS

GENERAL VOCABULARY

fraud deceiving other people for criminal reasons

ACTIVITY

▼ USING BIOMETRIC SCANNERS

- 1 Use the internet to do some research and create a table that compares the advantages and disadvantages of each method of biometric scanning (see *Unit 6 Software skills* (page 308) for more information about creating tables).
- 2 Create a survey to ask other people how they would feel about using each type of biometric scanner. What are their concerns?
- 3 What affects the reliability of each type of biometric scanner? Discuss your research findings and your thoughts with your teacher and the rest of your class.
- 4 What other factors could be considered when choosing a biometric security system?

CARD READERS

Card readers are used to read data stored on a card that is carried by a user. The data can be used to unlock doors, access secure areas, make payments or track people, parcels and even pet animals.

Cards can carry data using three methods. Each method needs a specialist type of reader.

- **Magnetic strip:** This is the least secure method as the data on the magnetic strip can easily be stolen by criminals who put the card through a card reader without the card owner's knowledge.
- **Programmable chip:** Data on a programmable chip is only readable when a correct PIN is entered into the reader. In 2005, the UK introduced the chip and PIN system, which reduced certain types of **fraud** by 67%.

ACTIVITY

▼ FRAUD

In the UK, online fraud rose 79% in the first three years after the country switched to the chip and PIN system. Discuss why this may have happened.



▲ Figure 1.57 Examples of cards using chip and PIN

- Radio Frequency Identification (RFID) and Near Field Communication (NFC):** RFID is a short-range wireless communication method, and Near Field Communication (NFC) is a branch of RFID. RFID tags are cheap and small and they can be included in a variety of objects such as cards, key fobs and smartphones. They contain a unique identification number (ID) that is linked to records in a database. For example, the first image in Figure 1.58 shows a traveller using a prepaid travel card. A unique ID stored on the card links to account information stored in a database. You will learn more about databases in Unit 6 Software skills (page 307).



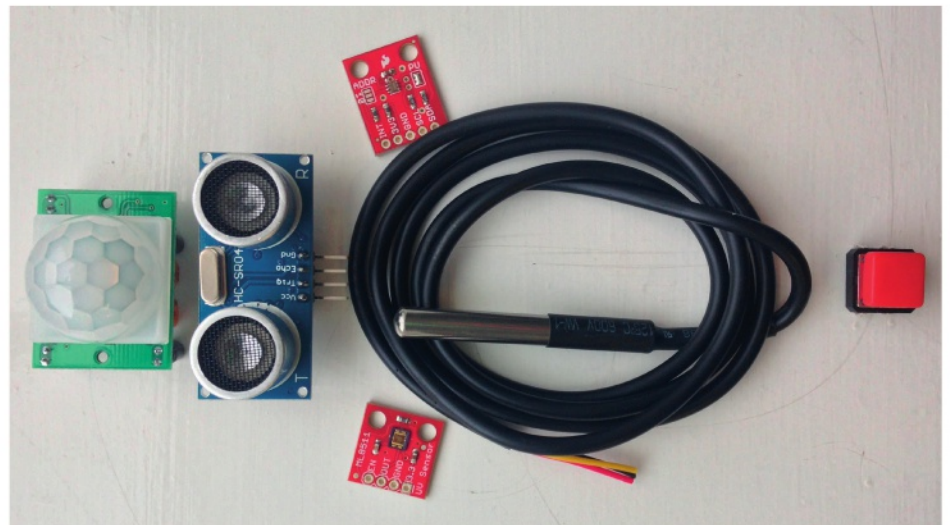
▲ Figure 1.58 RFID tags can be included in a variety of objects

SUBJECT VOCABULARY

sensor an input peripheral that inputs data about the physical environment
smart home a home equipped with devices that can connect to the internet and be controlled remotely by a computer or smartphone app

SENSORS

Sensors are used to input data about the physical environment. They can automatically input data without the need for human action. Their output is then processed by a computer. Sensors are one of the main features of smart devices such as smartphones and smart environments such as **smart homes**.



▲ Figure 1.59 (Left to right) motion sensor, **proximity** sensor, temperature sensor and button sensor; the red item at the top is a light sensor and the red item at the bottom is a UV sensor

GENERAL VOCABULARY

proximity how close something is relative to something else

The use of sensors has many benefits, such as:

- they can be placed in remote or dangerous places
- they can monitor continually
- they remove the possibility of human error
- they can sense things that people cannot (such as small changes in pressure or gas levels)
- the data is easily (sometimes automatically) converted to a digital form.

There are many different types of sensor to allow for the monitoring of a range of environmental factors. Some of these factors are:

- light
- moisture and humidity
- temperature
- proximity and distance
- motion and movement (such as Passive Infrared (PIR) sensors)
- pressure.

SKILLS

CRITICAL THINKING
INTELLECTUAL INTEREST AND CURIOSITY

ACTIVITY**▼ USING SENSORS**

- 1 For each environmental factor listed above, state one remote and one dangerous environment where a sensor could be used.
- 2 Research the appliances in modern smart homes that can use sensors. For each one, describe how sensors are used.
- 3 Research how sensors can help to prevent air traffic accidents. Can you find any instances where they may have caused accidents?



▲ Figure 1.60 Sensors are used in aircraft and data from them are displayed to the flight crew on instruments in the cockpit

OUTPUT

Output peripherals are connected to a computer and output the results of the computer's processing in various forms, including:

- electronic display
- printed text
- video
- audio
- tactile (touch) forms.

MONITOR

Monitors allow users to see the output from the computer on an electronic display. Features of monitors include:

- screen size, which is measured diagonally
- resolution, which is measured in pixels (see pages 9–10 for information about pixels and screen resolutions)
- energy efficiency measures, such as going into a low-power standby mode if no input is detected.

Some monitors also use touch screen technology (see page pages 26–27 for more information about touch screens).



▲ Figure 1.61 Monitors have evolved over time to provide better quality and more features

SKILLS

COMMUNICATION
EXECUTIVE FUNCTION

ACTIVITY

▼ USING MONITORS

- 1 Discuss the different uses for monitors.
- 2 Create a table of the uses for monitors with different sizes and resolutions (see *Unit 6 Software skills* (pages 220–223) for more information about creating tables).

PRINTER

There are three types of standard printer: dot matrix, inkjet and laser.

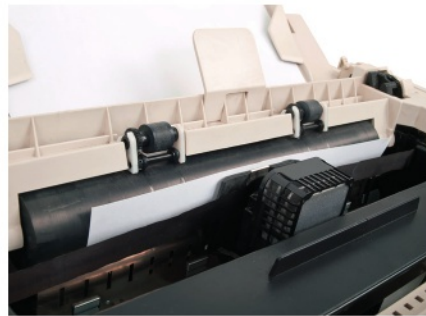


▲ Figure 1.62 Laser (top left), inkjet (right) and dot matrix (bottom left) printers

GENERAL VOCABULARY

carbon copy a copy of a document made using carbon paper (paper coated in a coloured substance that leaves traces on clean paper)

- **Dot matrix:** These printers are sometimes called ‘impact’ printers. This is because the print is made by hitting or ‘impacting’ the paper through a ribbon of ink, and this process is very noisy. The paper often has a number of **carbon copy** layers so it can make several copies of the same document as it prints it.



▲ Figure 1.63 A dot matrix printer

- **Inkjet printers:** These printers use cartridges containing different coloured ink. Black ink is held in a one cartridge, while the colour cartridge is often split into three colours: cyan, magenta and yellow. Tiny dots of these inks are sprayed onto the paper to form images or text.



▲ Figure 1.64 Cartridges used in an inkjet printer

DID YOU KNOW?

Many cartridges can be refilled to save money and protect the environment.

SUBJECT VOCABULARY

discharge remove the electrical charge from something
toner a type of ink

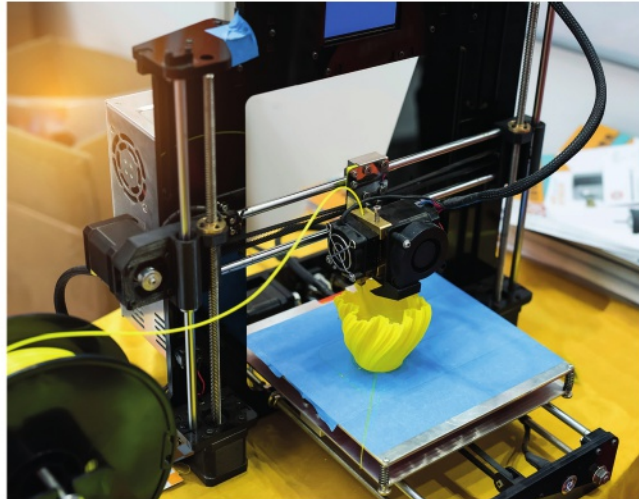
- **Laser printers:** These printers contain a rotating cylinder or drum that holds an electrical charge. A laser is used to **discharge** certain points on the drum and 'draw' an image. Electrically charged **toner** is attracted to those points on the drum and is heated onto paper that is passed over the drum.

▼ Table 1.3 Comparing printer types

	SPEED	PRINTER COST	COST PER COPY	COLOUR PRINTING	QUALITY	EXAMPLES OF WHERE IT IS USED
Dot matrix	Slowest	Cheap	Low	Rare	Low	When multiple copies are required.
Inkjet	Fast	Medium	High	Yes	High	Home printing and photographs
Laser	Fastest	Expensive	Medium	Yes	Highest	High-volume printing, often used in offices

3D PRINTER

Three-dimensional (3D) printers create real-life versions of digital models. These printers work by adding layers of heated material from the bottom of the model all the way to the top. 3D-printed models take a long time to create.



▲ Figure 1.65 A 3D printer

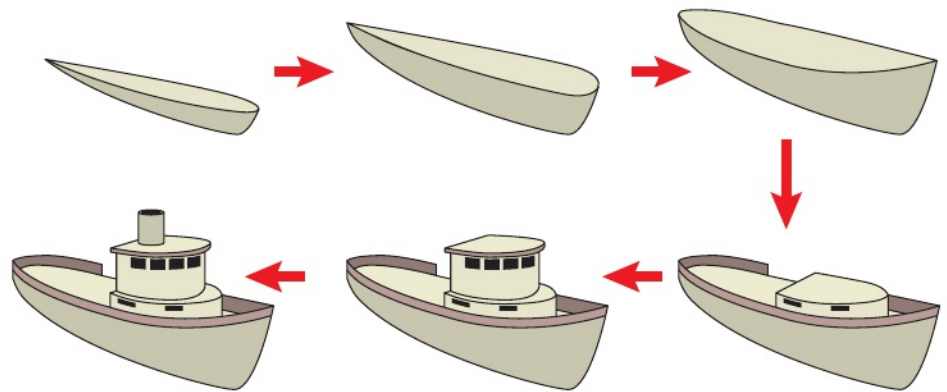
SKILLS INTELLECTUAL INTEREST AND CURIOSITY

ACTIVITY

▼ USING 3D PRINTERS

Find a video online that shows a 3D printer in action.

