Chapter 1: Hardware

In this chapter you will learn about the types of hardware used for input, output, processing and storage.

ICT

From the moment you wake, ICT affects you every day. In many cities, ICT systems control the power supply. Computers also print your electricity and telephone bills and many others. The milk you use at breakfast comes in a package marked with a bar code. The pattern of bars represents the identification number for the contents of the package. The checkout at the supermarket serves as an electronic point-of-sale machine, reading the pattern and recognising the number. The computer then knows which item has been purchased, and what its price should be. So the computer affects your breakfast! And computers are used to design and test many parts of the car, bus or bicycle that you use. The effects of ICT systems can be seen everywhere.

Input, output, processing and storage

A common feature of every computer is that its user always has some information to be processed. The user may type in the **data** (unprocessed information), then press a key or perform some other action so the processing can take place. When the job is complete, the answer is produced. So we have three stages: input, processing and output.

Figure 1.1 *Computers are now part of our everyday lives*

What is a computer?

A **computer** is an electronic machine that can follow a set of instructions to input, process, store and output data.

Let's look at each part of that sentence.

- **ELECTRONIC** – Computers are electronic devices. They use tiny electric currents, flowing through circuits, to do their operations.
- **MACHINE** – This is a device to do work easily.
- **INSTRUCTIONS** – The computer must have a sequence of instructions, given in a **program.** The computer will follow this sequence, so the program is essential in getting the computer to do its job.
- **INPUT** – is when data is typed in or otherwise entered into the computer.
- **PROCESS** – The computer processes data, just as you could process your ingredients to get a tasty cooked meal. Think of the computer program as a recipe with instructions to follow. Raw food goes in as input and, after processing, out comes the well-baked dish!
- **STORE** – A computer not only processes data, but can store or save it too.
- **OUTPUT** – This is when the computer displays text or graphics on the screen, prints, plays sounds or otherwise communicates to the user.
- **DATA** – This is the raw information to be processed – just like the raw food.

A computer is a *programmable* machine. Basically it can do whatever it is programmed to do. And notice carefully that it is just a machine. It automatically follows the set of codes or instructions given in a program.

What is the difference between data and information? **Data** means raw, unprocessed information. It could be numbers, or words and letters. **Information** is data that people understand. In order to understand *data,* you may have to interpret it.

For example:

The number 10092004 is data.

This can be interpreted as:

- A date 10/09/2004
- A sum of money $100,920.04

The interpreted data is information. That is, the date or the sum of money is information.

We need to be careful how we interpret data as it can mean quite different things when it is information.

Typically, a computer inputs data, processes it following program instructions, and outputs information. This is often a cyclical process with the user inputting data, viewing the output, and responding to the output by inputting more data. While the data is being processed, data can be retrieved from backing storage or saved on it. This is interactive processing and it provides the user with an immediate response. This can be like an active two-way conversation between the user and the computer.

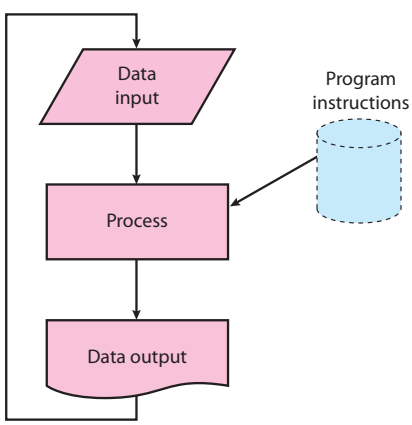


Figure 1.2 *Flow of data*

What is hardware?

Computer hardware is the equipment that makes up the physical ICT system. That is, the **keyboard,** the **monitor** screen, the **system unit** and everything inside it, and other devices connected to it, such as a **printer.** Usually, the monitor, keyboard and other devices are connected to the system unit.

- The **keyboard** has keys for alphabetic characters and numbers. There are extra keys for special functions.
- The **monitor** screen lets you see what you are doing.
- The **mouse** is your pointing device. As you move the mouse, a pointer on the monitor screen moves in the same direction as the mouse. You use the mouse to point, and click the mouse buttons to select.
- The **system unit** is the box where all the processing takes place. All the other devices are installed in it or connected to it.
- The **microprocessor** or **Central Processing Unit (CPU)** is the heart of the computer, and is inside the system unit.

A computer system may also include a **scanner,** a **modem, speakers,** a **DVD drive** and other hardware devices temporarily attached to it, such as a smart phone or an external hard disk.

An **input device** is for 'putting in' information to the machine. The keyboard is an input device; you type characters in using the keyboard.

The mouse is another input device. The monitor is an **output device.** Your computer uses it to display things to you. Another output device is the printer.

Look at Figure 1.3. The arrows show the direction of data flow. The keyboard sends information *in* to the system, hence the direction of the arrow from the keyboard to the system unit. Copy this diagram and draw in the arrows that are missing from the other lines. The big circles are for you to name some additional devices. Then draw in the arrows for those devices too.

Look for these keys on your keyboard:

Space bar	Alt
Ctrl	Del
Shift	Caps Lock
Tab	Enter
Backspace	Numeric keypad

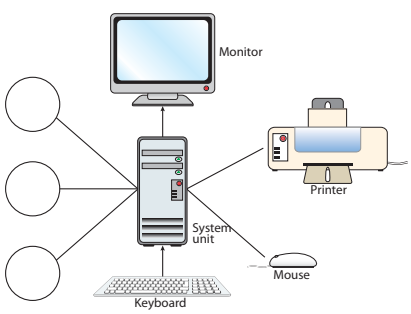


Figure 1.3 *Common computer devices*

Types of computer

At first, computers were very large, but today a complex circuit can fit on a single chip the size of your fingernail. This means that computers can now be small and yet very powerful. It also means that if someone today builds a large computer, that machine will be really powerful. A computer just as powerful as the original machines can now fit easily into a schoolbag.

Different types of PC

- A **desktop** PC usually has these basic components: a monitor, a keyboard, a system unit and a mouse.
- A **laptop** computer is slightly larger and much heavier than an A4 file (see Figure 1.5).
- A **tablet** computer is a laptop computer with a sensitive touch screen that can be used instead of the keyboard.

