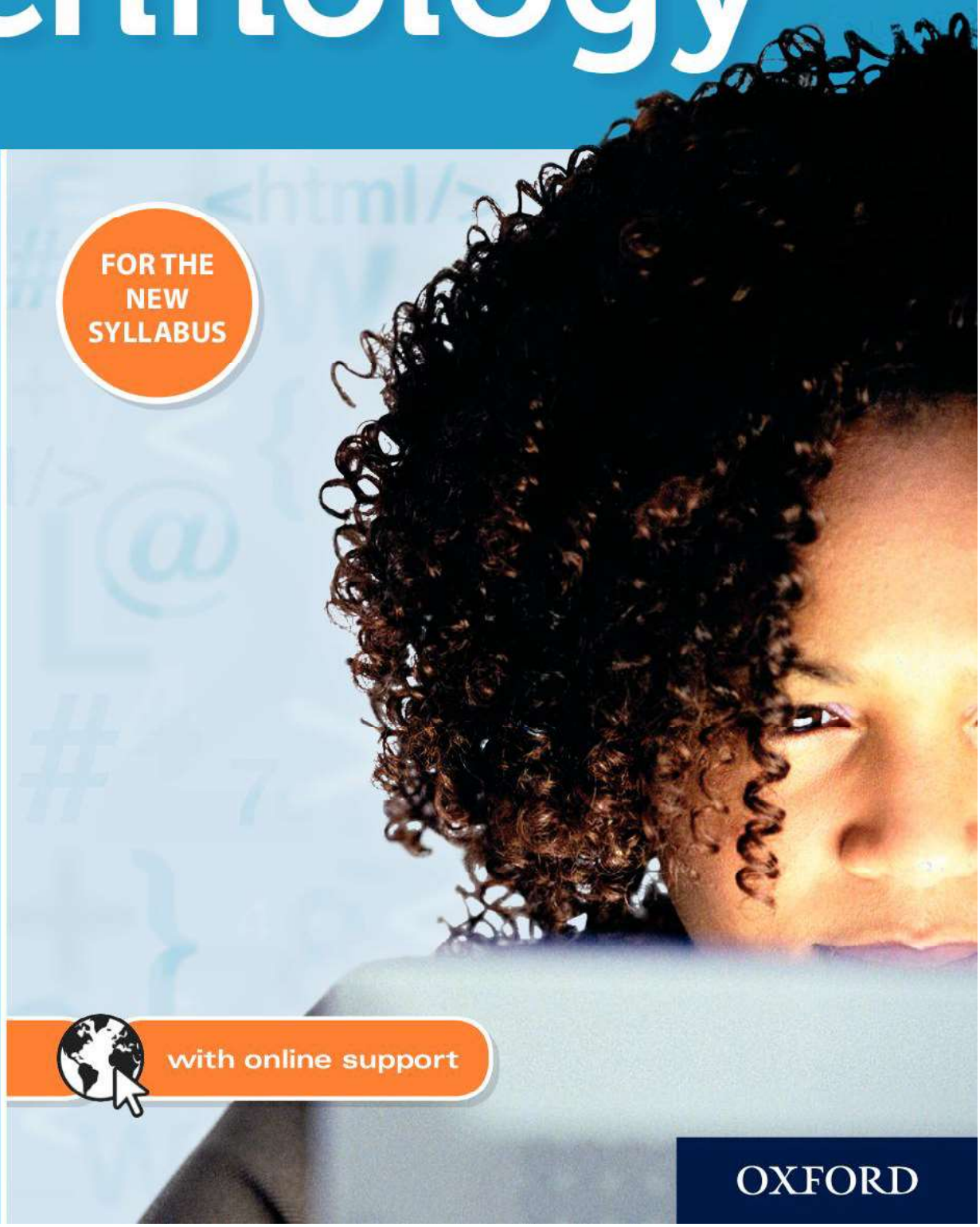
Oxford excellence for the Caribbean

Information Technology

THIRD EDITION

CSEC®

FOR THE NEW SYLLABUS



with online support

Glenda Gay
Ronald Blades

OXFORD

Oxford excellence for the Caribbean

Information Technology

THIRD EDITION

CSEC®

Glenda Gay
Ronald Blades

OXFORD
UNIVERSITY PRESS

OXFORD
UNIVERSITY PRESS

Great Clarendon Street, Oxford, OX2 6DP, United Kingdom

Oxford University Press is a department of the University of Oxford.

It furthers the University's objective of excellence in research, scholarship, and education by publishing worldwide. Oxford is a registered trade mark of Oxford University Press in the UK and in certain other countries

First published in 2019

British Library Cataloguing in Publication Data

Data available

978-0-19-843716-1

1 3 5 7 9 10 8 6 4 2

Paper used in the production of this book is a natural, recyclable product made from wood grown in sustainable forests.

The manufacturing process conforms to the environmental regulations of the country of origin.

Printed in India by Manipal Technologies Ltd

Acknowledgements

The publisher and authors would like to thank the following for permission to use photographs and other copyright material:

Cover: Jim Arbogast/Photodisc/Getty Images;

p9: Glenda Gay; **p15:** Auxin/Shutterstock; **p23 (TL):** Immfocus studio/Shutterstock; **p32:** RoSonic/Shutterstock; **p10 (L):** Federico Rostagno/Shutterstock; **p10 (R):** Gvictoria/Shutterstock; **p11 (L):** Sonate/Shutterstock; **p11 (R):** Hsvrs/iStockphoto; **p17 (TL):** Asharkyu/Shutterstock; **p17 (MR):** Wavebreak Media/Alamy Stock Photo; **p17 (BR):** Caiaimage/Sam Edwards/Getty Images; **p19:** Martyn F Chillmaid; **p20:** Tkachuk/Shutterstock; **p21:** Trial/Shutterstock; **p22:** OUP; **p23 (BL):** IB Photography/Shutterstock; **p23 (R):** Bplanet/Shutterstock; **p26:** Rose Carson/Shutterstock; **p29:** pixinoo/Shutterstock; **p31 (BL):** v74/Shutterstock; **p34:** Andrey_Popov/Shutterstock; **p35:** DR-images/Shutterstock; **p39 (a):** Topimages/Shutterstock; **p39 (b):** Coprid/Shutterstock; **p39 (c):** thanongsuk harakunno/Shutterstock; **p39 (d):** jultud/Shutterstock; **p47 (L):** Sean Locke Photography/Shutterstock; **p47 (R):** MARTYN F. CHILLMAID/SCIENCE PHOTO LIBRARY; **p53:** Patti McConville / Alamy Stock Photo; **p55:** Juta/Shutterstock; **p56:** Alice-photo/Shutterstock; **p68:** Anton Foltin/Shutterstock; **p74:** silverkblackstock/Shutterstock; **p75 (T):** Valentin Valkov/Shutterstock; **p72 (2G):** Oqbas/Shutterstock; **p72 (3G):** Lenscap Photography/Shutterstock; **p72 (LTE):** Leszek Kobusinski/Shutterstock; **p75 (BL):** Rvlsoft/Shutterstock; **p75 (BR):** Rose Carson/Shutterstock; **p79:** Winai Tepsuttinun/Shutterstock; **p80:** Rawpixel.com/Shutterstock; **p85:** Nor Gal/Shutterstock; **p86:** REDPIXEL.PL/Shutterstock; **p91 (T):** Whitemomo/Shutterstock; **p91 (B):** SpeedKingz/Shutterstock; **p94 (TL):** Ronstik/Shutterstock; **p94 (TR):** Sirtravelalot/Shutterstock; **p96:** ALPA PROD/Shutterstock; **p97:** Andrey_Popov/Shutterstock; **p98:** Steve Chenn/Getty Images; **p100 (TL):** KikoStock/Shutterstock; **p100 (TC):** Mimagephotography/Shutterstock; **p100 (TR):** LightField Studios/Shutterstock; **p130:** Angellodeco/Shutterstock; **p147:** Aqabiz/iStock/Getty Images.

Artwork by OUP and Thomson Digital.

Preface

In this, the third edition of Oxford Information Technology for CSEC, we are providing new material that incorporates the recent changes to the Caribbean Examination Council's Information Technology (IT) syllabus. Almost 20 years into the new millennium, it is clear how information and communications technology is an invaluable resource in every sector, including education. This textbook aims to support the interest of the Caribbean student in the use of ICT tools for productivity and problem solving. It will provide you with the support material to fully explore every section of the IT syllabus. The resources in the textbook are presented through topic discussion, worked examples and a wide range of questions. Our years of interacting with students and educators from across the region have helped us to design this resource material to be used effectively.

For the most part, the chapters have been aligned with the sections of the syllabus. However, we have maintained the separation of Chapter 1 (Fundamentals of hardware and software) and Chapter 2 (Information processing) to provide detailed treatment of these sections for the coverage of syllabus Section 1 (Computer Fundamentals and Information Processing).

Among the practical chapters is the updated Chapter 6 (Web page design), which provides material needed for the theory examination and the practical requirement for the School Based Assessment (SBA). Chapter 9 (Problem solving) and Chapter 10 (Program implementation) have continued to prove challenging to Caribbean candidates. Teachers can now choose which programming language their students can use, while the textbook continues to offer support in these areas of programming, with several examples and questions.

Chapter 11 introduces Pascal programming fundamentals for those comfortable with this method of writing code, while Chapter 12 introduces Visual Basic for Applications, which can support the Microsoft applications used for word processing, spreadsheets and database management.

Each chapter is subdivided into sections based on the specific objectives from the syllabus. End-of-section questions provide reinforcement on the topics covered in a section. There are more questions at the end of each chapter which take a different approach; testing learning from other chapters. The intention is to familiarise students and teachers with this approach to questioning for the new exam format, using real-world examples. The appendix includes useful hints for guidance through the SBA, whether candidates are working as individuals or as a part of a group.

It is our intention through this text to once again provide a supportive resource for each candidate to achieve success in their IT examination, as each candidate prepares to embrace new technologies which will inevitably arrive in years to come.

CSEC IT Structure	Syllabus Section
Paper 1: 1 ¼ hours: 60 compulsory multiple-choice questions. *30% of final mark*	*35 questions – Theory* *15 questions – Productivity tools* *10 questions – Problem solving*
Paper 2: 2 hours: Four compulsory questions from all areas of the syllabus. *45% of final mark*	*35 marks – Theory* *30 marks – Productivity tools* *25 marks – Problem solving and programming*
Paper 3-1: School Based Assessment (SBA). One practical assignment comprising word processing, web page design, spreadsheets, database management, problem solving and programming. *25% of final mark*	*Productivity tools* *Problem solving and programming*
Paper 3-2: Alternative to the School Based Assessment for private candidates. A theory and practical paper testing the skills required for the School Based Assessment. *25% of final mark*	*Productivity tools* *Problem solving and programming*

Contents

What's on the website?

- Answers to all End of Chapter Exam-style Questions in this book.
- Additional Exam-style Questions for each chapter with sample answers and examiner analysis.
- Interactive Paper 1 multiple choice test, Practice Paper 2, worked SBA Paper 3 with advice on online marking, SBA alternative Paper 3
- Answers to all Workbook questions
- Comprehensive glossary of terms used in this book.

www.oxfordsecondary.com/9780198437161

1.1 Basic computer components

Computers are an important aspect of information technology. A computer is an electronic device, operating under the control of instructions stored in its memory. Whether on its own or connected via a **network** (such as the Internet), it can:

- accept data (input)
- manipulate data (processing)
- produce results (output) from the processing
- store the data and results for future use (storage).

These four basic tasks of any computer represent the IPOS cycle (Fig 1.1).