3D printers are often used to create complex items, sometimes with working parts. Some of these items could not be assembled in any other way. Examples of 3D-printed items include aeroplane parts, artificial limbs, prototype models of cars and even food such as pasta and chocolate.



▲ Figure 1.66 Stages of building a 3D-printed model

SKILLS

INTELLECTUAL INTEREST AND CURIOSITY
PERSONAL AND SOCIAL RESPONSIBILITY
ETHICS
COMMUNICATION
REASONING/ARGUMENTATION

ACTIVITY

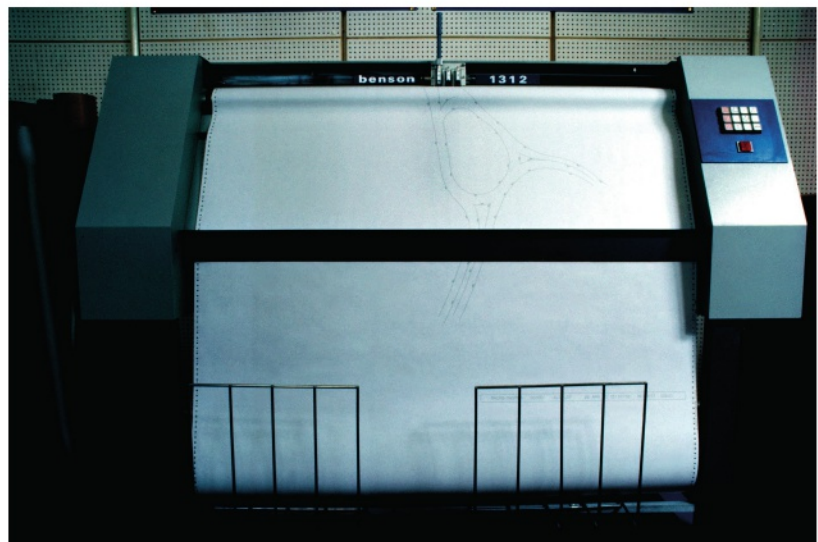
▼ TECHNOLOGY AND ETHICS

- 1 In 2013, someone published the plans for a 3D-printed gun online. Discuss the impact of this.
- 2 Write notes to support two opposing arguments. One argument should support the wide availability of 3D printers, and the other should argue against the wide availability of these printers. You could then use your notes to debate this topic in your class.

PLOTTER

DID YOU KNOW?

Plotters can also use a cutter attachment instead of the pen attachment to cut vinyl. This can be used to create stickers or images to go on printed clothing.



▲ Figure 1.67 A plotter

GENERAL VOCABULARY

cartographers people who draw and produce maps

Plotters are used by a variety of professionals, including product designers, architects, engineers and **cartographers**. The plotter draws high-quality images created in Computer Aided Design (CAD) software onto large sheets of paper. It does this by moving a pen across the paper to draw the lines, and the pen can be raised away from and lowered onto the sheet of paper. Some plotters can also roll the paper backwards and forwards.

SUBJECT VOCABULARY

optical zoom focusing a lens in order to zoom in on an object

digital zoom enlarging part of an image to produce the effect of zooming in

DATA PROJECTOR

Data projectors are used for home entertainment, such as watching television or playing games, and for giving presentations in classrooms and business meetings. They have the following features.

- **Light bulbs:** These bulbs can have various brightness levels (measured in lumens) and are expensive to replace.
- **Resolution:** Like monitors, they use different quality screens (see page 9–10 for more about screen resolutions).
- **Zoom functionality:** The projected image can be made larger by enlarging the image using either **optical zoom** or **digital zoom**.
- **Portability:** Some smaller and lighter projectors are available, and these are easier to move around.



▲ Figure 1.68 Data projectors are used to project a large image (or film) onto screens

SKILLS

ADAPTABILITY
SELF-DIRECTION

ACTIVITY

▼ TYPES OF PROJECTOR

- 1 Do some online research to find an appropriate projector for:
 - use in a classroom
 - a home entertainment system
 - a person travelling on business.
- 2 For each projector that you identify, find out how long its light bulbs last (on average) and how much the replacement bulbs cost.

SUBJECT VOCABULARY

stereo sound sound that comes from two sides (left and right)

surround sound sound that comes from four or more sides, used so that sounds from a film or television programme come from all around the viewer as they would in real life

GENERAL VOCABULARY

spatial awareness the impression of a realistic space

SPEAKER

Speakers allow a computer to output sound. Speakers often come in pairs to provide **stereo sound**. Multiple speakers are commonly used to provide **surround sound** in home entertainment systems. These speakers need a special amplifier that can deliver different levels of sound to each speaker to provide **spatial awareness**.



▲ Figure 1.69 A pair of speakers is required for stereo sound because one is used for the left side and one is used for the right side

SKILLS SELF-DIRECTION
PROBLEM SOLVING

SUBJECT VOCABULARY

mono sound sound that comes from a single speaker

SKILLS ADAPTIVE LEARNING


▲ Figure 1.70 A piezoelectric 'piezo' speaker used in a watch

ACTIVITY
▼ DIFFERENT TYPES OF SOUND

Do some research to find out when **mono sound** may be most appropriate. When might listeners prefer stereo sound?

A single speaker is usually used to provide low-quality audio feedback to a user. These speakers are often small and low-quality, and are often found in alert systems such as alarms and buzzers.

ACTIVITY
▼ USING LOW-QUALITY SPEAKERS

Think of the appliances and devices in your home that use low-quality speakers (you might want to start in the kitchen!).

CONTROL DEVICE

Control devices are also known as actuators, and they are components of a system that make something happen in the real physical world. These devices are often mechanical. Examples of actuators include:

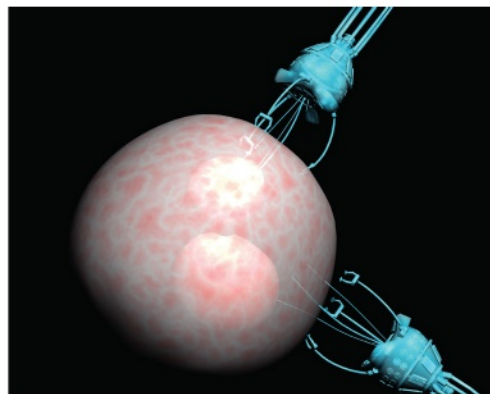
- valves
- pistons
- heaters
- coolers
- motors.



▲ Figure 1.71 Robots use actuators that are powered in many ways such as electricity, chemicals and compressed air

DID YOU KNOW?

Nanorobots are made up of tiny sensors and actuators that are capable of assisting a surgeon by carrying out very precise medical procedures.



▲ Figure 1.72 Nanorobots allow doctors to make smaller incisions or cuts and more precise movements than they could if they used their own hands

SECONDARY STORAGE (STORAGE)

GENERAL VOCABULARY

volatile likely to change, especially quickly or unpredictably

HINT

People often confuse storage and memory. You must know the difference between these terms, including what they do and the ways in which they are used.

SUBJECT VOCABULARY

virtual memory space on a computer for storing instructions and programs until they are needed or being used
motherboard the circuit in a computer with connectors to which other components connect

Secondary storage is often referred to as 'storage'. However, it should not be confused with primary storage or main memory, which are terms sometimes used to refer to Random Access Memory (RAM) or Read Only Memory (ROM). You will learn more about RAM and ROM on pages 59–61. Secondary storage is non-**volatile**, which means it will not lose data when the system's power is turned off.

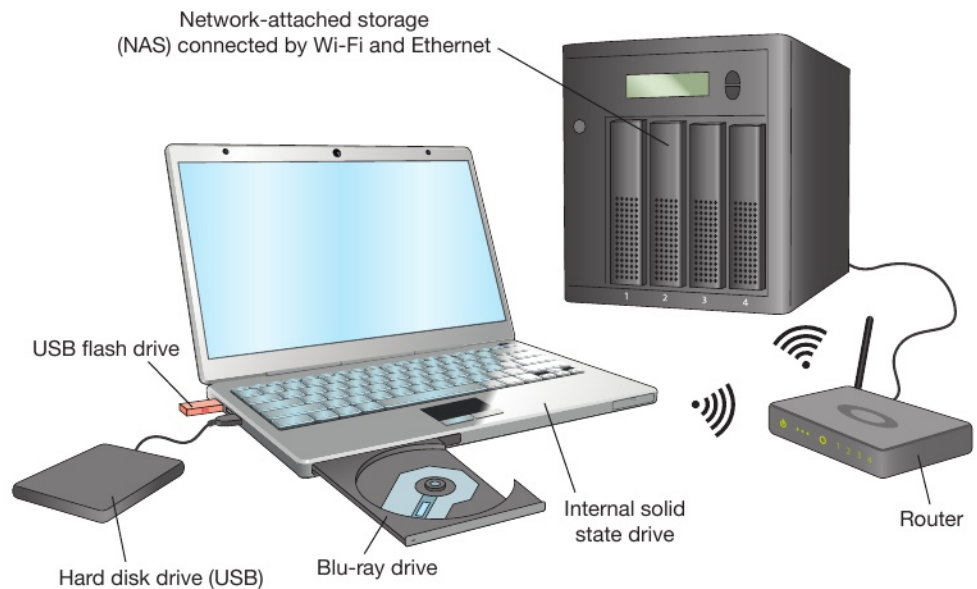
Secondary storage is used for:

- storing a document for future use
- storing an application, ready to be loaded into RAM when the user opens the application
- **virtual memory** (see page 60).

DEVICES

Storage devices are used to store data or software that is used in a computer system.

Storage devices can be either internal or external. Internal drives connect directly to the computer's **motherboard**. External devices are connected to the computer's motherboard through the different ports and adapters on the computer's exterior.



▲ Figure 1.73 Storage can be internal or external

There are different types of storage device.

- Hard disk drives (HDD) contain hard disk media. The drives provide a connection from the disk to the motherboard, either directly or using a wireless adapter like Wi-Fi or a wired port like USB.
- Solid state drives (SSD, often referred to as flash drives) contain flash memory media. They are otherwise identical to hard disk drives.
- Optical disk drives contain optical disk media. Newer drives are often compatible with older media. For example, a disk drive that can read Blu-ray media can also read DVD and CD media. This is known as **backwards compatibility**.

HINT

You must know the difference between a storage device and storage media. Remember: a storage device *contains* the storage media and *accesses* the data stored on it. For example:

- 1 flash memory is the media used to store data, whereas a USB drive is used to contain the flash media so that it can be read by the computer after it is plugged into a USB port
- 2 a DVD disk is the media used to store data, whereas a DVD drive reads the data on the DVD disk.

SUBJECT VOCABULARY

backwards compatibility the ability to be used with older technology without having to be specially adapted

GENERAL VOCABULARY

concentric (of circles or circular objects) sharing the same central point
spindle a rod around which something spins

SUBJECT VOCABULARY

platters circular plates
read/write head the part of a disk drive that passes across (or floats) the platters on a very thin layer of gas above the platters
seek time the time it takes for a read/write head to locate the area on the disk where the data to be read is stored

DID YOU KNOW?