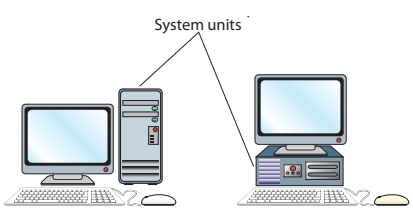


Figure 1.4 *Typical desktop PCs*

Figure 1.5 *A laptop computer*

Figure 1.6 *An Xbox 360 games console*

- A **notebook** computer is a small laptop computer that is about as big as an oversized book. A notebook computer is likely to be half the size of a laptop and is lighter and easier to carry.
- A **netbook** computer is a very small laptop that is optimized for Internet and email access. It is intended to be light and easy to carry and has a long battery life. For example, the Packard Bell Dot S2 netbook has a 10.1 inch screen, weighs 1.25kg and has a 10-hour battery life.
- A **hand-held** computer or **Personal Digital Assistant (PDA)** or **palmtop** can fit in one hand or in your pocket, but it is too small for general work. A PDA usually has a touch-sensitive screen. Although PDAs can be temporarily attached to a keyboard, you cannot comfortably type a long document into a PDA. A **smart phone** is a mobile phone with the functions of a PDA. Hand-held computing devices can perform a range of activities such as personal record-keeping and satellite navigation.
- A **games console** is a PC that is designed specifically for playing games and is likely to have these features:
    - A screen that displays graphics very quickly.
    - A large hard disk for saving games; gamers often have a large number of games.
    - A game pad used to control the games.
    - Possibly an Internet connection for playing online games.

  A desktop PC may have a better specification than a games console but it is likely to be more expensive. Examples of games consoles are: Microsoft Xbox®, Sony PlayStation® and Nintendo Wii®.
- An **embedded computer** is designed for and built into a specific application where it will perform a limited range of dedicated functions. The size and functionality of an embedded computer depends on the application. They may be very small devices built into a single microchip and may control, for example, DVD players and mobile phones.

Processors

A **processor** or microprocessor is built into a microchip that has memory and other components built into it. The microchip itself is often referred to as the 'processor'. If there is more than one processor built into the microchip, then the microchip is referred to as the 'processor' and processors built into it are referred to as **cores**.

The processor accepts input data, this is processed under the control of a stored computer program, and produces the output. A computer program being processed is loaded into the **RAM**. The program instructions are sent to the processor one at a time and the processor carries out the instructions.

An important feature of a processor is the speed at which it can process instructions. It is better to have more and faster cores, which will enable a computer to run applications quickly; however, faster multicore processors are expensive.

The processor speed required depends on what the computer is to be used for. An AMD Sempron or Intel Pentium Dual Core processor might be sufficient for a

Exercise 1.1

1. Daily life can be affected by ICT systems.

A	Listening to the radio
B	Doing the ironing
C	Feeding your pet
D	Watching TV

Put a cross in one box to show which aspect of daily life would not be affected immediately by the failure of an associated ICT system.

- ☐ A
- ☐ B
- ☐ C
- ☐ D

2. Describe the similarities and differences between data and information.

3. Explain what is meant by hardware.

4. Draw a labelled diagram of a desktop computer system showing the range of hardware devices that could be attached to it.

5. Describe the similarities and differences between a desktop computer and a laptop computer.

6. Describe the similarities and differences between a desktop computer and a hand-held computer.

7. Explain how a PDA user can benefit from having an external keyboard.

8. Figure 1.2 shows the flow of data through the input–output process. If the input was the intake of pupils into a school, describe what would represent the 'PROCESS', the 'INSTRUCTIONS' and the 'FINAL OUTPUT' (see Figure 1.8).

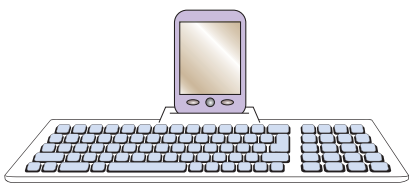


Figure 1.7 *A hand-held computer attached to a larger keyboard*

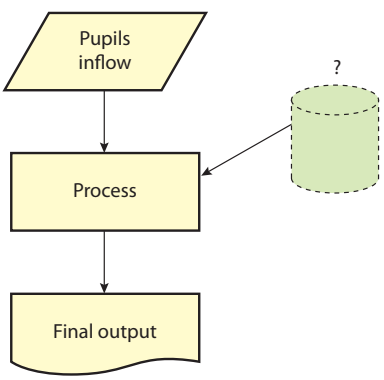


Figure 1.8 *Another form of data flow*

computer occasionally used for word processing, email and web browsing. However, a faster processor is required for a computer also used for playing online multimedia games and making heavy use of multimedia applications; an Intel Pentium Quad Core processor would be suitable.

An example of a microprocessor is the Intel Core 2 Duo E8600 Processor (3.33GHz, 1333MHz FSB, 6MB Cache). This processor has two cores and the speed at which these run is 3.33GHz. The **front side bus** (FSB) is the bus that carries data between the processor and memory and this can transfer data at a speed of 1333MHz. The **cache** is 6MB of RAM memory built into the microprocessor chip. Processing will be faster if there are more processors, running at faster speeds with a larger on-board cache.

Figure 1.9 *An Intel Core 2 Duo microprocessor*

Input and output devices

There are many devices for putting information into a computer, and for displaying the information that is output. The **peripheral** devices attached to a computer system are for input, output or storage.

Input devices

Input devices accept data signals, and translate them for usage and storage in the computer system.

Keyboards

Did you know?
A QWERTY keyboard takes its name from the first six letter keys in the top left-hand corner.

The most widely used input device is a keyboard. There are different types of keyboard and of these the QWERTY keyboard (see Figure 1.10) is the most popular.

Advantages of keyboards:

- Keyboards are almost always available as an input device. They are widely used at work.
- Many people know how to use a QWERTY keyboard, so help is usually available.

Disadvantages of keyboards:

- To use a keyboard efficiently, you need to know the layout and be able to touch-type.

Figure 1.10 *A QWERTY keyboard*

Numeric keyboards only have keys to input numbers and a few special characters. A **QWERTY keyboard** may have a numeric keyboard built into the right-hand side. Some devices have only a numeric keypad – for example, an automated teller machine (ATM), also known as a cashpoint.