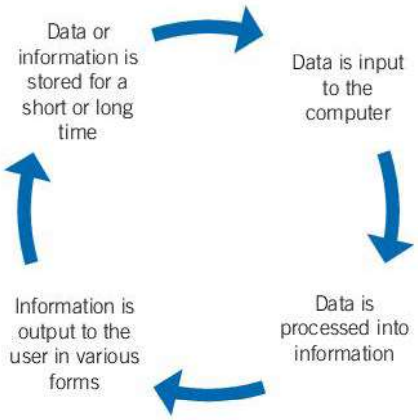


Fig 1.1 Four basic tasks of the IPOS Cycle

Components of a computer

The term 'computer' generally refers to desktop machines and laptops but it can also include handheld games consoles as well as portable devices, such as smartphones and tablets.

The basic components of a computer are categorised as either **hardware** or **software**.

Hardware

This is the name given to the physical parts of a computer (Fig 1.2). There are five general categories:

1 **The central processing unit (CPU)** is the brain of a computer and controls how the rest of the computer works. It includes the control unit (CU) and the arithmetic and logic unit (ALU). The CU carries out instructions in the software and directs the flow of data through the computer. The ALU performs the calculations and logic operations.
2 **Input devices** get data into a computer. A mouse, a keyboard and a scanner are all input devices.
3 **Output devices** get processed information out of a computer, for example to a printer, computer screen or even to speakers.
4 **Memory** enables a computer to temporarily store instructions and data.
5 **Storage media** include hard disks, CD-ROMs, DVDs, and USB flash memory sticks, while the **storage devices** include hard disk **drives**, CD-ROM drives and DVD drives. Most of these devices can read data whilst others, such as USB flash memory sticks, allow data to be saved as well as read.

Peripheral devices are located outside the CPU but are controlled by it. That is, they can be added to a computer system. Input, output and storage devices may be peripheral devices.

Software

This is the name given to computer programs that tell the hardware how to work. Without software the computer hardware would do absolutely nothing, as

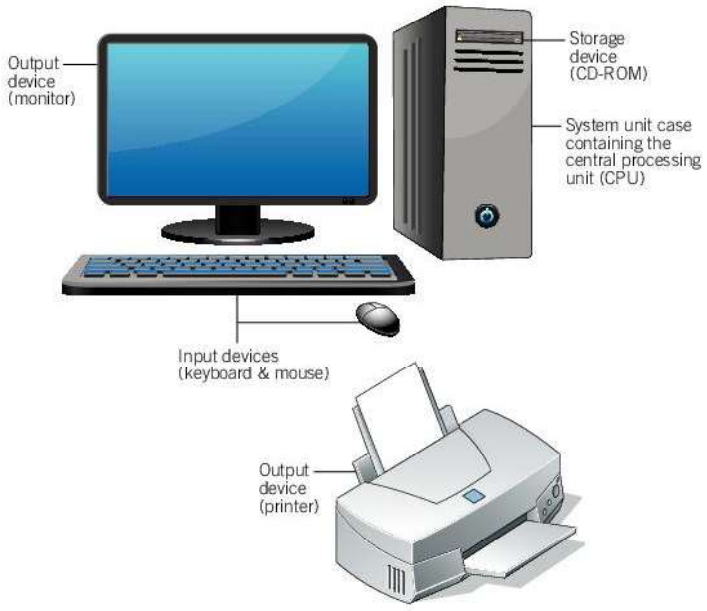


Fig 1.2 The basic categories of computer hardware

there would be no instructions. Software includes the following types of program.

Computer programs

These are instructions (programs) produced by programmers to create system and application software.

System software

This software is usually called an **operating system** since it controls the hardware and how all other software works. The most commonly used operating system is Windows, written by the Microsoft Corporation.

System software also includes **utility software**. This software aims to protect and maintain the system software, just as a mechanic maintains the smooth working of a car's engine when it is serviced. Examples of the tasks undertaken by utility software include: protecting software against damage caused by computer viruses, making copies of **files** ('backing up'), and recovering files after software has stopped working ('crashed').

Application software

Application software is software that instructs a computer to carry out a specific task. Word processors, spreadsheets and databases are all application software.

Information and communication technology

Now that we have discussed how data can be input, processed, stored and output to produce information, we introduce two important terms:

Information Technology (IT) is the term used to describe the equipment (hardware and computer programs or software) that allows us to access, retrieve convert, store, organise, manipulate and present data and information. IT may also refer to the use of such equipment and programs to produce the information.

Communications Technology (CT) is the term used to describe telecommunications equipment through which data and information can be accessed. Examples of CT equipment are phones, faxes, scanners, modems and computers.

Questions

1. List the four basic tasks of any computer.
2. State the name of the cycle that represents the four basic tasks listed in question 1.
3. What is the general name given to the physical parts of a computer?
4. Explain what each of the following terms represent:
   - **a** CPU
   - **b** CU
   - **c** ALU.
5. Explain the difference between an input device and an output device.
6. What is another name for system software?
7. What is the general name given to each of the following descriptions:
   - **a** computer programs that tell the hardware how to work
   - **b** telecommunications equipment through which data and information can be accessed.

Data must be provided in a suitable form for any computer system to be able to process it. So, it is always important to think of the different ways of entering data into a computer, particularly since all data needs to be entered as accurately as possible. 'Input' means to enter data, programs, commands and user responses into the memory of a computer. Therefore, an input device is any device that transfers data from the outside world into a computer.

Although most input devices can be connected to desktop computers, you probably come across others and do not realise it! For example, every time you use a remote control for a television or a games console, data is entered using a special keyboard.

There are many different input devices and media, each one being suitable for a different purpose. The two general categories of input devices are manual input devices and direct data entry (DDE) devices.

Manual input devices

With a manual input device, you must enter or transfer data into the computer yourself. Some examples of these devices are explained next.

Keyboard and keypad

A keyboard has a set of alphabet keys, a set of digit keys and various function keys, so the data entered by the person operating the keyboard is in the form of individual letters, words or numbers. When you press a key on the keyboard, a number (code) is sent to the computer to tell it which key you have pressed. The keyboard has the disadvantage that it is easy to make mistakes by pressing the wrong keys.

Other special keyboards designed to do just one job can be found on children's toys, games consoles and programmable robots used in primary schools. The 'keyboard' could be a picture of a farmyard. Pressing on an animal would cause the computer to make the noise of the animal. A keypad is a block of buttons that contain digits, symbols or alphabetical letters. Keypads can also be found on many keyboards.

Mouse

You can also move data directly into a computer using a range of input devices. The most common is a pointing input device called a **mouse**. As you move it along a flat surface, the pointer on the screen moves in the same direction. If the mouse has two buttons, the left one is

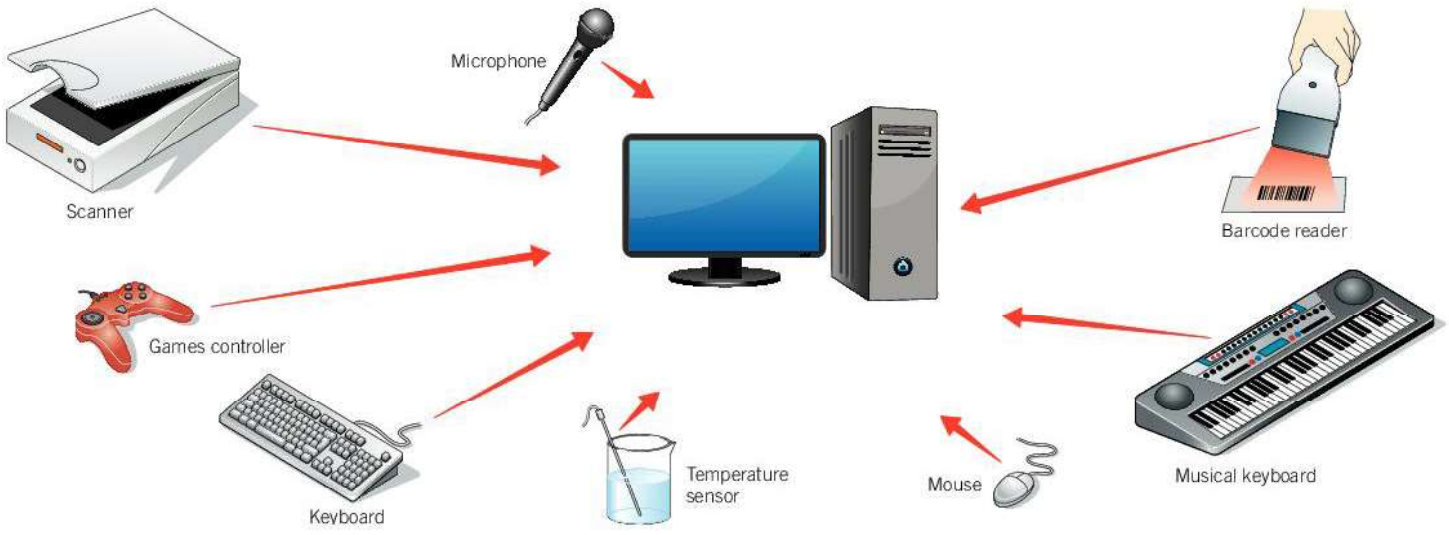


Fig 1.3 Input devices: getting data into the computer

used to 'select' items such as text and the right one is used to 'access' menus. The mechanical mouse has a rubber ball underneath to help it roll smoothly in all directions. The optical mouse uses light to track its movements. The cordless mouse is not physically connected to the computer, but instead uses infrared or radio waves to communicate with the computer.

Document scanner

A scanner allows you to transfer pictures, graphics and text to your computer. It scans the image from the top to the bottom one line at a time and transfers it to the computer. You can then take that copy and use it in a program, send it as an email attachment or print it.

Microphone

Data can be entered into a computer through a microphone. The computer responds to this data by carrying out instructions such as printing a document or turning the spoken words into text in a word processor. These are called voice-activated or voice-response systems.

Digitiser

Digitisers convert drawings and images into data. For example, a digital camera captures still and video images and stores them in electronic format for printing or editing later. A **webcam** is a type of digital camera connected to a computer, typically for transmission of still or moving images over the Internet or other network. Some computer users use webcams to see each other while chatting online, or for streaming live video. Other uses of webcams include monitoring traffic on highways and other surveillance.

Another type of digitiser is found in a graphics tablet, that can capture drawings and handwritten signatures. It is a flat, touch-sensitive drawing surface that uses a special pen called a stylus. Images from the graphics tablet are also shown on a monitor. When a transparent digitiser element of this kind overlays a screen it allows direct interaction with the screen.

Touch-sensitive devices

A **touchscreen** is another way to input data (Fig 1.4). It is a screen that is sensitive to touch, so you do not need to use a keyboard or mouse. Banks, malls and restaurants use touchscreen kiosks or touch terminals to provide information to the public. Touchscreens are also commonplace on handheld devices such as mobile phones and iPads.

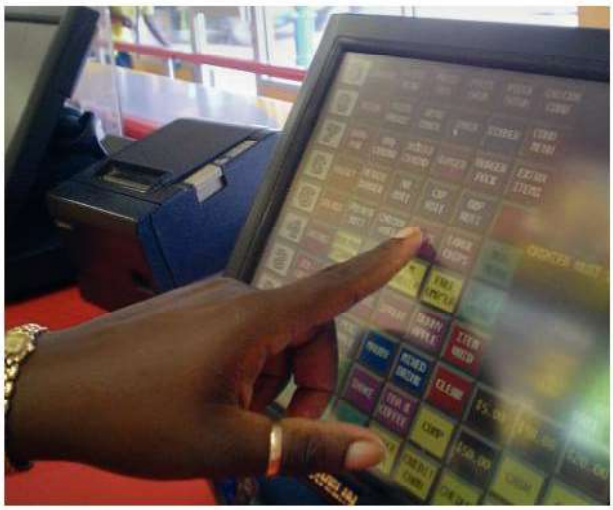


Fig 1.4 Touchscreens, such as the one shown here, are popular in public places as there is no need to use a mouse or a keyboard

A **touchpad** is a flat rectangular surface which also senses the movement of one or more fingers on its surface. These devices are usually found on laptop and notebook computers and function as a mouse does to move a pointer.