The gap between the platter and the read/write head is only a few nanometers wide. This means that a dust particle or even a smoke particle could cause a collision between the platter and the read/write head. To prevent this, hard drives use filters in their ventilation systems or are built as sealed units.

HINT

If a read/write head crashes into a platter, it can cause damage to data and the platter. This would not happen with a solid state drive.

DID YOU KNOW?

Optical media layers deteriorate (get worse) over time, so they have to be stored carefully to prevent data loss.

DID YOU KNOW?

Blu-ray disks get their name from the colour of laser used. The laser light is actually a violet colour, but perhaps 'violet-ray' was not considered a good enough name.

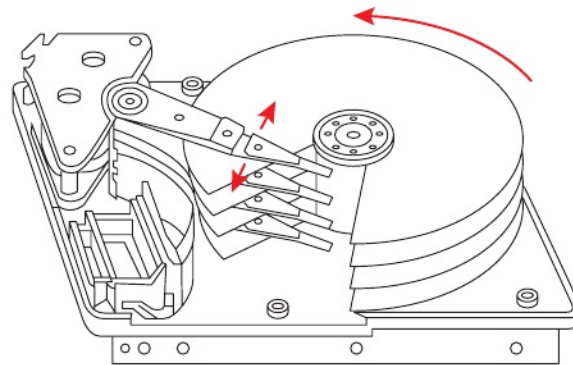
MEDIA

Hard disks

Hard disks are made up of many **concentric platters**. These platters make up a cylinder that spins on a central **spindle**. A **read/write head** moves on an arm across tracks on the platter. The amount of time that it takes the read/write head to access data on the tracks is determined by how fast the cylinder of platters spins and how fast the read/write head is moved across the tracks. When reading, a read/write head changes the magnetic field into electrical current. When writing, it transforms electrical current into a magnetic field.

Typical spin speeds are 5400 revolutions per minute (rpm) or 7200 rpm.

The average **seek time** for a read/write head is 4–15 milliseconds (ms).



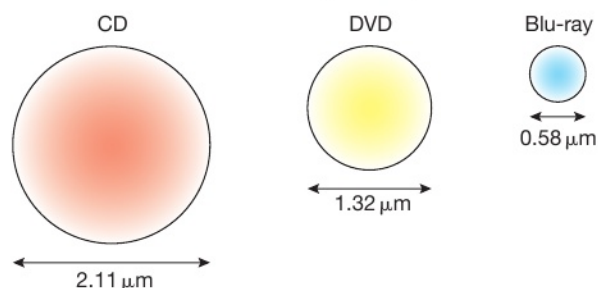
▲ Figure 1.74 Read/write heads move across a hard disk platter to access data as the cylinder spins

Optical media

Types of optical media include CDs, DVDs and Blu-ray disks.

- **CDs** can store up to 700 MB of data. The data is written to the disk using a laser, which writes data to a plastic layer beneath layers of aluminium and acrylic.
- **DVDs** look very much like CDs. Data is written to DVDs using a shorter wavelength of red laser light, which allows DVDs to store more data. They can store 4.7 GB on a single-sided, single-layer disk. Double-sided, dual-layer disks can store as much as 18 GB.
- **Blu-ray** disks are similar to CDs and DVDs, but use a scratch-protection coating. Violet laser light is used to store data at greater density than the red laser light used in DVDs. They can store 25 GB on a single-sided disk, and double-sided disks can store 50 GB.

All optical media is recordable and is known as CD-R, DVD-R or BD-R. Some CDs and DVDs can be rewritten (CD-RW, DVD-RW), and some Blu-ray media can be written then erased and rewritten (BD-RE).



▲ Figure 1.75 Comparison of various lasers used to store data on optical media

DID YOU KNOW?

One explanation of why flash memory is so-called is that each cell is flashed (flooded) with electrons, forcing it to hold its charge. One other explanation for the name is that data is written very quickly (or, in colloquial English, 'in a flash').

Flash media

Flash media are more energy-efficient than hard disks as they do not have moving parts. For the same reason, they are also less likely to fail when they are moved around. This makes them suitable for use in portable devices.

Magnetic tape

Magnetic tape was originally designed to record sound, but it is now also used to store data.



▲ Figure 1.76 Magnetic tape is mainly used for backing up data in large organisations

▼ Table 1.4 Comparing types of media

	HARD DISK	FLASH MEDIA	OPTICAL MEDIA	MAGNETIC TAPE
DATA ACCESS SPEED	Fast	Fastest	Slow	Slowest
MAXIMUM CAPACITY	Varies, up to 128 GB	Varies, up to many TB	CD 700 MB DVD 18 GB Blu-ray 50 GB	Varies, up to 185 TB
COST PER GB	High	Very high	Medium	Low
USE	Servers, personal computers, backups	Laptops, mobile devices	Multimedia (music, games and films), file backups	Whole system backups and archives
PORTABILITY	Not suitable	Yes	Not suitable	Not suitable

Storage media store data in binary form. This means that each **bit** of data holds one of two values: 0 or 1. Different media types interpret 0 or 1 differently.

- Hard disks change the magnetic charge of a platter to either negative or positive, depending on whether the value is 0 or 1.
- Optical media use tiny bumps on the disk's surface to represent 0 and 1.
- Flash media use different levels of electrical charge, held in tiny individual cells, to represent 0 or 1.
- Magnetic tape changes the magnetic charge of the tape to either negative or positive, depending on whether the value is 0 or 1.

SUBJECT VOCABULARY

data access speed how quickly data can be read from or written to media

capacity the amount of data that can be stored on media

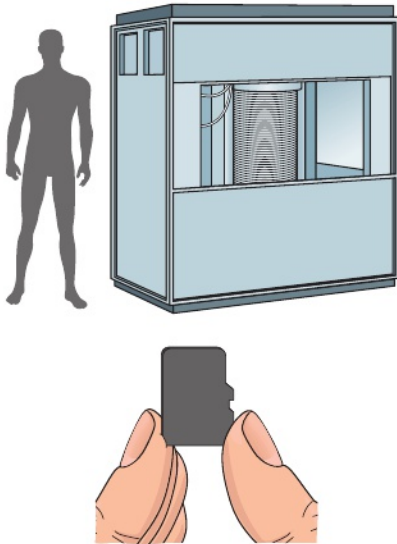
bit (binary digit) a single unit of information with a value of either 0 or 1; eight bits equal one byte

DID YOU KNOW?

The 'bi' in 'binary' comes from the Latin for 'two'.

HINT

You do not need to understand the units shaded in dark grey in the table for the International GCSE.



▲ Figure 1.77 The IBM 350 in comparison with a person and a 256 GB microSD card

▼ Table 1.5 Units of storage capacity

NUMBER OF BYTES	WITH UNIT SYMBOL	NAME
1000	1 KB	Kilobyte
1000,000	1 MB	Megabyte
1000,000,000	1 GB	Gigabyte
1000,000,000,000	1 TB	Terabyte
1000,000,000,000,000	1 PB	Petabyte
1000,000,000,000,000,000	1 EB	Exabyte
1000,000,000,000,000,000,000	1 ZB	Zettabyte
1000,000,000,000,000,000,000,000	1 YB	Yottabyte

The IBM 350 was the first disk drive. It was 172 cm high, 152 cm long and 74 cm wide, and it could store 3.75 MB of data. People could hire one for US\$38,400 per year. In 2016, manufacturers started selling the 256 GB microSD card, which is a flash memory card the size of a human fingertip. It was priced at US\$175 and can store the same amount of data as 68,266 IBM 350 disks!

DID YOU KNOW?

In 2017, it would take about 9457 trillion years to download one yottabyte of data with a good internet connection.

CHAPTER QUESTIONS

SKILLS CRITICAL THINKING

1 State **one** benefit of using barcodes in a supermarket. (1)

SKILLS REASONING

2 State **one** reason why small, built-in microphones are used in smartphones and laptops. (1)

SKILLS DECISION MAKING

3 Explain why capacitive touch screens do not work when you are wearing woollen gloves. (2)

4 State **three** computer systems that **do not** use monitors. (3)

SKILLS CRITICAL THINKING

5 State **two** benefits of using laser printers rather than inkjet printers. (2)

SKILLS PROBLEM SOLVING

6 State **two** types of business that use plotters. (2)

SKILLS REASONING

7 Explain why some 3D printers use biodegradable materials to create models. (3)

SKILLS CRITICAL THINKING

8 List **two** sensors used in smartphones. For each one, describe one way in which it is used by the operating system or an app. (4)

SKILLS REASONING/ARGUMENTATION

9 Discuss the advantages and disadvantages of using sensors in smart cars. (8)

SKILLS DECISION MAKING

10 Explain **one** reason why Blu-ray disks are used to store modern console games. (2)

2 SOFTWARE

The programs that run on a computer are called software. Programs are instructions that are carried out or executed by the computer's processor, which provides other instructions for the rest of the computer.

Some computers can only run one program at a time, while others can run multiple programs at the same time. Some computers are single purpose, which means that they are only able to run one piece of software (for example, the software used to control a microwave). Other computers are general purpose, which means that they are able to carry out a range of tasks (for example, the software used in a tablet computer).

There are two basic groups of software: system software and application software.



LEARNING OBJECTIVES

- Be able to identify the purpose of systems software and applications software
- Know about operating systems and system software tools such as utilities
- Know about the role/function of the operating system, including basic knowledge of:
 - single user and network
 - memory management
 - resource management
 - security
 - print spooling
- Know about software applications (apps), including office-productivity tools, web authoring, image and sound editing, presentation software, control software, project management software
- Know about software licensing types (free/open source and proprietary software)
- Understand that the purpose of communication software is to provide remote access to systems and to exchange files and messages in text, images, audio and/or video formats between different computers or users
- Know why software is updated, how it is done and possible risks to data/systems
- Understand that settings of ICT systems can be configured to meet the accessibility needs of individuals
- Be able to justify choices made in identifying and configuring hardware and software

SYSTEM SOFTWARE

Programs that are designed to maintain or operate the computer system are known as system software.

UTILITY SOFTWARE

Utility software is one form of system software, which carries out configuration and maintenance tasks.

SUBJECT VOCABULARY

utility software (also known as utilities) system software that carries out configuration and maintenance tasks

BACKUP

Backup utilities create a copy of files and programs. Backups can be set to run automatically (usually at a time when the system is not in use) or can be started by a user.