Figure 1.11 *An automated teller machine (ATM) or cashpoint showing the numeric keypad*

Pointing devices

There are many other input devices, including **pointing devices** that are used specifically for pointing to (and selecting) objects that are displayed on the monitor screen.

- The **mouse** is the most widely used pointing device. Some have a ball underneath that moves when you move the mouse, resulting in a similar movement of the pointer on the screen. An optical mouse detects movement using light instead of a ball.
- A **joystick** is a lever that gives you similar control to a mouse but its behaviour is slightly different. Joysticks can be used separately or can be

built into a **game pad**, where there are often two simple joysticks, one for each thumb (see Figure 1.12). Suppose you are playing a computer game, where you control a 'car' on the screen. The forward speed of the car may depend on how far forward you push the joystick. Moving the joystick left and right can determine the tightness of your steering turn. Some separate joysticks have handles that can be twisted, and some have 'throttle' buttons as well or these features can be built into a game pad. All of these features can have different effects, depending on the program being used. So the joystick or game pad can be more than just a pointing device.

- A mouse may have a ball underneath it which rolls as you move the mouse. If you turn it over, you can roll the ball with your finger. A **tracker ball** (see Figure 1.13) is like an upside-down mouse. The ball is on the top of the device and you move it with your thumb.
- **A trackpad** (see Figure 1.14) is a small, flat, square pad below the space bar. As you move your finger across the trackpad's surface, the pointer moves across the screen.
- A **graphics tablet** (see Figure 1.15) or graphics pad is a flat rectangular pad between 6 and 30 inches (15 and 76 cm) wide. It works with a stylus, which you move along the surface of the pad to produce drawings in the computer. There are several types of stylus. One, the puck, is a small rounded device with cross-hairs for tracing lines accurately and with a number of buttons. The stylus can also be pen-shaped. A graphics tablet is used mainly for computer-aided design and drawing.

Advantages of pointing devices:

- Many people find it easier to point and click than to use a keyboard.
- It is usually easier to access most of the features of the software being used.

Disadvantages of pointing devices:

- A pointing device is not useful unless a graphical user interface is being used.
- Some people find it difficult to control the on-screen pointer using a pointing device.
- It can be much harder to input text with a pointing device than with a keyboard.

Scanners

A scanner reads printed data into the computer. A number of different devices are referred to as scanners:

- A **hand-held scanner** reads the image while being dragged over it.
- In the case of a **flatbed scanner,** the image is laid flat on the scanner's surface, and is captured in a similar manner to that of a photocopier.
- A **sheet-fed scanner** feeds the image in through rollers. The scanner reads the image as the paper goes through. The image must be printed on a flexible sheet of paper.

Figure 1.12 *A game pad with joysticks built in*

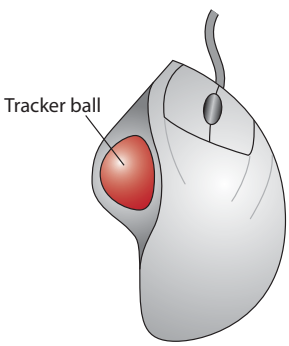


Figure 1.13 *A tracker ball*

Figure 1.14 *A trackpad on a laptop computer*

Figure 1.15 *Graphics tablet and puck being used to trace a drawing*

Figure 1.16 *A bar code*

There are also systems where the scanner reads a particular type of image, and the computer tries to interpret it as something meaningful. In this case, there needs to be a program to analyse the image. A **bar code scanner** or bar code reader is an example of such a system. This reads a pattern of bars representing the code number of the item on which it is printed. The bar code scanner usually passes a small laser beam over the pattern and reads in the pattern of reflected light. Bar code scanners may be hand-held, but some are built into the surface of a supermarket checkout counter. Many other devices can scan information that has been printed or encoded in some way.

Advantages of scanners:

- Scanners quickly convert printed images on paper to electronic form.

Disadvantages of scanners:

- The accuracy of the data input is unlikely to be verified.

Optical Mark Recognition (OMR)

Figure 1.17 *A UK National Lottery form. An OMR reader is used to input the information on the form*

OMR technology is used to interpret pencil marks on a piece of paper. An OMR reader can recognise the position of a mark or set of marks on paper, because the mark is darker than an unmarked area. The computer then records the mark's position and can analyse it to determine the meaning of the data. Marks made on this kind of form must be very clear, or they may not be properly recognised.

Advantages of OMR:

- There is no requirement to type in the information written on the paper form. Because of this, input is faster and less expensive.
- The person who fills in the form is responsible for the accuracy of the information on it.

Disadvantages of OMR:

- OMR forms must be printed very accurately because the position of the mark on the paper affects the accuracy of the input. Because of this, printing costs more.
- Verification checks on the input are unlikely to be carried out, so mistakes inputting the data are less likely to be detected.

Optical Character Recognition (OCR)

OCR is the identification of printed or written text characters by a computer. Printed text is scanned and input to the computer, which attempts to recognise the characters in it. These are then stored as text that can be word-processed. OCR can also be used to read handwriting. OCR software is often included when you purchase a scanner, so that any office with a scanner has OCR capabilities.

A similar process of character recognition is used to interpret handwriting on the screen of a PDA or tablet computer. PDAs and tablet computers have touch-sensitive screens that accept handwriting as input and have character recognition software that can convert it to text characters that can be word processed.

Advantages of OCR:

- Text printed on paper can be converted to electronic form and edited. This is especially useful for creating electronic versions of books printed before computers were available.

Disadvantages of OCR:

- Character recognition is not always accurate and the electronic text has to be checked carefully.

Magnetic ink character recognition

Magnetic ink character recognition (MICR) identifies data printed using a special magnetic ink. Instead of relying on reflected light to detect a character, it depends on the magnetic behaviour of the ink, which is activated by a magnetic field that can be detected by a MICR reader. Specially shaped magnetic ink characters are used to speed up recognition.

Do you notice the similarity between OCR and MICR? One difference is that one technology uses reflected light, while the other uses magnetic field patterns produced by the characters. Another important difference is that OCR systems can recognise handwriting and different types of text, but MICR needs specially shaped characters.

Advantages of MICR:

- Forms can be pre-printed with data which can be read by a computer. This can save time as otherwise all the data on the form would have to be typed in using a keyboard.