Pointing devices

A light pen is similar to a mouse, but is rarely used since touch-sensitive devices have replaced it. A variation of the light pen is a **stylus,** which is a small pen-like device with a plastic or felt tip that uses pressure instead of ink. A stylus is used to draw on graphics tablets or type on touchscreens to avoid using fingers on the screen.

Remote-control devices

These devices send data through signals each time a button is pressed on the device. The signal is received by another device that processes the instruction.

Remote control devices are used to change television and radio station channels, open electronic gates and manage slide presentations.

Biometric systems

These systems use some part of a person's body to uniquely identify them. There are two types of biometric systems that can identify someone. One is related to some aspect of the body using, for example, fingerprints, face or iris recognition (Fig 1.5), as well as the size and shape of the hand. These characteristics are consistent and rarely change. In contrast, a person's signature and tone or pitch of voice are related to the person's behaviour. For example, if you are nervous, then your signature or voice may change.

Fig 1.5 An electronic signature can uniquely identify a person

Direct data entry (DDE) devices

A direct data entry device can transfer information automatically from a document – such as a form or barcode – into the computer. You do not need to enter the information manually.

These devices are used when large volumes of data must be entered into the computer quickly. Previously, it took a relatively long time for a supermarket cashier to add up the cost of your grocery items using a cash register. Nowadays barcode systems make this task much quicker. There are various DDE devices available. As with manual input devices, different DDEs are suitable for different purposes. Some examples are explained below.

Barcode reader

A **barcode** is a group of vertical bars of different widths. Barcodes are found on almost all the products we buy. Groups of bars are used to represent different numbers which are often printed above or below the barcode. The numbers normally included in a barcode for a product represent its country of origin, manufacturer and item code. The price is not included in the barcode.

Barcodes are read into the computer using a wand or a fixed scanner. There are also camera-based barcode readers. Barcodes are not easily damaged and can normally still be read if they are creased or slightly wrinkled. They can be printed using a normal printer and ink, and so are cheap to produce.

Fig 1.6 A barcode is found on many products

A barcode is used to enter data directly into a system. The data collected from barcodes is used to produce customers' bills and to tell a store what has been sold. Goods can then automatically be re-ordered. These systems, known as electronic point of sale (EPOS) systems, enable large amounts of data to be input very quickly and accurately.

Smart card

Millions of people now pay for their shopping using credit, debit or store cards. The magnetic strip on the back of such a card is 'read' as it is being 'swiped' by a salesperson. This swiping transfers account information and the cost of the goods, into the banking system. This type of system is referred to as electronic funds transfer at point of sale (EFTPOS).

To gather information from the card, it is swiped through a machine which quickly and accurately reads the magnetic pattern. If the magnetic area on the card is scratched or gets soiled, then the information stored on the card can be corrupted. Such a card is used by businesses to reward loyal customers.

A card that does not rely on a magnetic strip is also now appearing. It has a built-in electronic circuit and a set of gold-coloured contacts. Putting the card in a special reader inputs the information held in the circuit. Such cards are called **smart cards**. They are more sophisticated than magnetic swipe cards.

Although smart cards are often called input devices, they are actually simple storage devices. When the card is put into a machine, data can be read from the card or written onto it. A smart card can store much more data than a magnetic strip.

Smart cards, unlike magnetic-strip-based cards, can carry all necessary functions and information on the card. Therefore, they do not require access to remote databases at the time of the transaction.

Fig 1.7 Smart cards have a built-in electronic circuit and a set of gold-coloured contacts

Optical mark recognition (OMR)

There are various ways of inputting letters, words and numbers automatically into a system. For example, when you buy a lottery ticket, you fill in the slip by putting lines through sets of numbers on a grid (Fig 1.8). This slip is then fed into a machine that reads the marks.

The computer system turns each set of marks into numbers and enters them into the draw. This method of entering data is called optical mark recognition (OMR) and relies on precisely positioned marks on a form being read by a special scanner. This data is then processed by the system.

If you have multiple-choice tests as part of your examinations, you will probably have to answer them on an OMR form. These answer sheets will be passed through a scanning system to mark your answers. This way of inputting data is fast and accurate. OMR is therefore used to read the data that has been added and then all the data can be transmitted to the computer automatically. The final information can then be produced without any need for human intervention.

Fig 1.8 Data can be entered into a computer in different ways. Lottery slips are an example of optical mark recognition (OMR)

Optical character recognition (OCR)

Another way of entering handwritten or printed text into a computer system is to scan the text using an optical character recognition (OCR) program. The scanned text is turned into a file that can be edited, reformatted and reprinted by a word processor. The accuracy of OCR is variable and can be poor, particularly if the original pages to be scanned are of poor quality.

OMR and OCR are often used together in a **turnaround document**. A turnaround document is one which has some unique information printed on it by a computer with other information which needs to be added to it by a human. It is then fed back

into a computer a second time to transfer the added information to the computer.

Magnetic ink character recognition (MICR)

Banks process millions of cheques each day. Every cheque has the cheque number, account number and branch code printed on it using magnetic ink (Fig 1.9). A magnetic ink character reader (MICR) reads this information along with the amount of the cheque into the banks' information systems, so that the cheques can be cashed.

MICR readers can only read one special font, which includes only numbers and a few punctuation marks. They can read characters very quickly and with 100% accuracy. Information printed in magnetic ink is also very secure since it is not possible to change the information by writing over it with a pen. The magnetically printed numbers are also not damaged by folding the cheque (as often happens). Both the reader used by MICR and the magnetic ink are expensive.

Fig 1.9 Magnetic ink symbols printed on the cheque

Sensors

The music industry uses musical instrument digital interface (MIDI) systems. Here, data is input through a piano-type keyboard or by sensors that respond to being struck. A wide variety of sounds can then be generated from one keyboard or set of pads.

Sensors are available which respond to a wide variety of signals. They can be used to collect data automatically into a system. For example, the Meteorological Office has weather forecasting systems that collect data from sensors around the world and in space. These sensors collect data on temperature, wind speed and direction, hours of sunshine and humidity. This data is processed to help meteorologists to predict the weather. As we know, the forecast is not always accurate, but large amounts of precise data are collected.

Information systems use sensors to input data so that the systems can decide what to do. When you approach an automatic door, a sensor tells the system you are there and makes the door open. Burglar alarms use sensors to inform the system when doors or windows have been opened or broken. This causes an alarm to sound or the police to be alerted automatically.

Table 1.1 *Input devices: advantages and disadvantages*

Input device	Application	Advantages	Disadvantages
Manual input devices			
Keyboard	(touch)		
Converts key strokes into binary digits. Carries out the commands of function keys such as 'End' and 'PgUp'	◆ Used to manually input text into the computer ◆ Used to type commands and instructions to computer systems	◆ Most common means of entering text ◆ Relatively inexpensive	◆ Continued use can cause repetitive strain injury ◆ Errors in transcription are common ◆ Speed of input depends on the user's experience
Mouse	(touch)		
Sends positional information to the computer, by clicking or scrolling of mouse buttons	◆ Acts as an interface between the user and the computer ◆ Used to issue commands directly to the computer	◆ Commands can be given directly to the computer (e.g. page down) ◆ Can activate commands by selecting icons directly	◆ Hand-to-eye coordination can be a problem ◆ Shifting between keyboard and mouse can be confusing

(continued)

Table 1.1 *Input devices: advantages and disadvantages (continued)*

Input device	Application	Advantages	Disadvantages
Joystick	(touch)		
Similar to a vehicle gear shift, but with buttons for different commands	◆ Generally used in game playing	◆ Ideal for games such as car racing and combat	◆ User has to become skilled at the sensitive movement of the joystick
Touchscreen	(touch)		
Allows the user to press parts of the screen to activate different functions	◆ Are located in public places such as restaurants and shopping malls where transactions can be made and information given	◆ Easy way to input options and choices ◆ Can be used by children and the physically challenged who are unable to use other input devices	◆ A limited number of values can be displayed on one screen at a time ◆ More expensive than a standard monitor
Scanner	(light)		
Used to capture an image in hard-copy and create a digital copy of the image	◆ Conversion of hard-copy images to soft-copy can be used to import and export documents and images across different applications	◆ Relatively cheap and easy to install ◆ Depending on use, flatbed or handheld scanners can be chosen	◆ The quality of the image depends on the quality of the hard-copy, scanner and scanner software
Graphics tablet	(machine-readable)		
Used to input lines and shapes through pressure and movement of a stylus on the tablet	◆ Captures input like hand-created drawings and signatures ◆ Resulting images can be displayed on a monitor	◆ Allows artists to sketch detailed digital drawings more easily than by using a mouse ◆ Can be used to capture signatures as a biometric	◆ Requires some practice ◆ More expensive than a mouse
Voice-recognition system	(sound)		
Data that is input in audio form. The input is analysed for commands which are then processed	◆ Allows users to dictate text or give commands directly to the computer	◆ The user can speak normally for dictation	◆ Must be trained to recognise voice patterns ◆ Software cannot interpret all English meanings
Direct data entry devices			
Barcode reader	(light *or* laser)		
Barcodes are groups of bars of different widths and are found on almost every product you buy. The codes are read into the computer using a wand or a fixed scanner	◆ Different groups of bars represent different numbers. These numbers represent the product's country of origin, manufacture and item code	◆ Data can be input much faster than it takes to be keyed in ◆ Not easily damaged ◆ Can be printed using a normal printer and ink and so cheap to produce	◆ The order of the data stored cannot be changed easily
Electronic Point of Sale (EPOS)	(laser)		
Data collected from the barcodes is used to produce information and update the database	◆ Used to record transactions and track inventory	◆ Prices of products can be easily updated ◆ Items can be easily scanned	◆ Depends on a reliable Internet connectivity
Optical Character Recognition (OCR)	(light)		
Text and graphics are scanned as soft copy	◆ Can be used to input large blocks of typed text	◆ Can speed up the typing process	◆ Accuracy of the text can be poor

(*continued*)

Table 1.1 *Input devices: advantages and disadvantages (continued)*

Input device	Application	Advantages	Disadvantages
Magnetic ink character recognition (MICR)	(magnetic)		
Data is printed as special characters using magnetic ink. This data is translated into text or values	◆ Used by banks to process cheques, by printing additional bank details (branch, account number)	◆ Is quick and highly efficient ◆ Both humans and machines can interpret the data ◆ Not easy to forge	◆ Has limited applications ◆ As the use of cheques becomes obsolete, its use is in decline
Optical Mark Recognition (OMR)	(light)		
Relies on the presence or absence of precisely positioned marks on a form being read by a special scanner. This data is then processed by the system	◆ Popular with lotteries and multiple-choice question sheets issued by examination boards	◆ Data input is very fast and accurate	◆ There is a limit to the number of responses ◆ Incorrect or inconsistent marking on the sheet may result in the data being rejected
Smart card	(magnetic)		
A magnetic strip containing encoded data about the owner of the card is placed on a plastic card	◆ Used to store data on debit, credit, loyalty, phone and other cards	◆ Can be used to store financial transactions ◆ Transactions are fast ◆ Saves the user from carrying cash	◆ Can be damaged ◆ May soon be replaced by embedded microchips
Musical Instrument Digital Interface (MIDI)	(sound)		
Can be used by musicians to create, manipulate and store sounds in a computer	◆ Used to store music from instruments or voice for editing	◆ Once stored, the data can be arranged in many ways	◆ Special software must be used to translate the music into a musical score

Questions

1 What is the general name for each of the following devices:
   - **a** transfers data from the outside world into a computer
   - **b** a flat rectangular surface which also senses movement of a finger on its surface
   - **c** a system that uses some part of a person's body to uniquely identify them
   - **d** transfers pictures, graphics and text to a computer
   - **e** transfers information automatically from a document, such as a form or barcode into the computer
   - **f** relies on precisely positioned marks on a form being read by a special scanner
   - **g** a document which has some unique information printed on it by a computer, but other information needs to be added to it by a human before it is fed back into the computer.