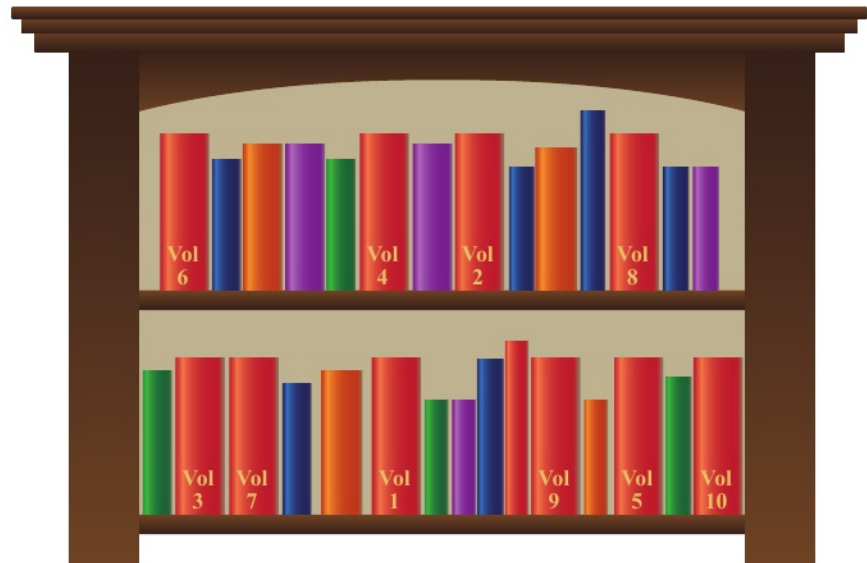
You will learn more about backups in *Unit 3 Operating online* (pages 104–105).

GENERAL VOCABULARY

fragmented broken into pieces

DEFRAGMENTATION

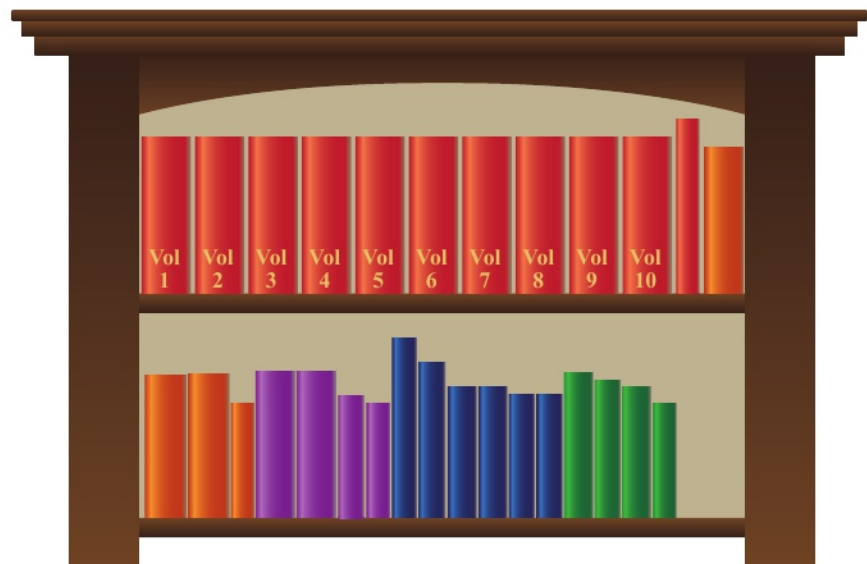
As data is stored to hard disk, some systems spread it across the disk wherever there is free space. This means that sometimes data is **fragmented** and stored out of order or out of sequence.



▲ **Figure 2.1** Data is sometimes stored in the nearest free space, which results in data getting out of sequence. This is an illustrative example.

Data from the same file may be spread over multiple locations on a platter, on different platters in the cylinder or sometimes even on different disks. When these files are loaded, data has to be retrieved from these multiple locations. The read/write head of the hard drive has to find this data, which takes extra time and slows down the process of loading the files.

To avoid this and to speed up the system, disk defragmentation utilities reorder the fragments of data so that they are stored as close to each other as possible.



▲ **Figure 2.2** Defragmentation puts the data back in order so that the read/write head does not have to search the disk for fragments of data. This is an illustrative example.

Defragmentation utilities are usually set to run automatically, but they can also be started by a user.

SKILLS

EXECUTIVE FUNCTION
INTELLECTUAL INTEREST AND CURIOSITY
SELF-DIRECTION

ACTIVITY

▼ DEFRAGMENTATION

- 1 Run a defragmenter analysis on your system. When was the analysis last run? How fragmented was the data last time the analysis ran?
- 2 Research the need for defragmentation on SSDs.

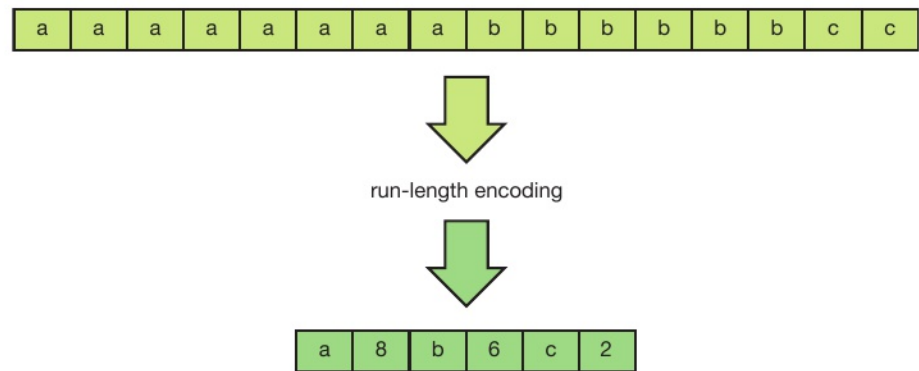


▲ Figure 2.3 Data can be compressed to remove unnecessary use of code or space in the file. This is an illustrative example.

COMPRESSION

Compression utilities reduce the original size of a file or set of files.

Where there are repeated patterns of data, rather than storing every repeated instance, only the first instance of the data is stored, alongside how many times it is repeated. For example, in Figure 2.4, there were eight instances of a, six instances of b and two instances of c in the original file. This data can be compressed to be stored as 'a8b6c2', which reduces the amount of storage needed.



▲ Figure 2.4 Run Length Encoding is one method of data compression

SUBJECT VOCABULARY

decompress extract data from a compressed file so that it can be read

The resulting compressed file is not usually readable by the original application. Compression utilities also have the ability to **decompress** (extract) the data from a compressed file so it can be read by the original application again.

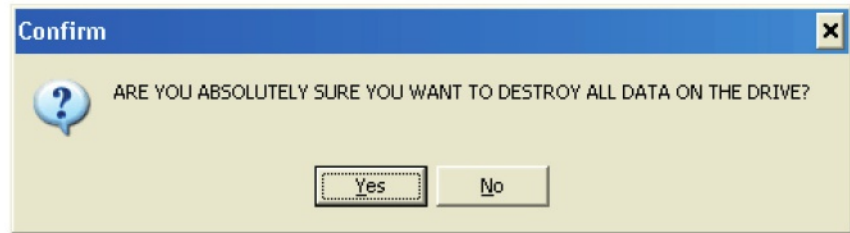
FORMATTING

Disk formatting prepares storage media such as a hard disk drive or USB flash drive for its first use. If a disk has already been used, then formatting it will make all of the data on the disk unreadable by normal applications.

DID YOU KNOW?

Different operating systems require disks to be formatted in certain ways in order to perform specialist tasks. Disks can also be formatted in a way that makes them compatible with all operating systems.

Disk formatting utilities make this process easy for users by providing them with the option to choose the file system, file unit sizes and the name of the disk. Perhaps most importantly, they make sure that the user really wants to format the disk.



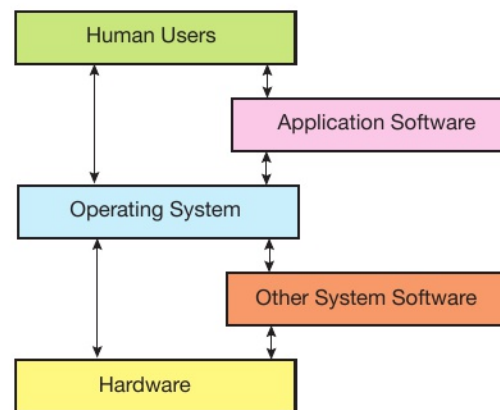
▲ Figure 2.5 Accidentally formatting the wrong disk could result in the unwanted loss of data

DID YOU KNOW?

Formatting a disk will not erase the data completely and it can still be recovered using specialist tools, but there are some utilities which will overwrite the data so that files cannot be recovered.

OPERATING SYSTEMS

The operating system (OS) allows the user to control and manage the computer's hardware.



▲ Figure 2.6 The operating system lets the user control the hardware, either directly or by using applications software or system software

GENERAL VOCABULARY

customise to change something in order to make it more suitable for a particular user or to make it look special or different from things of a similar type

Single-user operating systems only allow for a general user and do not provide the option to **customise** the user interface for different users. They are often found in household appliances.

Network operating systems have additional functionality, including:

- sending requests to a server when users log in with their username and password
- separating user accounts and ensuring that users cannot access each other's files
- providing access to network storage and shared resources such as networked printers.

MEMORY MANAGEMENT

The operating system allocates the required amount of memory (RAM) to one or more applications. When the application no longer requires the memory space, the operating system makes the space available for other applications to use.

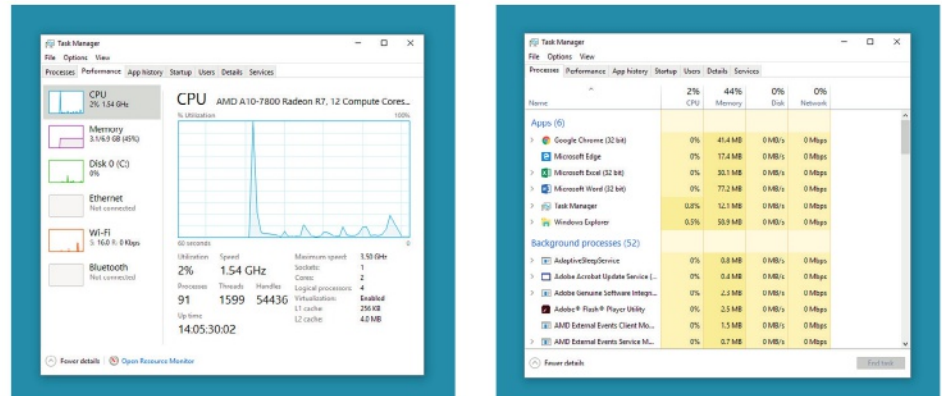
The operating system also handles the creation of virtual memory. See page 60 for more information about virtual memory.

SUBJECT VOCABULARY

graphics card a device built into or added into a computer to allow it to display visual graphics

RESOURCE MANAGEMENT

System resources include internal components, such as the processor and **graphics card**, and external devices, such as printers. As well as allocating memory, the operating system ensures that system resources are made available to applications when they are required. If a system resource is already being used by another application, then the operating system may say that the required resource is in use and place the additional request in a queue. For some resources, such as printers, the operating system can tell the user when the resource becomes available.