Disadvantages of MICR:

- MICR characters have to be printed in magnetic ink and this is more expensive.
- Characters printed in ordinary ink are not detected.

Figure 1.18 *MICR uses uniquely shaped characters, printed in magnetic ink*

Magnetic stripe card

A **magnetic stripe card reader** reads information from a magnetic stripe on the surface of a plastic card (see Figure 1.19) when it is swiped through the reader.

Stripe cards can be used to control access to buildings. For example, to gain access to a building or to leave it, a stripe card is passed through a reader that controls whether a door opens or closes. If the identification number on the card is recognised by the ICT system, the door will open; if not, the door remains closed. As a result, the ICT system knows who is in the building. Such a system could be used for registering school pupils; however, when large numbers of pupils enter a school at the same time, some may not bother to swipe their card through the reader. The ICT system can only know if a particular card is in the building and some pupils will give their cards to others to swipe for them. Such difficulties suggest countermeasures such as turnstiles or very careful supervision but these are often impractical as they can lead to long queues, disorder and the expense of employing supervisors.

Magnetic stripe cards are also widely used as bank or credit cards. In addition to being able to read the magnetic stripe, some devices can also write information to it. The stripe can store a permanent value, such as an account number, or a value that could change, such as the amount of cash you are allowed to withdraw from a cashpoint.

Figure 1.19 *A magnetic stripe card*

Advantages of magnetic stripe cards:

- They are often used as a form of identification that is small and light and can be carried at all times.
- The data recorded on the magnetic stripe is in electronic form and can be input directly into a computer.

Disadvantages of magnetic stripe cards:

- The data recorded on the magnetic stripe can be affected by electromagnetic radiation, such as that from televisions and computers.
- The data recorded on the magnetic stripe can be copied or edited. This is an opportunity for determined criminals to commit identity theft and fraud.

Smart cards

A **smart card** is similar in shape and size to a magnetic stripe card, but has a microprocessor chip embedded in it (see Figure 1.20). The chip can do some processing, as well as storing information. Special devices can communicate with the chip to read and write information on the card. Security features can be programmed into the chip.

Bank and credit cards used to be magnetic stripe cards but are now more usually smart cards or **Chip and PIN** (personal identification number) cards. These cards can be used to withdraw cash at a cashpoint. Cashpoints are specialised computer terminals with a small screen, numeric keyboard and smart card reader. The customer puts their card in the reader and is prompted to enter their four-digit PIN. If the PIN entered on the keyboard matches the PIN read from the card, the customer can proceed; if not, the card is either confiscated or returned to the

customer. Most ATMs will dispense cash and display the balance in the customer's bank account. In a similar way, bank and credit cards can also be used to pay for goods in retail stores such as supermarkets.

A Chip and PIN card provides very secure access to a bank or credit card account. The customer should remember their PIN (it should not be written down), and no one else should know it. For this reason, the numeric keyboard is shielded so that it is difficult for anyone other than the person entering their PIN to see what number is entered.

For example, an Oyster® card is an electronic smart card that can be used to pay for travel, as well as in shops, theatres and restaurants and for entry to tourist attractions. It is used very much like a bank or credit card except that it is preloaded with cash credits. This can be done on the Web or in a manner similar to withdrawing cash from a cashpoint. As a result, payments can be made without online access at the time. Payment is made by touching the Oyster card on a reader and the payment is automatically deducted. This speeds up payment. Oyster cards are in widespread use in London.

Advantages of smart cards:

- Often used as a form of identification that is small and light and can be carried at all times.
- The data recorded on the chip is in electronic form and can be input directly into a computer.
- The data recorded on the chip is more secure than data recorded on a magnetic stripe.
- The data recorded on the chip can be updated during transactions.

Disadvantages of smart cards:

- The data recorded on the chip can be affected by electromagnetic radiation; for example, from televisions and computers.
- The data recorded on the chip can be copied or edited by very determined criminals and used for fraud.

Figure 1.20 *A smart card showing the microprocessor chip embedded in it*

Digital cameras, digital video cameras and webcams

Digital cameras store pictures on a memory card in a format suitable for saving and displaying on a computer. Pictures can be transferred from the camera to the computer where they can be edited and enhanced in graphics software or viewed on screen. The pictures can be transferred to a computer directly by connecting the camera to the computer, or the memory card can be removed and read using a memory card reader, which may be built into the computer or connected to it. Television sets can also have memory card readers built in or connected so that several people can view the pictures together on a large screen.

The picture made by a digital camera (as for a printer or a monitor) is formed by a quantity of very small dots of different colours, merging to form a picture. The picture quality is related to the density (or closeness) of the dots making the picture, the accurate placement of the dots and the correctness of the colours being displayed. Thus an 'eight mega-pixel' camera uses eight million dots (the **pixels**) to form a picture, and so would usually produce better output than a 'two mega-pixel' camera.

Digital cameras may have a traditional viewfinder but more usually have a small LCD screen or both. The advantage of having both is that the viewfinder can be used if bright sunlight makes the LCD screen unclear.

A digital video camera or camcorder has similar functions to a digital camera but records moving images with sound. Camcorders can save recordings on a memory card but may also use DVD, miniDV tape or a built-in hard disk. All these formats are transferable to a computer for editing and storage and are likely to be playable on a home entertainment system.

A **webcam** is a type of digital video camera where the image captured is viewed using a computer. Recordings can be made but this is not always done. A webcam can be used to view a remote location. The computer connects to the webcam over the Web and the image is displayed on the computer screen. This has a variety of different uses:

- You could see if the weather is suitable for skiing by viewing the webcam in the mountains above Grindelwald in Switzerland.
- You could install a webcam at home for security and view this when you are out at work.
- You could attach a webcam to your computer and contact a friend who has a webcam so that you could both see each other while you are talking. You could use VoIP (Voice over Internet Protocol) software to do this. You could use a similar arrangement to practise speaking a foreign language.
- You could set up a webcam in a classroom and listen to a teacher from another school. This might be useful if you were learning to speak English and could not find a teacher locally.

Simple webcams have a fixed position and can see only one view; however, some webcams allow the user to turn them so that many different views can be seen.