2 What is the general name for each of the following processes:
   - **a** data is entered or transferred into the computer by hand
   - **b** to send data at a distance through signals each time a button is pressed on the device.

To get processed information out of a computer, you may need an output device. 'Output' means to show, print or store the results of processed data. The most common types of output are:

- Soft copy: this is not permanent. It includes output from a computer monitor, audio (sound) from speakers, electrical signals and output from one computer to another.
- Hard copy: this is also called permanent output since it is printed for you to review away from the computer. Examples are printed reports and pictures.

Display devices

Computers usually display output on a screen or monitor. Some monitors are separate and need to be plugged into the computer's system unit. Others, such as laptops and mobile devices, have their screens integrated to the system unit and keyboard. Televisions can also be used as computer monitors with some additional connections. Other display devices include interactive whiteboards (also called **smartboards**) used for teaching or presentations. These large touch-sensitive plastic boards respond to input either directly by connections to a computer or through other devices such as a projector, tablet or magnetic pen.

The most common types of display device include LCD (liquid crystal display) flatscreens and LED (light-emitting diode) screens on handheld devices and laptops.

A monitor contains a matrix or array of bright dots of red, green and blue (known as RGB). These can be blended to display millions of colours. Mapping the location and colour information of each bit of data creates a computer image. This is known as a bitmap (bmp). The bitmapped image seen on a monitor is made up of thousands of pixels. **Pixel** stands for picture (pix) element. Features of a computer screen include its size and resolution.

Fig 1.10 Various types of devices with displays

Features of a computer screen

Size

This is the dimension of the screen which shows the output. Common desktop screens are from 14 inches to 19 inches measured diagonally. Larger sizes are now available.

Resolution

This determines how clear and detailed the output on the screen can be. Pictures on a screen are made up of tiny dots (one dot = 1 pixel). The more pixels per inch, the clearer and more detailed the graphic.

Colour

The number of colours displayed can vary from 16 to 256 to 64 thousand to 16.7 million. The more colours, the smoother the graphics appear, especially photos.

Cursor/pointer

The cursor is a symbol that shows where you are working on the screen. It may appear as I for text and ↖ for the mouse pointer location.

Scrolling

This allows the text or graphic to be moved or up or down or brought into view on the screen.

Printing devices

No matter how simple or complex the data-processing operation is, the final result must be made available in a user-friendly form, and usually in the form of a permanent record. **Printers** are devices which output a hard copy of your work. The choice of printer depends on the speed, quality and quantity you want, and the cost. Some printers also perform the functions of a scanner, a photocopier and fax machine. Two main categories of printer are impact and non-impact.

Impact printers

Impact printers strike through a carbon or inked ribbon, like a typewriter. They are noisy and do not usually print acceptable graphics. However, they are useful for printing multiple copies using carbon paper, and printing payroll or financial reports that require continuous sheets of paper perforated to tear into individual sheets if necessary. Impact printers are largely obsolete now. However, there are still some dot-matrix printers in existence.

Dot-matrix printer

A dot-matrix printer uses pins to print a pattern of dots on paper. The main advantage of using dot-matrix printers is for printing multiple copies using carbon paper. The main disadvantage is the relatively poor quality of printing, which can be read but cannot be used for reproduction or for business letters.

Non-impact printers

These printers do not involve actually striking the paper. Instead, ink spray or toner powder is used. The characters are then fixed onto the paper by heating, for example. Because the printing element is simple and has no moving parts, these printers are inexpensive to manufacture and print quickly and quietly.

Inkjet printers

It is now possible to buy low-priced, good quality printers that can print in both black-and-white or colour. The quality of printout can be nearly as good as that of a laser printer, but inkjet printers are slower depending on what is to be printed. Speeds of 4 to 6 pages per minute may be achieved. Their cartridges need to be replaced more frequently than the toner cartridges of laser printers. Colour inkjet printers are ideal for use at home, where small-quantity output is required for greeting cards, photographs and school work. Ordinary paper can be used.

Laser printers

Laser printers produce attractive documents at a high resolution and are much faster than inkjets. They are used in many workplaces because they are quiet, print quickly, can be stocked with a large number of sheets of paper, and produce very high quality documents. The printout from most laser printers tends to be 300 to 1200 dots printed per inch (dpi). Many lines are printed simultaneously, and speeds of 8 to 12 pages per minute can be attained.

Colour laser printers are also available. They are far more costly to buy than colour inkjet printers, but produce higher quality images and are cheaper to run.

Thermal printers

Thermal printers use heat on chemically treated paper to form characters. Many automatic banking machine (ABM) receipts, debit or credit card slips and even some ultrasound scanned images are printed using thermal printers. These printers are quiet and more recent ones print quickly. However, the paper is expensive, and the print eventually fades if exposed to light or heat.

3D printers

Three-dimensional (3D) printers are similar to inkjet printers, but instead a 3D model is created layer by layer, from the bottom upward. The model is created over many hours, as each layer is printed on top of another. However instead of using ink as with the inkjet, the 3D printer uses melted plastic that sticks each layer to the previous one.

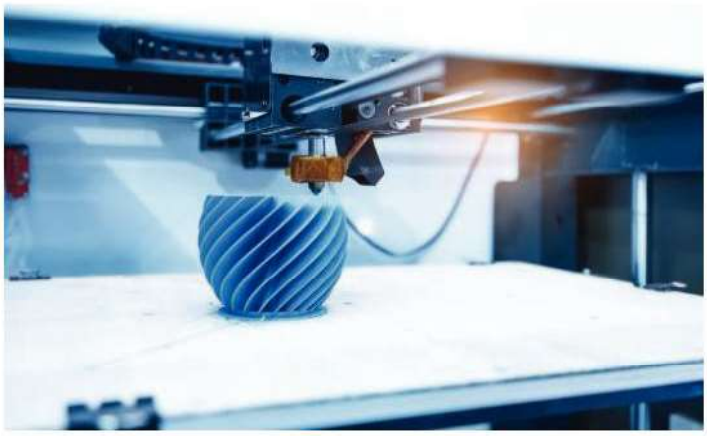


Fig 1.11 3D printers create a model layer by layer

Plotters

Car designers, architects and engineers who wish to print accurate charts, diagrams and 3D drawings, output not to a laser printer but to a plotter. A **plotter** uses coloured pens or toner to draw an image on paper (Fig 1.12). The paper is handled in different ways depending on the type of plotter. Flatbed plotters hold the paper still while the pens move. Drum plotters roll the paper over a cylinder, while pinch-roller plotters are a mixture of the two. The advantage of a drum plotter is that it can produce very large drawings.

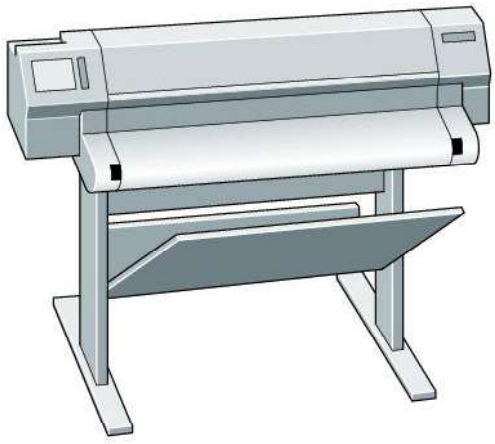


Fig 1.12 A plotter can produce very large drawings

Audio devices

Most computers sold to homes and schools include a sound card. This allows both the recording (input) and playback (output) of sound. Microphones record sound while loudspeakers can play sound to a group of people (Fig 1.13), however, headphones are more popular for users who wish to listen to the sound without disturbing anyone around them (Fig 1.14). These devices are small speakers that need to be placed close to one or both ears. Earphones or earbuds are very small headphones that fit inside the ear. A headset is a set of headphones, which has a microphone attached to allow you to speak and listen at the same time.

Fig 1.13 Microphones record sound while loudspeakers play back sound

Fig 1.14 Headphones, headsets and earbuds are more popular for users who wish to listen to the sound without disturbing anyone

Sound may also be output from a digital file or as music from a CD. Some software applications will allow word-processed text to be read back to the user. This can be very important to young children or the visually impaired.

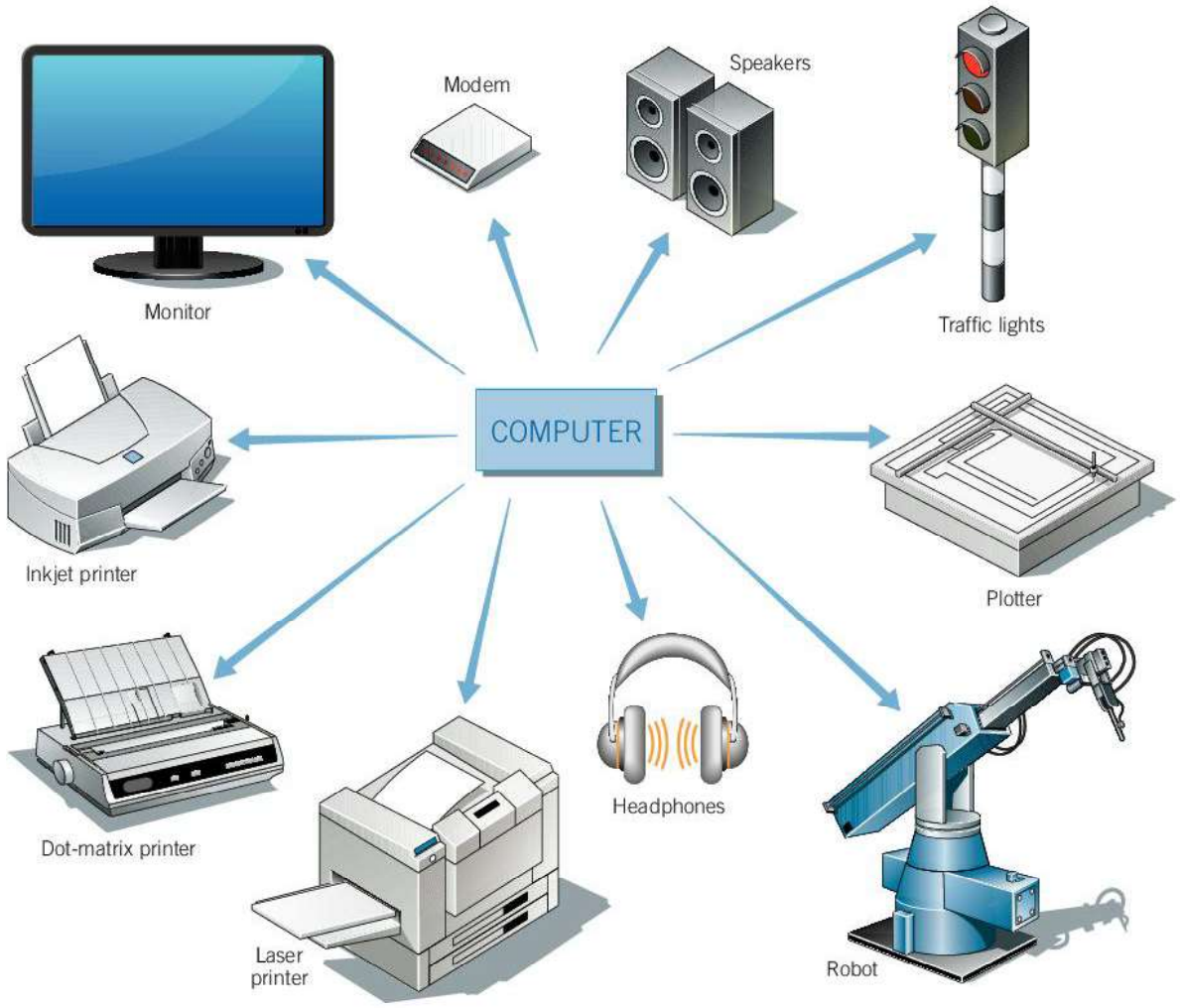


Fig 1.15 Output devices: getting data out of a computer

Questions

1 State three general types of output devices.

2 What is the general name for each of the following descriptions:
- **a** tiny dots that make up the pictures on a screen
- **b** devices which output a hard copy of your work
- **c** type of printer that is useful for printing multiple copies using carbon paper
- **d** type of printer that uses heat on chemically treated paper to form characters
- **e** a printer that uses melted plastic that sticks each printed layer to the previous one
- **f** very small audio output devices that fit inside the ears.