▲ Figure 2.7 Information about the use of memory and resources is provided by utility software

SUBJECT VOCABULARY

authentication the process of confirming that a user is permitted to access certain files, hardware and software

firewall a system (hardware or software) that protects a computer network from being used or looked at by people who do not have permission to do so

SECURITY

Operating systems can give users secure access to a computer's storage and other hardware through usernames and passwords, biometric scanning (see pages 27–28) or personal access cards. This process is called **authentication**. Operating systems can provide software **firewalls** to authorise or prevent network data from remotely accessing a service or application.

SUBJECT VOCABULARY

print spooling the process of keeping pages queued in order, ready to be printed by a printer

PRINT SPOOLING

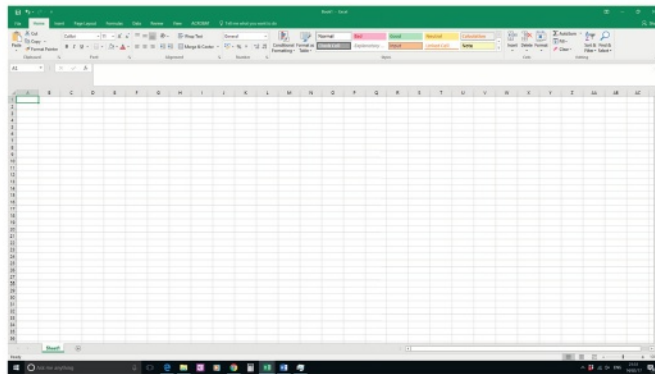
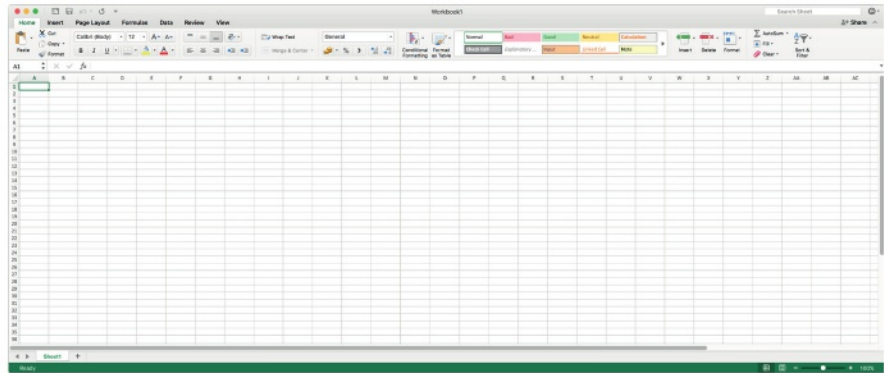
During large print jobs, the computer will have the pages ready for the printer faster than the printer can produce them. The operating system keeps each page in a queue ready for printing. This process is called **print spooling**.

APPLICATION SOFTWARE

Software applications (apps) allow users to produce a digital product, such as a presentation or image, or carry out specific tasks that are not related to the operating system.

Apps are usually downloaded from servers on the internet. Some devices, like smartphones and tablets, use operating systems that provide access to app stores. Some of these only make apps available to users after the store has checked the quality of the app and has ensured that the app does not include code that will harm a user's device or data. Apps can also be installed from storage media like DVDs.

You will learn more about online software in *Unit 4 Online goods and services* (178–179).



▲ Figure 2.8 Some developers provide versions of their apps for different types of computer and operating systems. The top window shows the Apple macOS version whilst the bottom window shows the Microsoft® Windows version.

HINT

When you are writing about application software in your exam, you should refer to the application by its type rather than by a particular name. For example, use the term 'word processing software' rather than the brand name Microsoft® Word.

You need to be able to identify the type of software that meets specific needs. Each type of application software has particular features that make it suitable to perform a particular function. Sometimes more than one type of application can complete the task, but you should consider which one is most suitable.

OFFICE PRODUCTIVITY SOFTWARE

SUBJECT VOCABULARY

application suite a collection of application software that share the same look and user interface; often, they can share data between each other and share some functionality
hyperlink a link that can be clicked in order to go to another location (often a web page on the internet)

Office productivity software is any application that can carry out work-related tasks. They are often available as an **application suite**.

WORD PROCESSING

Word processing software lets users create documents that mostly include words, but also some images. They can also include tables, **hyperlinks**, equations, simple drawings and shapes and charts. An example of word processing software is Writer from the LibreOffice application suite.

Word processors are a good choice of application for creating:

- letters
- reports
- essays
- books (for example, this book was written using word processing software).

Some word processing applications allow people to work together on a document. Comments can be added to the text so that others can understand the writer's intention and give feedback. The software can also track any changes made to the document, giving others the option to accept or reject those changes.

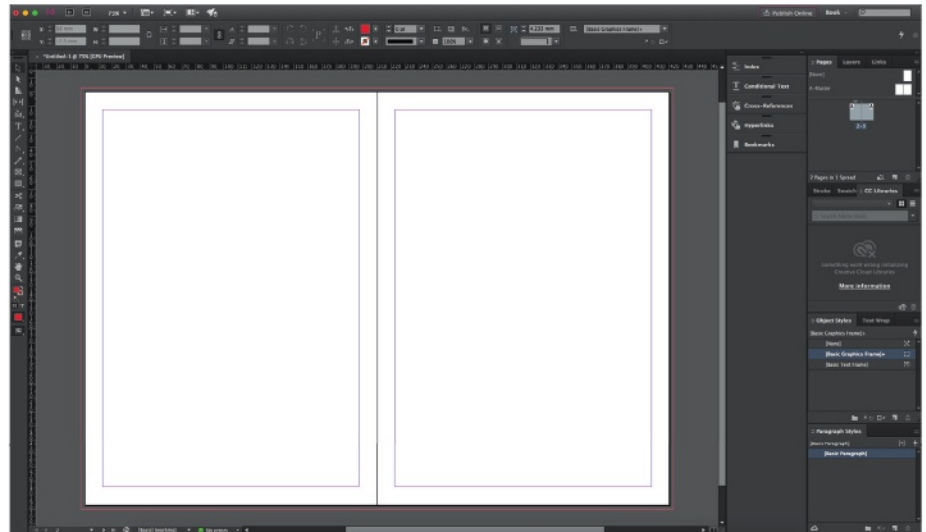
SUBJECT VOCABULARY

font the size and style of text

Word processing applications allow users to change the **font** and provide different layout views to allow users to position text and images on the page. They usually come with spelling and grammar checking tools that identify errors in the text as the user types.

DESKTOP PUBLISHING (DTP)

DTP software has many similar features to those in word processing software. The main difference is the way in which the software allows users to work with complicated page layouts. An example of DTP software is Adobe® InDesign®².



▲ Figure 2.9 Page layouts in DTP software help the designer to see what the final version will look like when printed

SPREADSHEET

Spreadsheet applications are used to do calculations. Users can use and create formulae and functions to perform automatic calculations on values that can be entered and changed later. These features allow spreadsheets to be used to model financial scenarios and answer ‘what if?’ questions, such as ‘**What** would the cost per ticket be **if** I changed the maximum number of staff required at my event?’.

Venue	Gold	1	3000	Venue	Gold	1	3000
Catering package	Gold	1	30	Catering package	Gold	1	30
Entertainment	Bronze	3	300	Entertainment	Bronze	3	300
Decorations	Silver	2	300	Decorations	Silver	2	300
Transport	Gold	1	80	Transport	Gold	1	80
Number of Staff required			20	Number of Staff required			30
Ticket price needed			£ 59.25	Ticket price needed			£ 55.92
Meets requirements?			No	Meets requirements?			No

▲ Figure 2.10 Two scenarios from a financial model

Venue	Gold	1	=VLOOKUP(C11,\$L\$3:\$R\$5,5)
Catering package	Gold	1	=VLOOKUP(C12,\$L\$3:\$R\$5,3)
Entertainment	Bronze	3	=VLOOKUP(C13,\$L\$3:\$R\$5,4)
Decorations	Silver	2	=VLOOKUP(C14,\$L\$3:\$R\$5,6)
Transport	Gold	1	=VLOOKUP(C15,\$L\$3:\$R\$5,7)
Number of Staff required			=ROUNDUP(D5/10,0)
Ticket price needed			=(G14-J14)/D5
Meets requirements?			=IF(D19>D8,"No","Yes")

▲ Figure 2.11 Formulae and functions are used for calculations that are carried out automatically when values change

2 ADOBE AND ADOBE INDESIGN ARE EITHER REGISTERED TRADEMARKS OR TRADEMARKS OF ADOBE SYSTEMS INCORPORATED IN THE UNITED STATES AND/OR OTHER COUNTRIES

An example of spreadsheet software is Microsoft® Excel®.

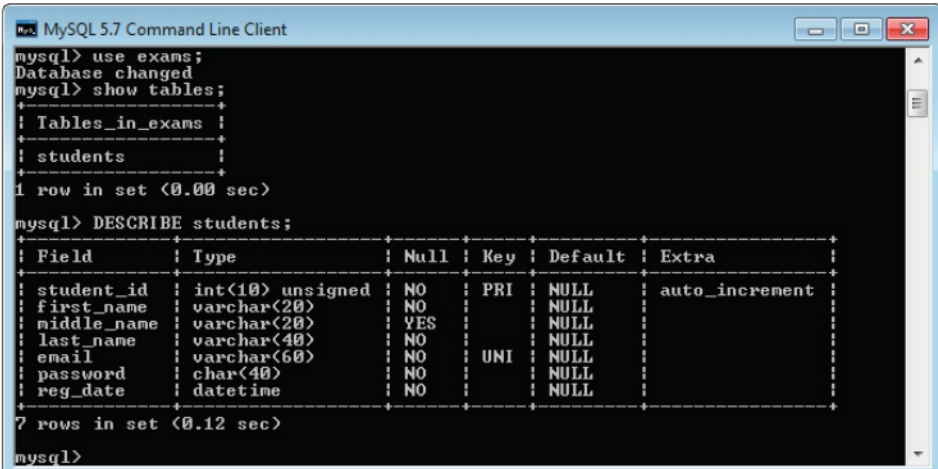
You will learn more about spreadsheets in *Unit 5 Applying Information and Communication Technology* (page 185) and *Unit 6 Software skills* (page 276).

DATABASE

Database management systems (DBMS) are used to enter, edit and search data. Some systems can also produce reports that dynamically display real-time changes to the data as it updates.