Advantages of webcams:

- Photos and video can be recorded in a digital form that can be saved on a computer. This makes backup easier, more reliable and more extensive.
- Digital photos and video can be displayed on a wide variety of devices, such as smart phones and television screens. This allows access in a wider range of locations and by several people at the same time.
- Digital photos and video can be sent by email.
- Digital video can be broadcast over the Internet so that TV programmes can be available on demand.

Disadvantages of webcams:

- Users tend to have more photos and longer videos and this creates a need for more backing storage.
- High-quality photos and videos can be in very large files. When these are sent by email or broadcast over the Internet, this uses bandwidth and slows down the network.

Figure 1.21 *A digital camera*

Biometric scanners

A **biometric scanner** is a pattern recognition system which makes a personal identification based on a person's unique physical characteristics. Biometric scanners can use face recognition, fingerprint matching, iris and retinal scans, voice recognition, and hand geometry. Biometric scanners can be built into mobile phones, desktop and laptop computers, and smart cards. They can be used to control entry to buildings, and can even replace keys in cars.

Advantages of biometric scanners:

- There is no need to remember to carry personal identification.
- The person has to be present. This makes identification theft and fraud much less likely.

Disadvantages of biometric scanners:

- Identification using biometric scanners is not yet sufficiently accurate. Permitted users will not be recognised at times, and blocked users will sometimes be permitted.

Figure 1.22 *A biometric scanner using finger prints*

Sensors

Sensors are used to input data about the environment into a computer. There are many types of sensors. They are available in many different shapes and sizes, and they have a wide variety of uses. For example, sensors can be used to record light intensity, temperature and pressure. Sensors usually produce a low voltage which must be converted to a digital signal for the computer using an analogue-to-digital converter (ADC).

Sensors are used extensively for data logging and control applications. They are essential in applications such as the following: automatic washing machines, automatic cookers, air conditioning controllers, central heating controllers, computer-controlled greenhouses, burglar alarm systems, control of factory production lines, robotics, and for monitoring scientific experiments and remote weather stations.

Advantages of sensors:

- Sensors can be placed in dangerous locations where people would be hurt.
- Sensors can continuously and reliably record data whereas to organise this using people could be much more unreliable and expensive.
- Sensors can record data that people do not sense or do not sense accurately, such as humidity.
- The data recorded by sensors can be automatically recorded in a form that can be processed by a computer.
- Data can be collected by a central computer from sensors in remote locations. People do not need to travel and this saves time and allows data to be collected more frequently.

Disadvantages of sensors:

- Sensors cannot interpret the data.
- Sensors detect a very restricted range of the different types of data.

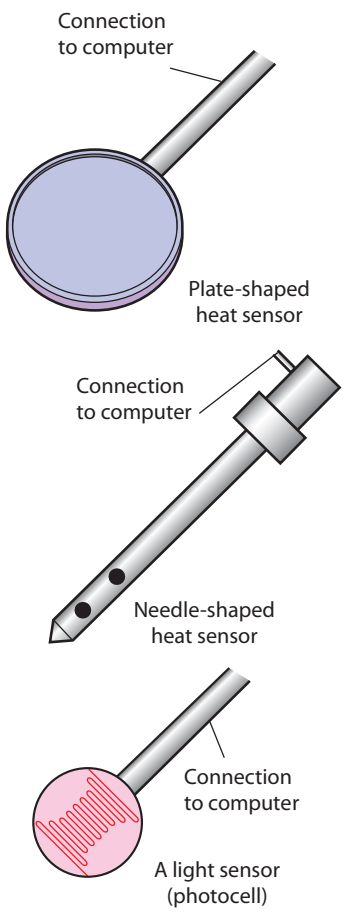


Figure 1.23 *Sensors are available in different shapes and sizes*

Audio input devices and technologies

There are various input devices and technologies relating to computer input from sound.

- A **touch-tone telephone** issues a beep whose frequency depends on the button being pressed. On the other end of the line is a computer with an input device that can analyse the beep to determine which button is being pressed. So your touch-tone telephone functions as an input device. You may then listen to a voice response from the computer.
- A **microphone** can be used to record sounds and voices, to give voice commands and for voice communication over the Internet.
- Your voice carries many tones, all making up the sound that people hear. People can recognise your voice because they can recognise the combination of tones that make up your voice. Computers have also been programmed to do voice recognition. **Voice recognition** software enables the computer to know who is talking but not what has been said.
- **Speech recognition** is often used for **voice command systems.** These require that the voice first be recognised, as above. A microphone is used to input the spoken words, which are then analysed by the program. The sound is compared with other sounds stored in the computer, to find the matching word; this match may be interpreted as a command. This is an unreliable process because a user can make words sound different at different times, and different users will say the same words differently. As a result, the software may have to be trained to recognise a particular user.
- **Natural language processing** is where a computer processes a sequence of instructions or data given in a natural language – for instance, spoken English. You could use natural language processing to dictate a letter or give instructions to a computer.

Advantages of audio input:

- People speak to the computer and do not have to learn how to operate a keyboard or other input device.

Disadvantages of audio input:

- Voice recognition software has to be trained to recognise human speech. This can be a very lengthy process if the computer needs to recognise the full range of words used.
- Voice recognition is not entirely accurate because people pronounce words differently and speak in a wide range of accents and different tones of voice.

Remote Control

Many devices can be operated using a remote control handset (see Figure 1.24). Here are some examples: televisions, video players and recorders, DVD players and recorders, satellite receivers, hi-fi music systems, multimedia projectors, model cars and airplanes, and garage doors.

The main remote control technology used in the home is infrared. The signals between a remote control handset and the device it is controlling are infrared light pulses, which are invisible to the human eye.

The **transmitter** in the remote control handset sends out a pulse of infrared light when a button is pressed on the handset. A transmitter is often a light-emitting diode (LED) which is built into the pointing end of the remote control handset (see Figure 1.25). The infrared light pulse represents a binary code that corresponds to a command, such as 'power on' or 'volume down'. A **receiver** is built into the device being controlled in a position where it can easily receive the infrared light pulses – for example, it is built into the front of a satellite TV receiver. The receiver passes the code to a microprocessor, which decodes it and carries out the command.