Some of the data you put into a computer will be needed right away for processing, while other data may not be needed for long periods of time. Therefore, different methods of storage are appropriate for different uses.

The main purpose of the CPU is to process instructions as quickly as possible. Main memory is located directly on the computer's main circuit board so that data can travel quickly to and from the CPU to be processed.

Main memory is located directly on the computer's main circuit board so that data can travel quickly to and from the CPU to be processed. Data stored at a specific memory location (called an address), can have its address contents accessed to be read from, written to or processed. The largest amount of data which can be moved together to be processed is called a **word**.

There are different types of computer memory. Let us look at some examples of computer memory and their features.

Types of memory

Random-access memory (RAM)

Inside a computer you will find one or more memory chips called **RAM (random-access memory)**. These hold the temporary operating instructions for the computer, its programs and the data. This is the place where the CPU receives the instructions and data it needs to do its job.

The advantage of RAM is that the computer can access data held in RAM almost immediately. The major disadvantage is that RAM is volatile – data held in RAM is lost when a computer is turned off or malfunctions. This is why we need to use other media to store data.

As computer programs and operating systems have become more complex, the size of RAM has increased. Most computers come with 2 to 8 GB of RAM as standard.

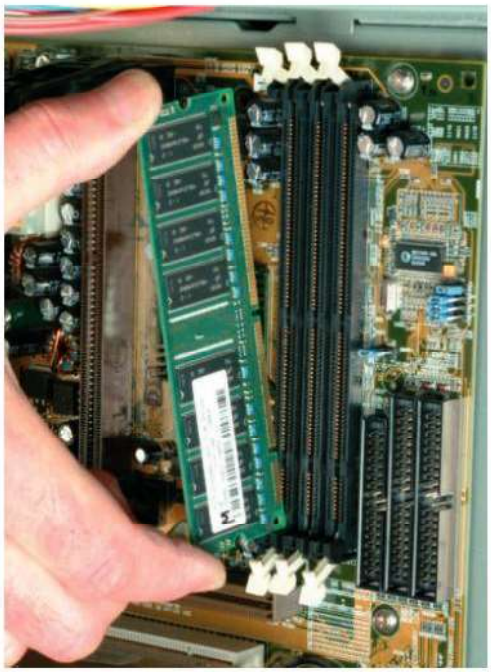


Fig 1.16 Random-access memory (RAM) – a close-up of a RAM memory module

Read-only memory (ROM)

When a computer is made, basic input/output instructions are put on **ROM (read-only memory)** chips. These instructions can be read, but not changed (non-volatile), and are available every time the computer is switched on.

Hybrid memory

Recently, as memory technology develops, the line between RAM and ROM has become blurred. Now, several types of memory combine features of both. These devices do not belong to either group; they are called hybrid memory devices. Hybrid memories can be read and written as desired, like RAM, but maintain their contents without electrical power, just like ROM. Flash memory is a variation of a ROM device that is typically used to store code.

How data is represented

Everything that the computer does results from the turning on and off of different combinations of microelectronic switches called transistors or **bistable devices**. The 'off' and 'on' states of the transistors are used to represent the zeros (0) and ones (1) that make up the binary number system. These zeros and ones are known as **bits** (binary digits). A bit is the smallest chunk of information or piece of data that a computer can work with – either binary 0 or binary 1. The more bits a processor can use, the faster it can compute (work things out) and the more memory it can access easily. When you use a computer, millions of switches are continually being switched on or off by an electric current.

A popular range of processors is the i5 or i7 series produced by Intel. The chip shown in Figure 1.17 is made up of over 27 million tiny switches (transistors) mounted on a slice of silicon.

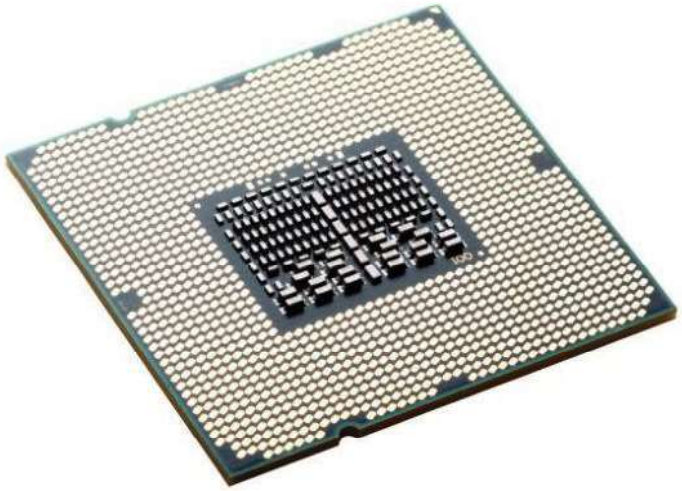


Fig 1.17 A close-up of an Intel i7 core processor

If you think of all of the programs on a computer, plus all the files that are saved, you can see that on each computer disk there are millions of bits. Computer memory and storage size is therefore given in **bytes** (8 bits make 1 byte), **kilobytes** (kB), **megabytes** (MB), **gigabytes** (GB) or **terabytes** (TB). 'Kilo' normally means a thousand, or 10^3. However, 1 kilobyte is 1024 bytes. This is because computers count by twos (binary) and powers of 2 and not in tens like humans. Therefore, 1024 is $2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2$, that is 2 multiplied by itself ten times.

Table 1.2 *Units of computer data storage*

1 kilobyte (kB)	$= 2^{10}$ = 1024 bytes
1 megabyte (mB)	$= 2^{20}$ = 1024 kilobytes = 1024 × 1024 bytes = 1 048 576 bytes
1 gigabyte (GB)	$= 2^{30}$ = 1024 megabytes = 1024 × 1024 kilobytes = 1024 × 1024 × 1024 bytes
1 terabyte (TB)	$= 2^{40}$ = 1024 gigabytes = 1024 × 1024 megabytes

Questions

1. Describe the main purpose of the CPU.
2. What is the general name for each of the following types of memory:
   - **a** holds the temporary operating instructions for the computer
   - **b** instructions can be read, but not changed, and are available every time the computer is switched on
   - **c** can be read and written as desired, but maintains its contents without electrical power.
3. State the name given to the smallest chunk of information or piece of data that a computer can work with.

Secondary storage refers to the media and methods used to keep programs, data and information available for later use. Secondary storage saves programs and data permanently, whereas primary storage uses main memory, which is temporary.

Devices and media

Secondary storage media keep data, instructions and information on the physical hardware of a computer for future use. Examples are hard disks, compact disks and tapes. **Storage devices** record and retrieve data, instructions and information to and from storage media. Examples are hard disk drives, compact disk drives and tape drives. So hard disks are storage media whereas hard disk drives are storage devices.

It is very important to have media and methods to store data and programs when a computer is turned off. Secondary storage can be generally grouped into local storage and cloud-based storage.

Local storage

Local storage involves users having storage devices or media with data in their possession or generally knowing of their location. These local storage devices include:

- magnetic media such as magnetic tape and hard disks
- optical disks such as CD-ROM, CD-R, DVD and Blu-ray
- flash memory.

Magnetic media

The cheapest way to store and back up data is on magnetic media, such as magnetic tape and hard disks.

Magnetic tape

Backing up to tape is vital for computer networks and organisations or businesses which need to store important and large amounts of data for a long time.

Magnetic tape is a narrow strip of plastic coated with ferrous oxide. The data is recorded along the length of the tape, with each symbol encoded in binary form across the width of the tape. It is unique since data can only be retrieved in the same order in which it was stored. Therefore, retrieving the 50th piece of data means accessing 49 pieces that precede it. The tape drive winds the tape from one reel to another by passing the tape over a magnetic head to read, write or erase the data as it moves (Fig 1.18). Magnetic tape is used primarily as a back-up storage medium since access to data is not as rapid as with other storage devices. Since creating a tape backup is a slow process it is often done at night or at the end of a working day.

Fig 1.18 Backup tapes such as this are used to make copies of large amounts of data on computer networks

Hard disks

Another common device that stores data is a magnetic disk known as a **hard disk** (Fig 1.19). Although it is possible to add external **hard drives**, most are inside computers, protected by rigid cases. Technically, the hard drive is the machinery that controls the motion of the hard disks which contain the data. But most people use 'hard disk' and 'hard drive' interchangeably.

Fig 1.19 Structure of a hard drive

Hard disks are popular for use with computers and laptops since they store a large amount of data. Hard disks ranging from 700 GB to 1 TB in capacity are now common. External hard disks are now available in capacities and speeds similar to internal disks.

Optical disks

Optical disks can store much more data than most magnetic media. There are three basic types of optical disk. Compact disk drives are also known as optical disk drives because they use lasers to store and read data.

You will already be very familiar with one type of compact disk – the audio CD that plays your favourite music. There is, though, another type of CD that is used only with computers. This is known as the CD-ROM (Compact Disk Read-Only Memory). The CD-ROM allows you to access up to 650 MB of stored data.

Many computers with CD-ROM drives can play audio CDs, but the term CD-ROM is always taken to mean any CD format which stores data, rather than audio tracks. CD-ROMs are read-only media, which means that you can only use the data on the disks.

CD-ROMs that contain software or programs are of the Write Once Read Many (WORM) variety. They cannot be changed once they are created. This is where the ROM part of their name comes from.

The major advantage of optical drives such as CD-ROMs is that they can store significant amounts of data. However, they can be easily damaged during handling and from exposure to light, heat or dust. Compact Disk Recordable (CD-R) and Compact Disk Rewritable (CD-RW) are types of CD that allow data to be written to (stored on) disks. However, the data on CD-RWs can also be erased. Many personal computers are sold with CD-R drives so that you can regularly back up data saved on hard disk.

Digital Versatile Disks (DVDs) are used for storing any kind of digital data and gaming software. They can store much more data than CD-ROMs, enough that full-length feature films can be put on DVD. They are known for replacing the VHS cassette tapes which were used to distribute movies, and as a result, DVDs are often referred to as digital video disks.

A DVD-Video holds video programs and is played in a DVD player linked to a TV or monitor. DVD-ROM, like CD-ROM, holds computer data and is read by a DVD-ROM drive linked to a computer. The massive storage capacity of DVDs, coupled with the fact that digital technology produces better pictures, are the main reason DVDs replaced videotapes.

Blu-ray Disks (BD) were designed to replace the DVD by storing several hours of video using a storage capacity of up to 100 GB. Its main use is for distribution of video game software and feature films that can be viewed in high-definition resolution.

Flash memory

USB (Universal Serial Bus) flash memory drives are also known as jump drives, memory sticks or flash drives, and can be convenient alternatives to

Fig 1.20 Optical disks can store large amounts of data and typically used for storing digital data, movies and gaming software

hard drives. Their storage capacity is typically 8 to 256 GB, although there are larger capacities available. They can be used for storage and data backup, but are mostly used for transfer of computer files, since they can store and transfer data faster than the CD and can be read by many devices.

Flash memory drives combine the best features of the memory devices described thus far. They store large amounts of data, are low cost, non-volatile, fast (to read, but not to write), and electrically reprogrammable. These drives have become increasingly common since they use a standard-type USB connection with computers and laptops.