DBMS software features include:

- data entry forms so that users can input data
- query editors so that users can select all data that meets certain criteria
- report builders so that users can display data in a more readable format.



```

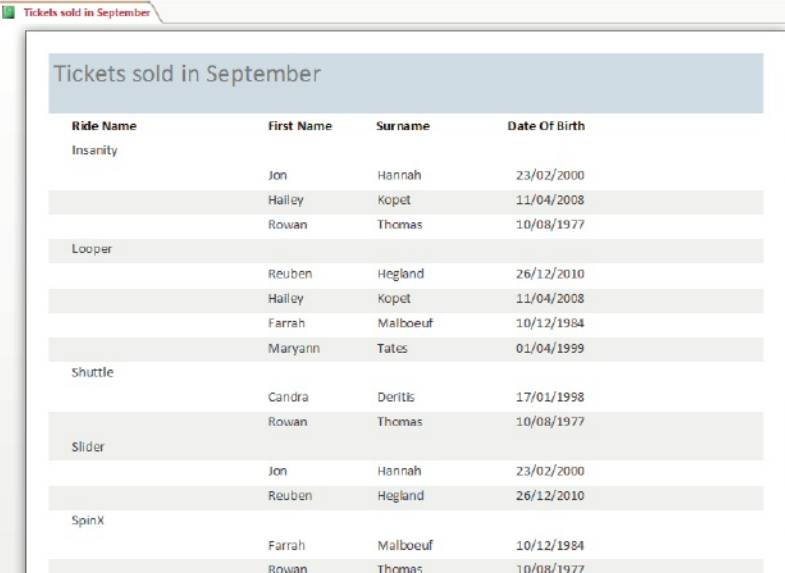
mysql> use exams;
Database changed
mysql> show tables;
+-----+
| Tables_in_exams |
+-----+
| students        |
+-----+
1 row in set (0.00 sec)

mysql> DESCRIBE students;
+-----+-----+-----+-----+-----+-----+
| Field      | Type          | Null | Key | Default | Extra          |
+-----+-----+-----+-----+-----+-----+
| student_id | int(10) unsigned | NO   | PRI | NULL    | auto_increment |
| first_name  | varchar(20)     | NO   |     | NULL    |                |
| middle_name | varchar(20)     | YES  |     | NULL    |                |
| last_name   | varchar(40)     | NO   |     | NULL    |                |
| email       | varchar(60)     | NO   |     | NULL    |                |
| password    | char(40)        | NO   |     | NULL    |                |
| reg_date    | datetime        | NO   |     | NULL    |                |
+-----+-----+-----+-----+-----+-----+
7 rows in set (0.12 sec)

mysql>

```

▲ Figure 2.12 This DBMS software uses a command line interface and contains fewer features



Tickets sold in September			
Ride Name	First Name	Surname	Date Of Birth
Insanity	Jon	Hannah	23/02/2000
	Halley	Kopet	11/04/2008
	Rowan	Thomas	10/08/1977
Looper	Reuben	Hegland	26/12/2010
	Halley	Kopet	11/04/2008
	Farrah	Malboeuf	10/12/1984
Shuttle	Maryann	Tates	01/04/1999
	Candra	Deritts	17/01/1998
	Rowan	Thomas	10/08/1977
Slider	Jon	Hannah	23/02/2000
	Reuben	Hegland	26/12/2010
SpinX	Farrah	Malboeuf	10/12/1984
	Rowan	Thomas	10/08/1977

▲ Figure 2.13 A report from a database

An example of DBMS software is Oracle® MySQL.

You will learn more about databases in *Unit 6 Software skills* (pages 307–333).

WEB AUTHORING

SUBJECT VOCABULARY

Hypertext Markup Language (HTML) a computing language read by web browser software

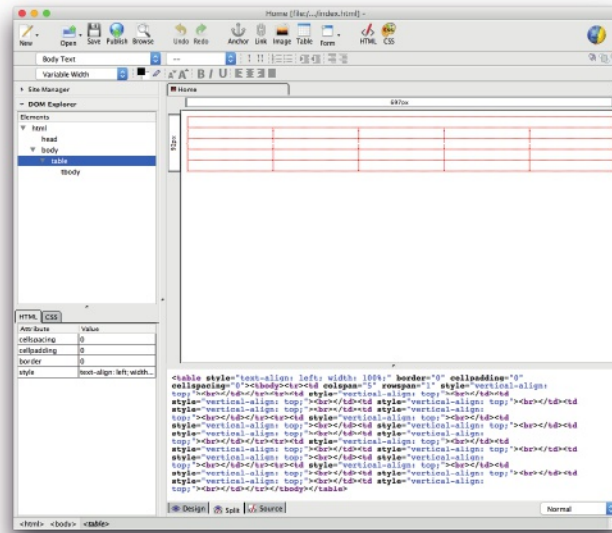
intranet a computer network used for exchanging or seeing information within a company

web server a computer that stores web pages and sends them to other devices that request them (often using web browser software)

Web authoring software lets users create web pages that include text and images. The pages are output as **Hypertext Markup Language (HTML)**. HTML is read by web browser software such as Google® Chrome™³, Microsoft® Edge or Mozilla® Firefox®⁴. Web browsers translate HTML into pages that people can see and read. Web pages can be linked together to create a website for people to view on an **intranet** or on a **web server** on the internet.

You will learn more about web browsers on page 55 and in *Unit 2 Connectivity* (page 87).

Although some people prefer to create or customise web pages by writing their own HTML, some applications will allow users to produce complex websites with little or no experience of HTML coding. These applications are sometimes called 'What You See Is What You Get' (WYSIWYG) editors, because the published page will look very similar to the page that the user edits in the web authoring application. An example of web authoring software is Adobe® Dreamweaver®⁵.



▲ Figure 2.14 Some web authoring software can display the code and design views one after the other

IMAGE EDITING

SUBJECT VOCABULARY

bitmap a computer image that is stored or printed as an arrangement of bits

vector graphic a graphical image made up of points and lines

Image editing applications let users create and change **bitmap** images, such as digital photographs, or **vector graphics**, such as drawings or logos.

GRAPHICS EDITORS

Graphics editing applications allow users to create or edit vector graphics. An example of graphics editing software is Serif® Affinity Designer⁶. Features of graphics editors include:

- vectorising images (that is, converting or tracing bitmap graphics to vector graphics)
- layers (that is, having the ability to place some graphics on top of others)
- adding text
- adding or drawing shapes and lines
- resizing, aligning or moving shapes and lines
- altering the colour of shapes, lines and fill areas.

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4 MOZILLA FIREFOX IS A TRADEMARK OF THE MOZILLA FOUNDATION

5 ADOBE AND ADOBE INDESIGN ARE EITHER REGISTERED TRADEMARKS OR TRADEMARKS OF ADOBE SYSTEMS INCORPORATED IN THE UNITED STATES AND/OR OTHER COUNTRIES

6 "SERIF" AND "AFFINITY" ARE BOTH REGISTERED TRADEMARKS OF SERIF EUROPE LTD

PHOTO EDITORS

These allow users to edit and enhance digital photographs and images. An example of photo editing software is GNU Image Manipulation Program (GIMP). Features of photo editors include:

- adjusting brightness and contrast
- resizing the image
- altering sharpness and blurring
- applying filters and effects such as distortion
- red-eye removal
- **cropping**.

SUBJECT VOCABULARY

cropping using a photo editor to remove the edges of an image

SKILLS

INTELLECTUAL INTEREST AND CURIOSITY
ETHICS
COMMUNICATION
INTERPERSONAL SKILLS

ACTIVITY

▼ EDITING IMAGES

Go to the website of the cosmetics company, Dove, and search for the key terms 'evolution video' to find the video *Evolution*, which is about the way in which the beauty industry uses image editing applications. Watch the video, then discuss the impact that image editing applications can have on society.



▲ Figure 2.15 There are many photo editing apps available for smartphones; finished images can be stored to local storage or shared online

SOUND EDITING

SUBJECT VOCABULARY

mute silence an audio track

solo only play one particular audio track

tempo the speed at which a track is played

Sound editing software allows users to edit audio files or to join together different audio files in order to create multitrack music or soundtracks for video. An example of sound editing software is Audacity®. Features of this software include:

- cut and join audio clips
- **mute** and **solo** some audio tracks
- alter volume levels for individual tracks
- change **tempo**

GENERAL VOCABULARY

reverberation prolonging a sound

SUBJECT VOCABULARY

normalisation increasing the average volume of a piece of audio to a defined maximum level

- frequency equalisation (changing the levels of high and low pitch frequencies)
- add effects like **reverberation**
- apply audio processing:
 - reverse
 - noise reduction
 - **normalisation**
 - fade the volume in, so that it gets louder, or out, so that it gets quieter.

PRESENTATION SOFTWARE

SUBJECT VOCABULARY

slide a single page of a presentation
pathway the sequence of or route through a series of slides

Presentation software allows users to create engaging multimedia content, including images, text, animation and video. This content can be placed on **slides** or **pathways** that are used to illustrate and support the spoken content of a talk given to an audience. An example of presentation software is Prezi™⁷.

Some applications allow users to practise timings and add narration that automatically plays back on the appropriate slides. These slides can be set to advance automatically after a set period of time, or on command from the presenter. Notes can be added to the presentation to remind and prompt the presenter to speak about specific points during the presentation.

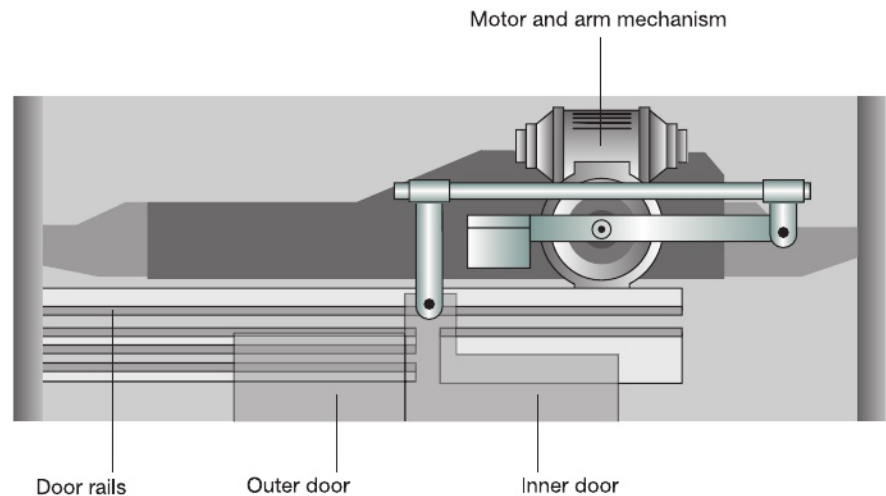
CONTROL APPLICATIONS

Control applications are used to make something happen in the physical environment. This type of software is often used to automate the movement of control devices or actuators, such as motors. See page 37 for more information about actuators.