The remote control handset will often have two LEDs that light up at the same time when a button is pressed. One LED is the infrared transmitter and the light from this is invisible. The other LED emits a visible light and this is to reassure the user that the remote control is functioning (see Figure 1.25).

Some handsets only work when they are pointing directly at the receiver on the controlled device, while others work when they are pointing generally towards the receiver. This is because the strength of the infrared light pulse varies. A handset with more than one infrared LED or a very powerful LED can produce a stronger, broader signal.

Figure 1.24 *A remote control handset*

Advantages of remote control:

- Less movement and energy are needed to operate remote controlled devices.
- Inaccessible or hidden devices can be controlled.

Disadvantages of remote control:

- Some devices cannot be operated without the remote control handset. If this is lost or damaged, the device cannot be used.

Figure 1.25 *The LEDs built into a remote control handset*

Output devices

Monitors

Monitors are also known as **visual display units (VDUs).** They come in different styles and quality levels. Screen colour quality, resolution and clarity are just some of the features that affect how desirable a particular monitor is to you.

Picture elements

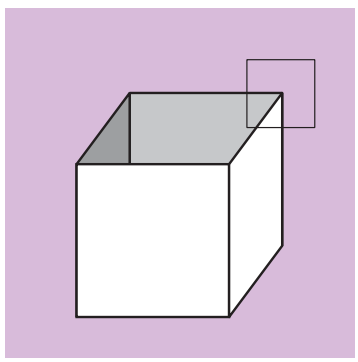
Although the picture on a computer monitor may look sharp and clear, it is made up of many illuminated dots known as **picture elements** or **pixels.** The dots are usually so tiny that you would not normally notice them individually – you just see the whole picture. If you could actually see the picture elements, the picture would look jagged (see Figure 1.26).

The screen itself may perhaps have 1024 screen dots going across the screen, and 768 from top to bottom. In this case the screen is said to have a **resolution** of

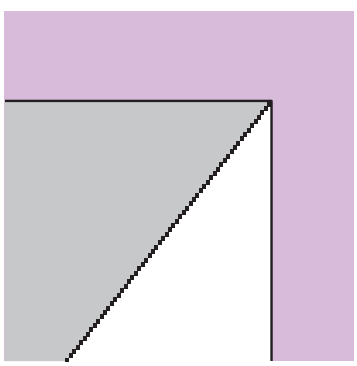
1024 by 768. These screen dots are not the same as picture elements, because some software packages use picture elements that are much bigger than the tiny screen dots. For many packages, however, the picture element is as small as the screen dot – this is the smallest possible size for the pixel.

Graphics cards

The graphics card which is also known as the **video card or display card** is housed within the system unit, and controls the signals going to the monitor screen. Higher-quality cards can produce very clear graphics very quickly. Some computer games demand advanced display cards and high-quality monitor screens.



A perfect box



Close-up view of the top right corner, showing the picture elements (pixels)

Figure 1.26 *Picture elements*

Cathode ray tube (CRT) monitors

Cathode ray tube monitors used to be the commonest type of monitor. CRT monitors can be relatively bulky (see Figures 1.27 and 1.28).

Liquid crystal display (LCD) monitors

Liquid crystal display technology allows the screen to be flat, instead of bulky as with CRT monitors. LCD screens consume less power than CRT displays. An LCD screen is generally more compact than a corresponding CRT display (see Figures 1.27 and 1.28).

LCD monitor screens vary considerably in size and resolution. For example, a typical 15-inch screen might have a resolution of 1024 × 768 pixels and a 30-inch screen 2560 × 1600. Higher-quality screens have more pixels per inch. Small screens built into PDAs and smart phones are likely to have a lower quality display with fewer pixels per inch.

LCD screen technology is currently the most popular for use with PCs. However, there are other alternatives; for example, plasma displays (which are clear and bright) and electroluminescent displays (which have the potential to support very large flexible displays).

Touch screens

A **touch screen** is not just an output device; it is a two-way user interface. You can interact with the computer by touching pictures or words on the screen. Touch screens are widely used with tablet PCs, PDAs and Smart Phones. There are different touch screen technologies. For example, the iPhone uses a capacitive touch screen. This is glass panel with a layer that stores electrical charge on it facing outwards. When you touch the screen, you conduct some of the electrical charge, reducing it at that point. The iPhone knows where you touched the screen because it knows where the charge was reduced. This is why the iPhone works best if you use your finger to operate it. Resistive screens often work best with a stylus because they work by detecting changes in the electrical charge when internal charged and conductive layers are pressed together.

Figure 1.27 *Front view of a CRT monitor and an LCD monitor*

Figure 1.28 *Side view of a CRT monitor and an LCD monitor*

Multimedia projectors

A **multimedia projector** or data projector projects an image that would normally be displayed on a computer screen onto a larger, separate screen. This allows the image on the screen to be shared with an audience in a large room. Multimedia projectors are almost always used when giving a computer-based presentation. They can be found in school classrooms, university lecture theatres and commercial training organisations. Multimedia projectors are also used with home entertainment systems, enabling people to watch TV and DVDs and to play computer games.

Interactive whiteboards are large touch sensitive panels used as screens for multimedia projectors. They are operated as touch screens. Some use capacitive or resistive technology but others use an optical 'curtain'. Breaks in this curtain are detected and so the computer knows which part of the interactive whiteboard has been touched.

Advantages of monitor screens:

- Enables the use of a graphical user interface.
- Interactive, on-screen use of a computer is more natural and intuitive than programming.

Disadvantages of monitor screens:

- Screen size can limit the extent and detail of what can be seen. For example, it is possible to refer to several printed pages at the same time. It could be much more difficult to arrange this on a monitor.
- Screen displays can be difficult to read for people who have impaired sight.