Fig 1.21 Memory sticks provide additional storage, and are non-volatile and faster than most magnetic and optical storage media

Flash memory cards

These cards are inserted into digital cameras, video games consoles, laptop computers, MP4s, digital cameras, mobile phones and other music players. Mobile phones, for example, contain a Subscriber Identity Module, also called a SIM card, that stores the phone's unique number, along with data such as contact numbers and text messages. These cards vary in size, and their storage capacity ranges from 2 GB to 1 TB. The various devices, however, dictate the appropriate type and size of memory card it uses, so many are not interchangeable.

Fig 1.22 Flash memory cards vary in shape, size and capacity and can be used in a range of devices

Cloud-based storage

Cloud-based storage involves storage of data by users on multiple computers anywhere in the world. The exact location of this data is not known by its owners.

If you have used Facebook, Twitter, Instagram or YouTube, have an email address with Gmail or have used a mobile app, then you have probably used cloud-based storage already.

The **cloud** is an unlimited and powerful remote network of interconnected specialised computers. You can store your data such as school work, photos, email messages and videos at any time, from anywhere, once you have access to the Internet. This saves you from deleting data from your secondary storage device or

transferring it to other storage devices to free space. When you use cloud-based storage, the data is not stored on a single remote computer somewhere in the world, but on lots of different computers. If one computer stops working, your data is still stored on another one.

Some cloud-based storage is free. For example, Dropbox and Google Drive give users access to about 15 GB of storage. However, businesses pay to have their data stored in the cloud for easy access and backup purposes. Users pay for the data storage, which can change as the amount of their data increases. You may never know where your data is stored, but you can access it using your computer or other devices and applications.

With cloud-based storage, millions of people from anywhere in the world can interact with the application at the same time. Access to data is immediate once they have access to the Internet.

As with any type of storage, there is always the risk of your data becoming accessed, deleted, stolen or corrupted, whether as an error or a deliberate act. Users with similar email addresses can receive each other's messages. Storing sensitive data in the cloud can also be a security concern.

Table 1.3 *Storage devices: advantages and disadvantages*

Storage	Advantages	Disadvantages
Magnetic media		
Hard drive Storage capacity: many gigabytes and getting larger	◆ Stores and retrieves data quickly ◆ External hard drives are portable	◆ Internal hard drives are not portable
Tape Storage capacity: many terabytes	◆ Used to back up data on hard disks ◆ Low-cost storage	◆ Not generally used with desktop computers ◆ Slow – so only used for network back-ups
Removable hard drives Storage capacity: many gigabytes and getting larger	◆ Removable and portable ◆ Relatively cheap	◆ Can be misplaced, or damaged since they are portable ◆ Need specific cable to connect to computer or device
Flash memory		
Storage capacity of USB memory stick: typically 8 GB to 256 GB Storage capacity of memory card: 2GB to 1 TB	◆ Compact shape ◆ Operates faster than an optical disk ◆ Can hold more data than an optical disk	◆ USB memory stick requires a USB port ◆ Some do not have write-protection ◆ Can be easily misplaced or stolen
Cloud-based storage		
Storage capacity: 15 GB for individual users of some applications. Limitless for others who pay for the service	◆ Users from anywhere in the world can interact with the application at the same time	◆ Data can be accessed, deleted, stolen or corrupted

(continued)

Table 1.3 *Storage devices: advantages and disadvantages (continued)*

Storage	Advantages	Disadvantages
Optical storage		
CD-ROM (Compact disk read-only memory) Storage capacity: 650 MB	◆ Very cheap to produce, particularly on a large scale ◆ Good way of distributing software	◆ As CD is read-only, data cannot be changed or deleted ◆ Slower access times than hard drives
CD-R (Compact disk recordable) Storage capacity: 650 MB	◆ Possible to add data (write) to the CD-R in more than one session ◆ Good for backing up files	◆ Should have a CD-R recorder to write to a disk ◆ CD-R software has varying capabilities
CD-RW (Compact disk rewritable) Storage capacity: 650 MB	◆ CD-RW can be erased and reused as many times as required ◆ Good for backing up files	◆ Should have a CD-RW recorder to write to a disk ◆ CD-RW does not work in all CD players
DVD (Digital versatile disk) Storage capacity: 4.7 GB up to 17 GB	◆ Excellent for showing video ◆ As with CD-R and CD-RW, there is a range of ways of writing (storing) data on DVD	◆ Has replaced CDs, producing better quality videos than CD-ROMs ◆ DVDs do not work in CD-ROM drives
Blu-ray Storage capacity: 25 GB up to 100 GB	◆ Blu-ray was intended to replace the DVD. Main use is for distribution of feature films and video games ◆ Can be viewed in a high-definition resolution	◆ Requires a Blu-ray player or optical drive ◆ More expensive than CDs and DVDs

Questions

1 State the general name for the type of storage that saves programs and data permanently.

2 List three categories of local storage.

3 What is the main use of magnetic tape?

4 What type of secondary storage is most suitable for use in digital cameras and mobile phones?

5 Explain one advantage of, and one concern associated with using cloud-based storage.

System software is the name given to the software that controls hardware and how all other software works. Examples of system software include operating systems and utility software.

Operating system

The most commonly used system software is called an operating system. Without an operating system, a computer would not work. Popular operating systems include Microsoft Windows 10, Apple's Mac OS X and many versions of LINUX. Popular mobile operating systems include Apple iOS and Google Android.

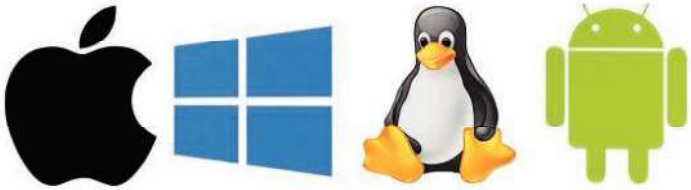


Fig 1.23 Common operating system logos: from left to right they are Apple, Windows, Linux and Android

Booting

The process of starting a computer is known as booting. The first thing a computer does when you turn on the power button is to check that it is working properly by following certain instructions held on a ROM chip known as the BIOS. It will then look for an operating system to tell it what to do next. The operating system is loaded from disk to the computer's random-access memory (RAM).

Hardware control

The operating system supports tasks like accepting input and transferring data between primary and secondary memory or displaying output. It also sets the rules for controlling hardware resources such as peripheral devices like keyboard and mouse, the amount of memory used, CPU time allocation and disk space used.

Software control

The operating system controls how all software applications, games or other programs work on the computer.

Memory management

When a program or data is too large to fit into main memory, a method called **virtual memory** can be used to split the program into manageable blocks. The required blocks are swapped between main memory and secondary storage to accommodate the program or data.

Input/output management

Since each device has a program called a **driver** that allows the device to communicate with the computer, the flow of information among devices must be managed and coordinated.

Process management

Process management allocates time for processes to use the CPU, checks on processes waiting to use the CPU, and signals when the CPU is available.

File management

Files need to be saved, copied, renamed and deleted. A file manager checks the amount of memory needed to perform these tasks and manages the organisation of the files in secondary storage.

Utility software

Utility software is specialised software that tries to protect and maintain the system software. Examples include protecting software against damage caused by computer viruses, backing up files and recovering files after software has stopped working (crashed).

Questions

1. Explain the purpose of system software.
2. Name one computer operating system and one mobile operating system.
3. State the name of the term that matches the following descriptions:
   - **a** the process of starting a computer
   - **b** a method used to split a program into manageable blocks.

Data must be processed by the most suitable means. It can then be transferred to one or more computer systems for more processing, for output or for storage.

Batch processing

A **batch processing** system is one where data is collected together in a batch before processing starts. Batch processing is most suitable for tasks where a large amount of data is processed on a regular basis. When a batch job begins, it will continue until it is completed, or until an error occurs.

Examples of batch processing systems include those that process utility bills such as water and electricity, payroll systems and examination report card systems. Credit card companies also process billing in batches. The customer does not receive a bill for each separate credit card purchase but one monthly bill for that month's purchases. The bill is created through batch processing, where all the data is collected and held until the bill is processed as a batch at the end of the billing cycle.

Advantages

- Once the data is submitted for processing, the computer may be left running without human interaction.
- Jobs can be scheduled for a time when the computer is not busy.

Disadvantage

- There is always a delay before work is processed and returned since batch jobs are usually stored up over a period of time.

Time-sharing

A time-sharing system allows many users to share time on a single computer. Each user is given a slice of CPU time by the computer. The computer works so fast that each user seems to be the sole user of the computer.

One example of a time-sharing system is a bank's bankcard system, which allows hundreds of people to access the same program on the mainframe at the same time.

Other operating system controls include:

- multi-tasking: allowing more than one program to run (work) at the same time: for example, using a desktop publishing program while a graphics program is still running
- multi-processing: executing programs using two or more processors simultaneously
- multi-programming: executing two or more programs at the same time using only one processor
- multi-user: allowing more than one user on a computer network to access the same file at the same time.

Online and real-time processing

Computers and peripheral devices are online when they are connected to a main processor and turned on, so that the operator can interact with them. Printers are online, for example, when they are ready to receive data from the computer to print. Most printers have an online button you can press to turn the machine on. If it is turned off, then you are offline. You can also be online if you are connected to, say, the Internet through a modem or network.

A real-time processing system processes data without significant delay, making it always up-to-date. Since a processing system must be connected to one or more computers to process data, then it must also be online. However, note that online does not necessarily imply that processing is real-time since there may be some delay with an online system. Examples of real-time processing systems include aeroplane landing control systems, electronic fund transfer systems and ticket reservation systems.

Advantages

- No significant delay for response.
- Information is always up-to-date.

Disadvantages

- The computer must be dedicated solely to the task.
- The computer must be continually online.

Data transfer

Most computer users will, at some time or another, need to transfer files between computers. School students may need to transfer their work from a computer at home to the school network via cloud-based storage, by using a secondary storage device such as a flash memory stick or by emailing the work to themselves to retrieve when they are at school. **Uploading** data involves transferring data from your computer to another computer on the network or the Internet, while **downloading** involves receiving data to your computer from another computer on the network or the Internet. Updates to software packages, such as Microsoft Office, are downloaded from the Internet using file transfer protocol (FTP) (see section 3.2).

Before transferring data, it is also sometimes necessary to reduce the file size. The process of reducing the size of a file for storage, or for sending via the Internet, is known as file compression. WinZip and Winrar are popular programs for compressing files. They can also be used to group files together into a single file for easier transmission. File compression is important because some files can take up a large amount of disk storage space.

The larger the file size, the longer it takes to send via the Internet. Users of the Internet will also know that web pages containing pictures can take a long time to load. Some popular file formats give smaller file sizes than others because they are a compressed file type (Table 1.4).

Table 1.4 *File compression*

Type of data to be compressed	Compressed file format
Graphics	◆ JPEG (Joint Photographic Experts Group): a common image file found on computers and the Internet ◆ PNG (Portable Network Graphic): a common image file format to find on a computer and the Internet
Music	◆ MP3: a digital audio file for listening to music on computers and digital media devices
Video	◆ Versions of MPEG (Moving Pictures Experts Group): MP4 files can also contain audio, video, images, and text data

Questions

1 State the most suitable type of processing mode for each of the following examples:
   a printing 400 cheques for employees' wages
   b a computer that can access the Internet
   c a printer is plugged in and turned on.

2 State the most suitable term for each of the following descriptions:
   a transferring data from another program to the one you are using
   b the process of reducing the size of a file and/or combining files for storage or transmission.

3 Suggest the most suitable compressed format for each of the following files:
   a a picture of a family
   b a video of a birthday party
   c a recording of a song by a school choir.

You have seen that an operating system such as Windows is essential for a computer to work. Most of the software we use regularly has been created to do specific tasks – for example, word processing or desktop publishing. The term for software such as this is application software or an application program. Application software is defined as any program that enables the computer to carry out one or more specific tasks.

General-purpose software

The most popular applications are those that are not specific to any organisation or business and can be used by anybody. The programs you use at school or home – for word processing, databases, spreadsheets, presentations, drawing and painting – will be such programs. These programs are known as general-purpose software, because the user decides what to use the software for. For example, you might want to use a word processor to write a letter, or to design a poster for a school play.