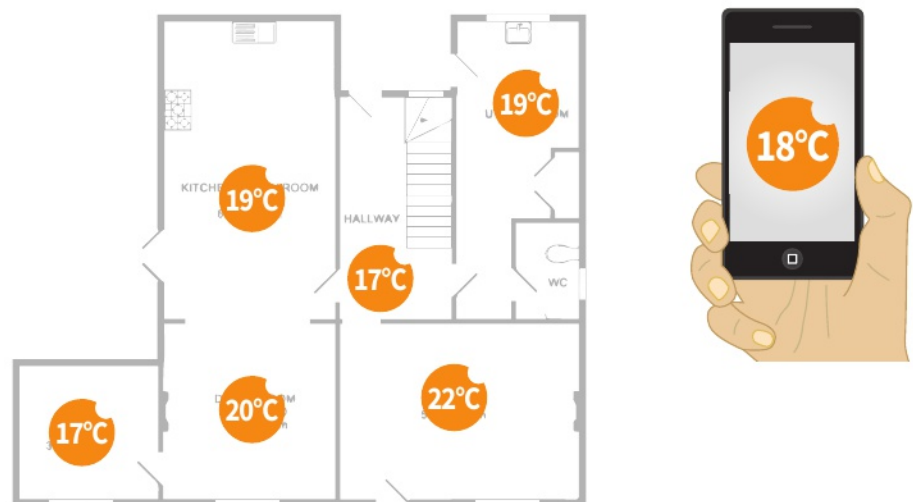
▲ **Figure 2.16** Astronauts on the International Space Station use control software to move a robotic arm into position in order to capture a supply capsule

Control software takes input from one or more sensor(s), makes a decision based on the input value and then outputs something, such as a command, as a result.



▲ Figure 2.17 Lift doors are opened and closed automatically by control software when a sensor detects that the lift is level with the floor and has stopped

Control software is often used in engineering, vehicles and building control systems. However, a developing group of control applications is in the area of home automation systems, where devices can be monitored and controlled using a smartphone app.



▲ Figure 2.18 Smartphone apps can be used to control home heating and cooling systems

SKILLS ADAPTIVE LEARNING
INTELLECTUAL INTEREST AND CURIOSITY
COMMUNICATION

ACTIVITY

▼ REMOTE CONTROL

- 1 Discuss the objects in your home that you think could be connected to the internet in order to be switched on or controlled remotely.
- 2 Now discuss potential ways in which you could automatically control these connected things in your home based on changes in the environment that are detected by remote sensors or sensors in a smartphone. See Figure 2.19 and the Did you know? feature for some examples.

DID YOU KNOW?

Some smartphone apps can control internet-connected devices in certain situations. For example, if the smartphone calculates that its location is within 10 metres of a garage door, it will send an instruction via the internet to the garage door motors to turn on and open the door.

SKILLS

INTELLECTUAL INTEREST AND CURIOSITY
CONTINUOUS LEARNING

ACTIVITY

▼ **THE INTERNET OF THINGS**

Do some research to find out what is meant by the term, 'the internet of things'.

Control applications are often created by programmers rather than general users and they are not as easy to modify as other application software.

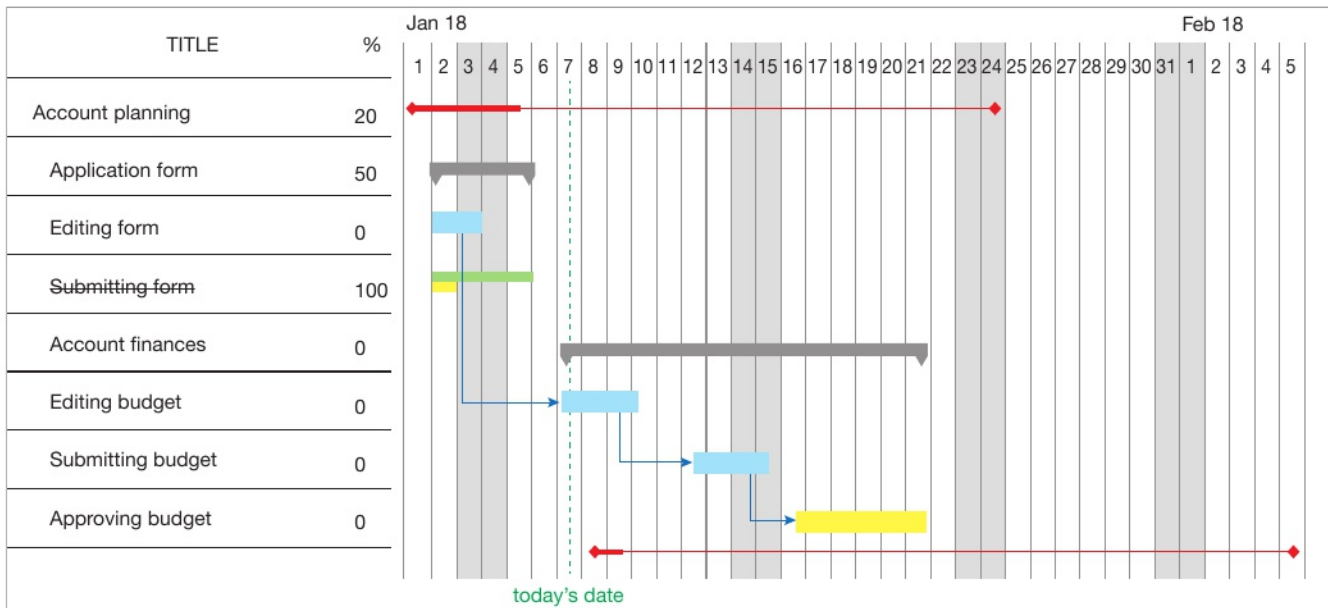
PROJECT MANAGEMENT

GENERAL VOCABULARY

timeline a linear graphical representation of events and the time and order in which they occur
critical path the shortest time a project will take to complete (if no problems or failures are experienced)
milestone a time or date by which a task must be completed

Project management applications are used to help plan and track the individual tasks in a project, so that project managers can make the most efficient use of the available resources. Some tasks cannot be started until a previous task is completed or has been partly completed, so it is important for a project manager to see which tasks are dependent on others. When all of these dependent tasks are combined together into a **timeline**, it is easy for the project manager to see the **critical path**. These applications can also be used to set **milestones**.

Project management applications can be used to allocate tasks to individual people or groups of people. They often provide the option for individuals or groups of people to be allocated to more than one task. Some project management applications also provide tools for tracking the costs and arranging for resources to be delivered on time.



▲ **Figure 2.19** Gantt charts are often used to visualise the timelines and milestones for the individual tasks in a project

COMMUNICATION SOFTWARE

Communication software provides remote access to systems and allows users to contact people using the internet. It can be used to send files and messages as text, images, audio and video.

SUBJECT VOCABULARY

file transfer protocol (FTP) a method of exchanging data and files across a network

WEB BROWSERS

Web browsers allow users to view web pages and websites created in web authoring software and hosted on servers that are connected to the internet. These servers may be in another country. Different browsers have different features and compatibility with file types used on the World Wide Web.

Browsers also allow users to access other systems that use the internet but are not on the World Wide Web, such as **file transfer protocol (FTP)** servers.

EMAIL

Emails can be sent and received by software installed on a computer. This locally installed software acts as a client to an email server (see page 89 for more information about the client-server model). In addition, it often stores or uses a database of contacts, which is sometimes available as another application.

As well as locally installed applications, users can access email through webmail software, which they reach through a web browser. Webmail is an example of a web application that is hosted on a web server and accessed using an internet connection. Some webmail applications allow users to store emails offline for access when they do not have an internet connection.

Email applications often provide features such as labels to help organise emails and **filters**.

SUBJECT VOCABULARY

filter a computer program that only allows certain types of information to pass through it

SOCIAL MEDIA

Social media can be accessed through a web browser or by using locally installed apps.



▲ Figure 2.21 Apps are available for mobile devices as well as PCs



▲ Figure 2.20 Social media companies give access to their services through their web pages

Some apps provide access to multiple social media accounts. App developers create apps that people can download and install on their digital devices. TweetDeck is an example of communication software used with social media.

SMS

Short messaging service (SMS) applications are found on mobile phones. They allow users to send up to 160 text characters per message using the mobile phone network. They do not require an internet connection.

MMS

Multimedia messaging service (MMS) applications extend the capabilities of SMS. MMS can deliver more than 160 characters per message and can include video, animations, images and audio. Like SMS, they are sent using the mobile phone network and do not require an internet connection.

INSTANT MESSAGING

Instant messaging applications are very similar to MMS applications, but they require a connection to the internet. They can allow users to see when other users are typing, and users can also prevent others from seeing when they are typing. Messages sent via instant messaging applications can include location data.

SUBJECT VOCABULARY

software licence a legal arrangement that gives a user the right to install and use software

SOFTWARE LICENSING

Sometimes, users require a **software licence** to be able to install and use software on a computer.

There are many types of software licence and the details of software licensing are complicated. To make things easier to understand, you can think about the two types of software that are available:

- free or open-source
- proprietary.

DID YOU KNOW?

Using software without a required licence is called software piracy. Software distributed without the right to do so is called pirate software.

FREE OR OPEN-SOURCE

SUBJECT VOCABULARY

free software software that can be modified or distributed by a user

open-source software software for which the source code is made available to users

source code a collection of instructions that forms a piece of software

HINT

The key difference between the terms 'free' and 'open-source' is that 'free' describes the program and 'open-source' describes the source code.

Free software licences give users the right to study, modify, copy or distribute a program. The user can decide if, and how much, to charge for a copy of the software or any service provided by the software. This means that free software can be made available for a fee or free of charge. 'Free' refers to the user's freedom to charge whatever they want because there are no restrictions on the use of the software.

Open-source software licences make the **source code** available to users so that they can modify how the software works, or distribute the modified or unmodified software.

KEY POINT

In the case of free software, the term 'free' does not refer to whether or not users have to pay for the software. It refers to the fact that the software is free from usage restrictions.

PROPRIETARY

SUBJECT VOCABULARY

proprietary software software that is marketed and distributed by its owner under a brand name

freeware proprietary software provided free of charge to users

SKILLS

ADAPTIVE LEARNING
DECISION MAKING
INTERPRETATION

Proprietary software is software that is marketed and distributed by its owner under a brand name. The software owner can decide the fee for the software and whether or not the software should be distributed.

Proprietary software can be made available for a fee or free of charge. When no fee is required, the software is called **freeware**. Unlike software distributed under an open-source licence, software with a proprietary licence usually does not make its source code available.

ACTIVITY

▼ CATEGORISING SOFTWARE

Think about the examples of software types that you have read about in this chapter. Group these examples into the categories 'free or open-source' and 'proprietary'.

SUBJECT VOCABULARY

update (noun) a change or addition to a computer file so that it has the most recent information; (verb) to make a change or addition to a computer file so that it has the most recent information

bugs errors in the program's source code

compatibility ability of one device, system or application to work with other devices, systems and applications

usability the ease with which a device or application can be used

GENERAL VOCABULARY

vulnerability weakness or exposure to harm

SOFTWARE UPDATES

Updates to software are released by software developers for the following reasons:

- fixing security **vulnerabilities** or **bugs**
- increasing **compatibility** with newer operating systems
- improving performance and efficiency
- introducing new features
- improving **usability**.

Software updates are usually made available for download from a server on the internet. Some updates can be scheduled to happen automatically when they are released.

It is important to back up a system and files before updating software in case the update introduces problems, such as removing components that other software needs in order to function.