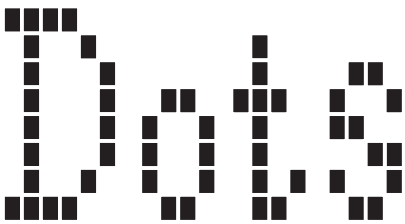


Figure 1.29 *Enlarged dot-matrix printing produced by an inkjet printer showing how the dots form characters*

Printers

- Printed output is often called a **printout** or **hard copy.** An **impact printer** usually strikes through an inked ribbon, making marks on the paper. A **non-impact printer** uses a non-striking method to form the image on the paper. Examples of non-impact printers are laser printers and inkjet printers.
- **Inkjet printers** use tiny dots of ink sprayed onto the paper, forming the shapes of characters and pictures. Inkjet printers are quiet and produce good quality output. They usually produce colour prints, and are very popular for home and small-office use.
- **Laser printers** use laser light to make patterns of ink on a drum. This drum then transfers the ink to the paper, and finally a heating process fuses the ink to the paper. Laser technology gives excellent quality, and prints quickly. Laser printers are widely used but are more expensive than inkjet printers, and often only print in black and white.
- **Thermal printers** use heated wires to mark dots on the surface of a heat-sensitive paper.
- **Thermal dye transfer printers** use special coloured dyes heated into a gas. This process gives the best quality of colour printing, but is very expensive and requires special paper.
- **Thermal wax transfer printers** use molten wax, forming tiny dots of different colours on the paper. These coloured wax dots blend to produce tones.

Buffers and spooling

Printers (and some other devices) are much slower than the computers and networks that send information to them to be printed. So that the computer does not have to wait for the printer to finish printing, most printers have a **buffer** (a small amount of memory) built into them. A document sent to the printer will be quickly saved in the buffer so that the computer can do other tasks while the printer is printing the document.

A buffer will only hold a few short documents, and on large networks many users may be sharing the same printer. To avoid users having to wait, documents are first put into a queue on a server and then sent for printing in turn. This queuing process is known as **spooling.**

Did you know?
You can see this process in action. If you are using a computer with a local printer attached, print a long document then turn off the computer but not the printer. The printer will continue printing and will print that part of the document that is in its buffer.

Print quality

All these types of printer use very small dots to produce pictures. The smaller the dot, the better the quality of the picture. An important measure of print quality is the number of **dots per inch (dpi).** The higher the dpi, the better the picture. In addition, for the best-quality output the dots must be accurately placed.

Printers and paper

Printers can use different types of paper.

- Many printers use sheets of A4 paper.
- Some printers have a long stream of **continuous paper** flowing through. Usually the paper is perforated, so that it can be torn easily to produce separate pages of output. There may be several sheets together, either impregnated with carbon or with carbon sheets between them, so that multiple copies are produced at once.
- In pre-printed stationery, certain information – for instance, the name of a company – has already been printed on the paper. This is usually the case with utility bills, which are printed with a high-volume single-coloured printer on forms that already have coloured logos and other symbols printed on them.

Photo-printers

Photo-printers are specially designed to print digital photographs. A memory card storing pictures taken by a digital camera can sometimes be plugged directly into the printer, and the pictures printed. In other cases, the camera can be directly connected to the printer.

Advantages of printers:

- Printed output can be viewed without the need for a computer.
- Many people and organisations still use paper-based communications and similar legacy methods.

Disadvantages of printers:

- Printing is slow and expensive compared with electronic communications and storage.
- Paper is bulky and deteriorates in storage.
- Printed materials are more difficult to access and distribute. For example, printed photographs can be viewed by a limited number of people compared with digital photographs displayed on a TV screen, and it is more difficult and expensive to send copies to others.

Plotters

A **plotter** draws lines on paper using differently coloured pens. In a flatbed plotter, the paper is held still while the pen moves. Other plotters have the pen moving from left to right, while the paper goes forwards and backwards. Yet others use wires to draw charged patterns on special paper, then fuse toner onto the

electrically charged patterns. If a job essentially consists of lines – for instance, a graph – a plotter will quickly draw the required lines. An upright plotter can also handle very long sheets of paper, because of the way the paper flows, and can produce long continuous lines. Plotters are frequently used in **computer-aided design.**

Advantages of plotters:

- Much larger and longer sheets can be printed.

Disadvantages of plotters:

- Printing is very slow.
- Plotters are usually more expensive than printers.

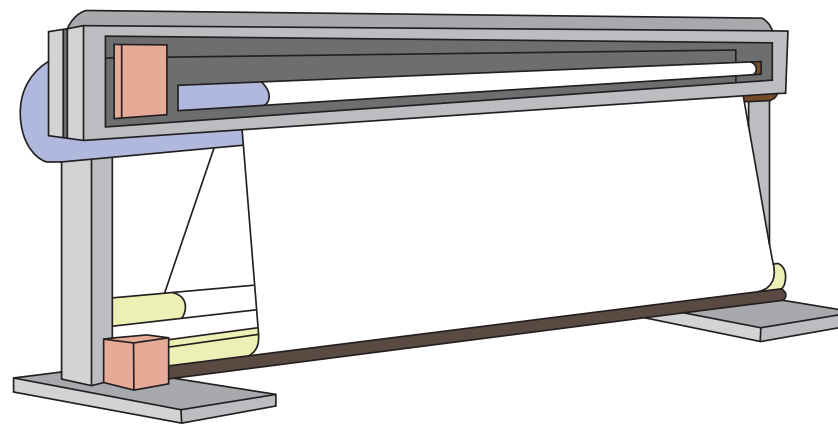


Figure 1.30 *An upright plotter*

Multi-function printers

Printers are now being built in combination with scanners, and sometimes with fax machines. Combining a printer with a scanner produces the effective functionality of a photocopying machine, as well as providing the separate functions of scanning and printing.

Advantages of multi-function devices:

- A multi-function device takes up much less space on the desktop than the individual devices it replaces.
- A multi-function device is usually less expensive to buy than all the individual devices it replaces.
- A multi-function device will be used more before it becomes obsolete.
- A multi-function device can be replaced more frequently, having provided good value, so that more modern technology is available for use.

Disadvantages of multi-function devices:

- If part of the device develops a fault, all the functions may be unavailable.
- Only one person at a time can use a multi-function device.

Speakers

Many computers have two **speakers** which can be used to listen to the sound output by a computer in mono or stereo. Sound systems with more than two speakers are increasingly common. **Headphones** are two small speakers built into a headset. Sound is needed when computers are used to play music, to make telephone calls using VoIP, to listen to voicemail, to play video and DVDs for entertainment or education, and to listen to online TV and radio.