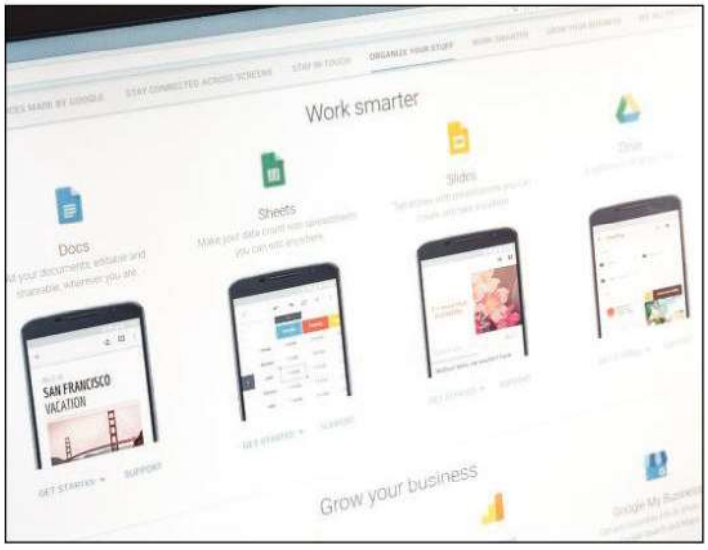


Fig 1.24 Data in online applications such as Google docs, sheets and slides can be updated in real time and shared with multiple users

General-purpose software is much cheaper because it has been used by millions of people over a number of years and is generally error (bug) free. Some applications are even available online, where information can be accessed anywhere or updated by multiple users at the same time. Popular examples of application programs (software) are given in Table 1.5.

Customised and custom-written software

Customised software is general-purpose software that has been modified to perform specific tasks for the user. Word-processing, spreadsheet and database programs are examples of general-purpose software that can be customised by automating certain parts of the software or writing and adding programming modules to perform specific tasks.

In contrast, custom-written software, which is also known as bespoke or tailormade software, is software written for use in specific organisations such as the military, in hospitals for medical equipment, or in banks and other financial institutions. It also involves specific training, since users need to be able to use it efficiently. Other examples of tailormade software include that used by air traffic controllers, who manage the flights of thousands of aircraft; accounting software; airline reservation software; and computer-aided design. These are not general-purpose, since the users of these kinds of software (for example, accountants and engineers) are trained in a particular field of expertise. Since this software is specific to an organisation or business it can be very costly to create and may take a long time to write before it can be used.

Specialised software

Specialised software is written solely for a specific task rather than a range of functions. Examples include the software on your mobile phone for your camera. It will only allow you to manipulate and share the photos. Another example would be an online card game, which would only allow you to play that particular game.

Integrated software

Many computers are sold with **integrated software** already installed. Integrated software is the term for a program that includes all the major types of application (for example, word processing, spreadsheet and database) and brings them together into a single **software package**. Microsoft Office and Adobe Creative Suite are examples of integrated software.

The large software companies such as Microsoft sell their main application programs together in one package. Although packages such as these are sold as integrated software, it is not true integrated software, as the programs are also still separate applications.

Choosing software should be no different from choosing any tool for a job. Just as in construction, you decide whether to use a drill or a hammer to carry out a particular task, so with software you need to decide what it is you actually need to produce, and then choose the most appropriate program. This is very important when choosing programs to use for your coursework.

Table 1.5 *Popular application programs*

Type of software	Examples of application programs	Purpose
Word processing	Microsoft Word, Google Docs	Writing letters, reports and other documents
Desktop publishing	Microsoft Publisher, Google Slides, Adobe PageMaker	Producing newsletters, leaflets and posters
Databases	Microsoft Access	Searching and sorting data
Spreadsheets	Microsoft Excel, Google Sheets	Commonly used for finance, budgeting and so-called 'number crunching'. Also used for creating models, simulations and 'What if?' queries
Graphics	Microsoft Paint, Adobe Photoshop, Adobe Illustrator, Adobe InDesign	Painting and drawing
Computer-aided design (CAD)	AutoDesk AutoCAD, DesignCAD	Producing detailed plans or models, often in 3D. Used by engineers and architects, e.g. for plans of buildings or in the design of cars
Integrated software	Microsoft Office, Adobe Creative Suite	All the major application programs – word processing, spreadsheet and database – are closely related and the output from the various programs can be transferred or embedded into each other with minimal errors
Presentation software	Microsoft PowerPoint, Prezi	Delivering slideshows and presentations to an audience – normally using a large screen

Questions

1 State the most suitable term for each of the following descriptions:
   - **a** software that is written for use in specific organisations
   - **b** software that is written solely for a specific task rather than a range of functions
   - **c** a program that includes all the major types of application.

2 Name two applications that can be used online and shared among users.

3 What type of application software would you use for:
   - **a** creating presentations
   - **b** monitoring weather patterns for the Meteorological Office.

User interfaces are found wherever digital technology exists. How you interact with and use this technology is controlled by the **computer–user interface**, also known as the human–computer interface (HCI). A user interface involves various ways of capturing or transferring data between a user and the computer system. The interface therefore can be graphical, text-based, or even audio–video-based, depending on the application, meaning that it can be a hardware interface, software interface or a combination of both.

Since a user interface helps the user to interact with a system, it should:

- have an attractive design
- be simple to use
- have a quick response time
- have instructions that are easy to understand
- have a consistent layout if there are multiple screens.

Hardware interfaces

Hardware interfaces such as touchscreens, sensors, digital cameras and special keyboards are input devices that were discussed earlier in the chapter. An example of a hardware device with a user interface is a games controller (Fig 1.25). The layout of the buttons, touchpad, joysticks and hand grips together form the user interface that carries out the various functions.

Fig 1.25 Hardware interfaces include games controllers with buttons that perform various functions

Software interfaces

Software interfaces are available after the computer has booted up and the operating system has been loaded, allowing the user to interact with the computer or device through an interface. Software interfaces include online forms for data entry, dialogue interfaces such as navigational systems in some vehicles and Amazon's Alexa on their talking Echo speaker unit. There are four main types of software interface:

- command-line interface
- menu-driven interface
- graphical user interface (GUI)

Command-line interfaces

Command-line interfaces require you to type in commands using a special language. This special language makes command-line interfaces difficult to use, especially for new computer users. In recent versions of Windows, it is called Windows PowerShell (Fig 1.26).

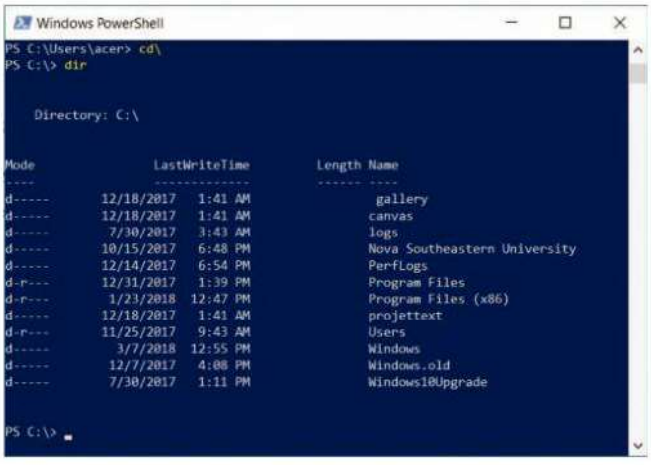


Fig 1.26 An example of a Windows PowerShell command-line interface

Menu-driven interfaces

A menu is a list of options from which you can choose what you want to do. Application programs use menus as an easy alternative to learning program commands. **Menu-driven interfaces** were developed to try to

make the interface friendlier and easier to learn. You can control the computer by choosing commands and available options from a menu, using the keys on a keyboard or a mouse. For example, depending on your choice, another set of options may appear on the screen for you to make another choice (Fig 1.27). This continues until you reach your final selection.

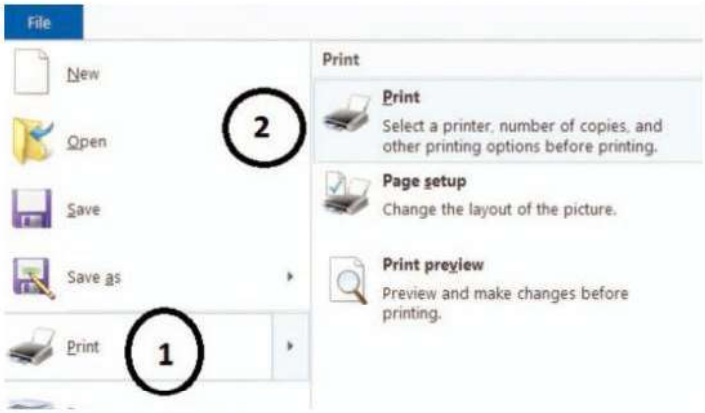


Fig 1.27 Menus allow you to make a series of choices from a list which produces another list until your final selection

Menu-driven interfaces can also be verbal rather than visual. An example is an automated answering service, where you press 1 on the keypad for a department, 2 for another department, or 0 for the operator. These interfaces can be easy to follow but can become confusing as the number of menu options increase and you need to retrace your previous options.

Graphical user interfaces

All computers are now supplied with a **graphical user interface (GUI)** installed because it is presently regarded as the type of user interface which is easiest to use. The main features of a GUI include its ease of use for beginners, and ability to cut and paste or 'drag and drop' data and files among applications. However, GUIs require a lot of memory, which can slow processing time. Sometimes simple tasks take longer than necessary because of the number of functions or steps required.

A GUI comprises Windows, Icons, Menus and Pointers also called **WIMP**. Figure 1.29 shows an example of a GUI with icons and menus on the computer desktop.

Windows

A window is a part of the screen that holds its own document or message. Most computers now use window-based programs (Fig 1.28). A window can take up the whole screen or can be resized, moved or shrunk (minimised). Each time you open a **folder**, you see its contents in a new window. More than one window can be open at the same time. This is particularly useful if you want to move from one window to another or to copy files from one window to another.

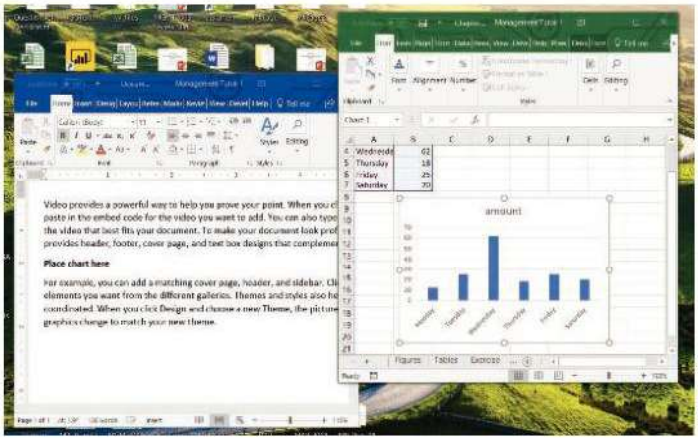


Fig 1.28 An example of two window-based programs (word processor and spreadsheet program) that are open at the same time

Icons

An **icon** is a tiny picture of an object that is displayed on screen (Fig 1.29). Normally, you can use the icon in some way. For example, by using the mouse to double click on the icon of the Microsoft Excel spreadsheet program, you will start the program.

Fig 1.29 Icons allow you to easily recognise programs in a graphical user interface (GUI)

Icons are designed to make things easier for computer users. Instead of having to remember commands, all you have to do is remember what the icons look like. Icons are not just for programs. There are icons for folders, the recycle bin (wastebasket), disk drives and printers.

Menus

An advantage of using menus in Windows or on a Mac is that, for most programs, the first few menus are always in the same order. They also carry out the same functions, no matter which program you are using. For example, the file menu is first and enables you, among other things, to create, save and print a document.