CHAPTER QUESTIONS

SKILLS ADAPTIVE LEARNING

SKILLS INTERPRETATION

SKILLS REASONING

SKILLS REASONING

SKILLS INTERPRETATION

SKILLS INTERPRETATION

SKILLS CRITICAL THINKING
REASONING
COMMUNICATION
PRODUCTIVITY

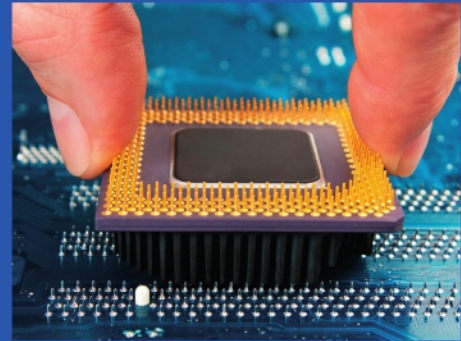
SKILLS PROBLEM SOLVING

SKILLS REASONING

- 1 State what is meant by the term 'application software'. (1)
- 2 State **three** types of utility software. (3)
- 3 Describe the role of the operating system. (2)
- 4 Explain why utility software allows the user to schedule backup processes. (2)
- 5 Explain the benefit of using compression utilities to archive files. (2)
- 6 Describe how presentation software can help a presenter to give a talk. (2)
- 7 Describe **one** use of control software in a relevant industry. (2)
- 8 Discuss why a building company might use project management software. (8)
- 9 State **three** types of service provided by communication software. (3)
- 10 State **two** reasons for updating software. (2)

3 MEMORY AND PROCESSORS

Memory is used to store instructions. The processor executes those instructions. Both of these parts of the computer system have a big impact on the performance of the system. Specifically, they affect the speed at which software can be loaded and the speed at which software tasks can be completed



LEARNING OBJECTIVES

- Know that RAM stands for Random Access Memory and that ROM stands for Read Only Memory
- Be able to describe the characteristics and uses of flash memory
- Be able to describe the characteristics of RAM and ROM, the differences between them and the impact on the user of the size of ROM/RAM
- Understand the function of the processing unit (CPU)
- Know how the speed of a processor is measured

MEMORY

Memory can be accessed faster than secondary storage. Memory is used to store instructions so that the processor can fetch the instructions quickly in order to process them.

There are three types of memory that you need to know about:

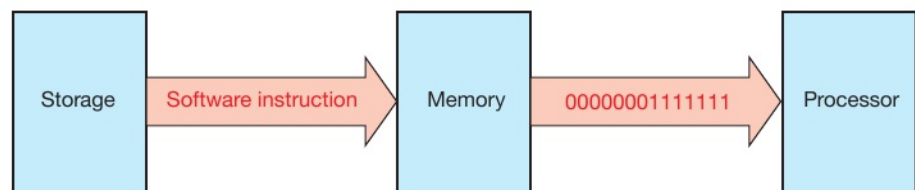
- Random Access Memory (RAM)
- Read Only Memory (ROM)
- Flash memory.

RANDOM ACCESS MEMORY (RAM)

HINT

- Two examples of secondary storage are hard disks and SSDs (see page 38).
- Memory is often called main memory or primary storage, and storage is often called secondary storage.

Software is loaded into RAM from a computer's secondary storage. The processor then fetches software instructions from memory and executes them.



▲ Figure 3.1 Processors fetch software instructions from memory. The processor then decodes and executes the instructions

RAM is **volatile**, meaning that it cannot store data when it has no power. This means that, if you turn off your computer's power, any data held in RAM will be lost.

IMPACT OF THE SIZE OF RAM ON THE USER

RAM is used to store programs that are in use. The more RAM that is available, the more programs can run at the same time. This is important when you need to use many files or programs at the same time.

When the computer system does not have enough space in RAM, the operating system creates virtual memory by using an area of secondary storage. Secondary storage is much slower than RAM, so the user will notice a big decrease in system performance when the processor has to access instructions from virtual memory. When a solid state drive (SSD) is used as secondary storage, data is swapped to and from the SSD quickly and frequently. Although SSDs have faster access times than hard disk drives, this constant swapping can greatly reduce the performance of the SSD.

When programs or files are closed, they are removed from RAM. As space in RAM becomes available, active programs are moved into RAM from virtual memory, and this will improve the performance of those programs.

A user can add more RAM to a system, but only up to the maximum supported by the computer and operating system. Adding more RAM can improve the performance of a computer system when the user is using multiple files or programs at the same time. It can also be useful to increase the amount of RAM when programs are updated, as the updates often include more complex features that require the use of more memory.



▲ Figure 3.2 A user can increase the amount of RAM using RAM slots on a motherboard

SKILLS INTELLECTUAL INTEREST AND CURIOSITY
REASONING

ACTIVITY

▼ USING RAM

- 1 Choose two operating systems. Research the maximum amount of RAM that can be installed for each one.
- 2 Research the cost of 4 GB of RAM today. What would that have cost last year? Investigate the price over the last five years and look at the price trend. What do you notice?

READ ONLY MEMORY (ROM)

SUBJECT VOCABULARY

boot start up

ROM stores data permanently. Unlike RAM, ROM is **non-volatile**, meaning that data is not lost when the power is turned off. ROM is used in computer systems that store only one programme (single purpose computers), such as calculators, digital watches and washing machines. General purpose computers, such as home PCs and laptops, also use ROM to **boot** the system and load the operating system from secondary storage.

- ROM is generally used to refer to memory that cannot be changed after manufacture. Its full name is Mask Programmed Read Only Memory.
- PROM stands for **Programmable** Read Only Memory. It is manufactured with the ability to be written to, but it can only be written to **once**.

Although the computer system cannot swap instructions in and out of ROM, it is possible to change the contents of some types of ROM so that the data on it can be updated. These types of ROM are called:

- EPROM (**Erasable Programmable** Read Only Memory)
- EEPROM (**Electrically Erasable Programmable** Read Only Memory).

The contents of EPROM and EEPROM can be erased and then rewritten to. Data stored in EPROM can be erased by exposing it to strong ultraviolet (UV) light. Data stored in EEPROM is erased by applying a voltage to one of the pins on the ROM chip. This means that you do not have to remove the ROM chip to erase the contents of EEPROM.

EEPROM later developed into flash memory (see pages 13 and 62 for more information about flash memory).

SUBJECT VOCABULARY

firmware a type of software that controls a hardware device

The process of erasing and rewriting the contents of EPROM or EEPROM is used when updating the **firmware** for a device (see page 57 for more information about software updates).

SKILLS INTELLECTUAL INTEREST AND CURIOSITY

ACTIVITY

▼ USING DIFFERENT TYPES OF ROM

- List five digital devices that use PROM that do not need to be edited.
- List five digital devices that use EPROM or EEPROM that can be edited.

DIFFERENCES BETWEEN RAM AND ROM

▼ Table 3.1 Comparing the characteristics of RAM and ROM

	RAM	ROM (all types)
STORES DATA WHEN POWER OFF?	No (volatile)	Yes (non-volatile)
CAN SWAP INSTRUCTIONS IN AND OUT?	Yes	No
ACCESSIBLE IN ANY ORDER?	Yes	Yes
INTENDED TO STORE...	Temporary data	Permanent data
CAN BE UPGRADED?	Yes	No

FLASH MEMORY

Flash memory is a type of EEPROM. Like other types of ROM, it is **non-volatile**. It does not have any moving parts, so it has a fast access time and low power consumption. Because of its low power consumption, flash memory is used in the SSDs that are used in portable devices, such as laptop computers, as these devices often rely on internal batteries for their power. Flash memory is often used as removable storage in USB drives and SD cards.

SUBJECT VOCABULARY

processor cycle the process of fetching a program instruction from memory, decoding the actions required by the instruction and then executing those actions

PROCESSORS

A processor is made up of one or more Central Processing Units (CPUs). These carry out software instructions. In processors that are made up of more than one CPU, each CPU is referred to as a core. For example, in a quad-core processor, four cores are working during each **processor cycle**. This means that it can do up to four times as much work as a single-core processor.

DID YOU KNOW?

In multi-core processors, each core can run more slowly than in a single-core processor. This saves energy and produces less heat, which means that the processor requires less cooling. This makes the computer quieter as the fan does not have to cool the system. Reducing the amount of time in which the fan is running also reduces the amount of energy that the system uses, making the system more environmentally friendly and further increasing the battery life of mobile devices.

SUBJECT VOCABULARY

clock cycles per second used to measure processor speed; the number of times per second the processor can carry out one or more instructions

Processor speed is measured in **clock cycles per second**. This is the number of times per second the processor can carry out one or more instructions. Clock cycles are measured in units called hertz (Hz), kilohertz (kHz), megahertz (MHz) and gigahertz (GHz).

▼ Table 3.2 Measuring clock cycles

Name	Abbreviation	Clock cycles per second
Hertz	Hz	1
Kilohertz	kHz	1000
Megahertz	MHz	1000,000
Gigahertz	GHz	1000,000,000

Although clock cycles measure processing speed, there are other factors that affect how much work a processor can do in a given time. A user should also consider the amount of work that a CPU can do in each clock cycle. Different processors can carry out more instructions per core in each cycle.

SKILLS REASONING
ADAPTIVE LEARNING
HINT

When thinking about the scenario in Question 2, consider that Person A moves more times per hour, but Person B moves more sand each time they move.

ACTIVITY
▼ WORKING AT DIFFERENT SPEEDS

It can be useful to think of processing speeds in relation to people or machinery working.

- Two people are each moving a large pile of sand from one place to another by hand.
 - Person A can move 100 portions every hour.
 - Person B can move 10 portions every hour.

Who will finish first: Person A or Person B?

- Now imagine that Person A uses a spoon to move each portion and Person B uses a digger to move each portion. Who will finish first now?
- Now Person C is also trying to move their own pile of sand. They are using a digger at the same rate as Person B, but Person C's digger has four buckets (a 'quad-core digger!'). Who will finish first now?



▲ Figure 3.3 The fastest does not always finish first

CHAPTER QUESTIONS
SKILLS REASONING

1 State what is meant by 'ROM'. (1)

SKILLS INTERPRETATION

2 State what is meant by 'RAM'. (1)

SKILLS INTERPRETATION

3 Explain why increasing the amount of RAM in a system improves the user experience. (3)

SKILLS REASONING

4 Describe what virtual memory is and why it is used. (2)

SKILLS INTERPRETATION

5 List **three** characteristics of RAM that make it different to ROM. (3)

6 Explain **two** reasons why the characteristics of flash memory make it suitable for use as secondary storage in smartphones. (4)

7 Which **one** of these describes the term 'clock cycle'? (1)

A The number of times per second that a processor can carry out instructions.

B The number of instructions that a processor can carry out each second.

C The number of times that a processor can load instructions for processing.

D The number of times that each process repeats in a processor.

I'M ONLINE



I'M ONLINE

About Me
I want to meet someone who has moved to the level of a developer.



personality
ambitious/Playful
honorous/Wild
positive/Nurturing
romantic, So
my free time