Speakers are also needed for **speech synthesis,** where a computer reproduces human speech. The voice need not be a recording and could be computer-generated. For instance, you can have a text-reading program that takes a word-processed document in electronic form and reads it aloud.

Advantages of speakers:

- They allow computer systems to be used for a wide range of multimedia applications.
- Interaction with a computer using voice recognition and speech synthesis is more natural and intuitive than programming.

Disadvantages of speakers:

- Applications that use speakers can be difficult to operate for people who have impaired hearing.
- Voice recognition systems can be difficult to set up and use.

Sound cards

A **sound card** controls the input and output of audio. Audio input through a microphone and output through speakers are usually analogue and the sound card will handle conversion to and from the digital signals which can be processed by a computer. A sound card will also handle digital audio input from, for example, DVD and the Internet.

The uses of sound cards include providing the sound for multimedia applications such as music, video or audio editing, preparing and giving presentations and playing games.

Sound cards may be:

- Built into the motherboard in a PC and integrated with it.
- Specialised sound cards that plug into the motherboard.
- External devices that plug into the USB or firewire port on a PC. These are often used with laptops which often have a limited integrated sound card.

Sound cards may have features such as:

- **Polyphony**, which is the ability to play more than one sound or voice with each sound being played independently at the same time.

- Output through one or more sound **channels**. For example, mono, stereo (two channels), quadraphonic (four channels) or more. Some sound cards now support up to eight audio channels.
- Recording (input) and playing (output) of different sounds at the same time.
- Surround sound or 3D audio that gives the impression of sound being output from different positions.
- The ability to restore the detail and clarity of compressed files, such as mp3 music files.
- On board memory to help provide faster sound processing.
- USB, firewire, optical and other ports to enable DVD recorders and other devices to be connected.
- **Musical Instrument Digital Interface (MIDI)** support to connect synthesizers or other electronic instruments to the computer.

Control devices

In control applications, computers make events happen using **control devices** or **actuators.** Examples of actuators are valves, heaters, coolers and motors. These can be powered by a range of different sources of energy, including electricity and compressed air. Actuators also include devices such as buzzers and alarms, which can warn us about various events: a burglar has entered through the window, the automatic cooker has finished cooking our pizza, or the microwave oven has defrosted the frozen chicken.

Advantages of control devices:

- Actuators enable a computer to perform physical tasks in the real world. For example, computers can control a central heating system or a mechanical digger.

Disadvantages of control devices:

- Actuators perform physical operations when instructed by a computer. This can be dangerous for people if their presence is not known to the computer.

Exercise 1.2

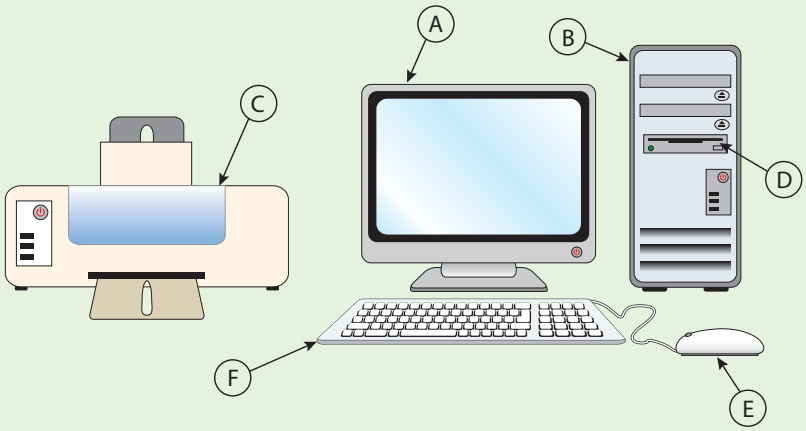


Figure 1.31 *Parts of a computer system*

1. a) Look at Figure 1.31 and complete the table below using words from this list.

Monitor	Word processing sotware	Keyboard
System unit	Network cable	Mouse
Spreadsheet	Printer	Operating system
Email	Scanner	DVD drive

Label	Name
A	
B	
C	
D	
E	
F	

b) Write down the labels of the parts of the computer used for input.

c) Write down the labels of the parts of the computer used for output.

d) Other than the monitor, which parts of a computer would you use:

- ✓ to type a letter
- ✓ to draw a picture on the screen
- ✓ to print a report.

2. Name three input devices that can be used to point on the monitor screen, and explain why different pointing devices are needed.

3. Describe three ways to input data and describe what they are used for.

4. Discuss the advantages and disadvantages of an inkjet printer and a laser printer to a home user.

5. Explain why a computer needs speakers.
6. Name two output devices and describe what they are used for. How would they be connected to the computer system shown in Figure 1.31?
7. Describe one type of pre-printed stationery and one use for it.
8. Is a games console an input device or an output device? Give reasons for your answer.
9. A pelican crossing has input, processing and output. State whether each of the following is used for input, processing or output: button, bleepers and red light.

Pelican crossing	
Device	**Input, processing or output**
Button	
Bleepers	
Red light	

10. Describe the advantages and disadvantages of multi-function printers that combine a printer, scanner and fax compared with using three single-function devices.

End of Chapter 1 Checklist

1. Computers are now commonplace, and affect our lives in many ways every day.
2. An ICT system carries out a task in three main stages, which may overlap: **input**, **processing** and **output**.
3. A computer is an electronic machine that can follow a set of instructions to input, process, store and output data.
4. **Hardware** is the equipment that makes up the complete ICT system: the components such as the keyboard, the monitor, the system unit and everything inside it, a printer, a scanner and speakers.
5. Input devices include the **keyboard**, pointing devices (such as a **mouse**, **joystick**, **game pad** or **trackpad**), **scanners**, **magnetic stripe readers**, **OMR readers** and **light sensors**.
6. Output devices include **monitors**, **printers** and **speakers**.
7. Printers can be divided into impact and non-impact printers. An **impact printer** strikes an inked ribbon which makes marks on the paper. A **non-impact printer** uses a non-striking method to form the image on the paper. This type includes laser printers and inkjet printers.
8. Printers use different kinds of output medium, such as single A4 sheets of paper, continuous paper and specialist paper for printing photographs or other digitised images.
9. **Multi-function printers** combine a printer, scanner and fax machine. Combining a printer with a scanner produces the effective functionality of a photocopying machine.