Pull-down menus are activated by clicking on the menu item (such as 'File') using the left mouse button. The menu pulls down just below the menu item, and you can scroll down through the various items. More complicated pull-down menus can produce additional pull-down or pop-up menus.

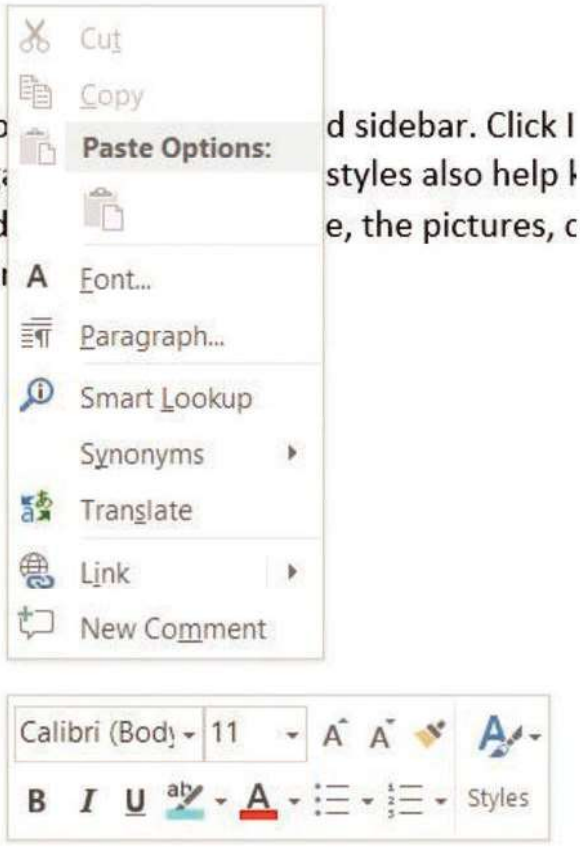


Fig 1.30 A pop-up menu from Microsoft Word

Pop-up menus (Fig 1.30) are activated by clicking anywhere on the document screen using the right mouse button. Some standard commands and options are available on these menus, including the cut, copy and paste commands.

Pointers

The most common pointing device is a mouse. As the mouse is moved, a pointer moves around the screen. The pointer is a very important part of a GUI, as it enables you to control the computer and to choose window items, to select text in a document or cells in a spreadsheet, and to create drawings and shapes. Other pointing devices include, graphics tablets, joysticks and digital pens for use with touchscreen devices.

Improving interfaces

Software companies spend a great deal of time and effort trying to improve the interface so that the computer is easy to use. An important part of this is to design the system software and application programs so that they work exactly the same way each time they are used, and the menus are always in the same place.

People use computers for many hours a day. Therefore, the screen design and screen colours must be visually pleasing and soothing. However, some colours might be impossible for the visually impaired to see, therefore audio hardware interfaces have become useful.

Questions

1. For each of the following, indicate whether it is a hardware interface, software interface, or a combination of both:
   - **a** display screen on a printer
   - **b** pressing a code on a keypad to open a door
   - **c** shouting a command to a device which responds with certain actions.
2. Explain what would cause a menu to confuse a user.
3. State what the following terms mean:
   - **a** WIMP
   - **b** GUI.

We need computer systems in almost every aspect of human life: from preparing meals, to maintaining cars and travelling to work or school. For example, a control system uses machines to accept input as instructions to produce output, such as changing the red, amber and green of traffic lights or a moving a robot arm to pack eggs. A communication system usually transports data through the network from one point to another. A computer information system is responsible for the collection of data, its processing into information, and the overall management and distribution of this information.

Computers and communication devices can therefore manage large amounts of information at a faster rate than manual systems, such as filing, sorting and mailing.

Fig 1.31 Information systems are now an essential part of office work

When choosing a computer information system for a particular application, you need to consider:

- what hardware is used, such as input, storage and output devices
- what software is used, including the choice of custom-written, general-purpose and specialised software
- what processing takes place
- what human–computer interface is used
- which people are involved and what work they do
- what data is required.

The first four points were discussed earlier in this chapter. You can now apply this knowledge to decide which systems and applications are appropriate in various computer-related fields based on their input, processing, storage and output needs.

Types of computer systems

Computer information systems can be chosen to suit different users and tasks. They are also classified by their processing speed, storage and portability.

Mainframe

This term originally referred to the cabinet containing the CPU or 'main frame'. **Mainframes** are very large capacity computers with several CPUs, capable of supporting hundreds or even thousands of users simultaneously. Those such as the IBM zEnterprise mainframe are built with spare components to prevent breakdowns. Data flows between peripherals and communication devices. Users may connect to the mainframe remotely, and only the system administrators will have direct access to the physical computer. Primary and secondary storage are therefore extremely large. Organisations such as banks, airlines, universities and government departments use mainframes – they are very expensive to buy, and need full-time staff for their operations, maintenance and upgrades.

Desktop systems

Also simply called a computer, a **personal computer** or **desktop system** (Fig 1.32) fits on an office desk. It is easy to buy, upgrade and maintain. Its tasks are for a single user. Memory sizes are increasing but it is not uncommon to find primary storage sizes of 8 GB (RAM) and hard-disk sizes of 1 TB. Most computers now contain multiple processors (CPUs) working at speeds of 3 GHz. Their main use is for office and school work, games and entertainment, Internet access and data communication (including email).

They can, however, be linked in a network with more powerful computers.

Fig 1.32 A typical personal computer

Mobile devices

Mobile devices (also called handheld devices) include laptops, notebooks, netbooks, tablets, smartphones, e-readers and games consoles. They are similar to personal computers but are smaller, lighter and contain batteries so that they are not restricted to being connected to electrical outlets.

Embedded system

An **embedded system** is a dedicated computer system that is designed for one or two specific functions. These systems are therefore embedded as a part of a complete hardware device called an embedded device. They consume very little processing power and may or may not be able to connect to the Internet. The main aim is to increase the reliability and performance of the device. Embedded devices can be found in digital watches, printers, washing machines, banking ATM machines and even four-wheel drive vehicles and large installations such as traffic lights. Some embedded devices have no user interface, while others may use simple menu systems or touchscreens.

Questions

1 State the most suitable type of computer for each of the following descriptions of computer systems:

- **a** used by secretaries for general office work
- **b** very large capacity computers with several CPUs
- **c** consumes very little processing power and may or may not be able to connect to the Internet.

Troubleshooting basic computer problems

A number of simple problems can occur when using a computer, but a few checks can be performed to identify the possible cause(s). These checks can determine whether the problem can be rectified immediately or if there may be a need to seek further technical assistance.

Computer, laptop or mobile device does not respond when power is turned on

1. Ensure that the power cable is connected to the power connector on the back of the computer or device and plugged into the electrical outlet.
2. If it is plugged into a power strip or surge suppressor, check that the power strip is connected to an outlet and turned on.
3. Make sure that the electrical outlet is working. This can be done by testing it with another device such as the monitor or a printer.
4. Briefly bypass the surge suppressors, power strips and extension cables in turn, which connect the computer directly to the power outlet, to verify that the computer turns on.
5. Try using another power cable that is suitable for the device. If the power turns on, then the cable needs replacing.

Printer problems

1. Ensure the printer driver is installed on the computer.
2. Ensure that the printer is plugged into a power strip or outlet and the printer is turned on.
3. Check that paper is not stuck in the printer. Open the printer and remove the component that holds the paper. You may need to remove the ink or toner cartridge to see if paper is stuck under the cartridge. You may see an error message on the monitor or the printer lights may indicate what the error could be.

Printer is receiving power but is not printing correctly

1. Ensure the printer contains one or more ink cartridges or that the correct toner is installed.
2. If the print quality is poor, the ink or toner cartridge may need to be replaced.
3. Ensure printer settings for ink cartridge alignment, paper orientation, margins are correctly set.
4. If the print quality is low, check the print quality being used – options are provided to set the quality of print being used from the printer. Draft, Normal and Best are examples of print quality you may see for an inkjet printer.
5. Some printers use Wi-Fi, so check on the display panel to see if the printer's Wi-Fi is connected.

If no paper is seen when you try to print

1. Ensure no parts of the printer are open.
2. Check that paper is correctly placed in the printer.
3. Verify that the correct data cable is being used, and the cable is connected to the computer and the printer.
4. Ensure that you have selected the correct printer. Several printers may be installed, and you must choose the required printer in the print dialogue window (Fig 1.33).

Fig 1.33 Check that the correct printer has been selected

Printout is blank

1 Change the ink or toner cartridge
2 If the problem persists, seek further technical assistance since the nature of the problem may require an experienced technician or a new printer.

Monitor problems

Blank screen

1 Check the monitor power light – if it is off, then press the button to ensure that the monitor is turned on. If the power light is on, then the monitor has power. Alternatively, if the monitor light is blinking or in a different colour, then the monitor may be in power save mode. Press a key on the keyboard or move the mouse.
2 Check the monitor cable connections. Check to ensure that the monitor power cable is connected to an outlet, power strip or surge suppressor. Check the monitor data cable is connected to the computer correctly.
3 Ensure the electrical outlet is working by testing with another device.

Screen difficult to read

1 Monitor settings may need to be adjusted (such as colour, contrast or brightness).
2 Ensure that no strong sources of magnetism are near to the monitor – such as speakers and amplifiers.
3 Monitors should be kept away from external power sources such as fans and fluorescent lamps and radios. These can cause the screen image to appear to vibrate. Nearby power sources should be turned off to check for interference.
4 Monitors facing bright sources of light such as windows and lights can make the images difficult to see. The monitor should be turned away from strong light sources.

Battery problems

For laptops and mobile devices, check the amount of charge in the battery. Move the cursor arrow over the battery icon while the laptop is connected to power adapter to view the remaining charge. Figure 1.34 shows some phases of battery use.

Fig 1.34 Different phases of battery use

The battery may need charging or replacing if:

- the laptop or mobile device shuts off when the power adapter is unplugged
- the device powers off soon after use
- the battery icon indicates that a battery is not detected or found.

Try another cord of the same make and model. If the battery charges then the power cord may need replacing.

Questions

1 You have been watching YouTube videos on your phone for about 45 minutes, then your phone suddenly powers off. Give one possible cause for this problem.
2 You found a printer cartridge still enclosed in its packaging. Since your printer needs ink, you decided to replace your empty cartridge with the one you found. However, the printer still does not print on the paper. Explain why this problem may occur.

Multiple choice questions

1 Which of the following enables a computer to temporarily store instructions and data?
- **a** hardware
- **b** input devices
- **c** memory
- **d** peripheral devices.

2 Which of the following controls the hardware and how all other software works?
- **a** application software
- **b** computer programs
- **c** operating system
- **d** peripheral devices.

Questions 3 to 5 are based on the following devices:
- **i** keyboard
- **ii** keypad
- **iii** touchpad.

3 Which of the devices contains only a block of buttons that contain digits and symbols?
- **a** **i** only
- **b** **ii** only
- **c** **iii** only
- **d** **i** and **ii** only.

4 Which of the devices is not suitable for the visually impaired?
- **a** **i** only
- **b** **ii** only
- **c** **iii** only
- **d** **i** and **ii** only.

5 What is the main method to use these devices?
- **a** Laser
- **b** Light
- **c** Sound
- **d** Touch.

Questions 6 and 7 are based on the following printer types:
- **i** dot matrix
- **ii** laser
- **iii** thermal.

6 Which of the following are non-impact printers?
- **a** **i** only
- **b** **ii** only
- **c** **i** and **iii** only
- **d** **ii** and **iii** only.

7 Which printer uses ink that fades over time?
- **a** **i** only
- **b** **ii** only
- **c** **iii** only
- **d** **i**, **ii** and **iii**.

8 Each of the following has its screen integrated with the system unit and keyboard *except*:
- **a** personal computer
- **b** laptop computer
- **c** mobile phone
- **d** notebook computer.

9 Which of the following systems relies on precisely positioned marks on a form?
- **a** EPOS
- **b** MICR
- **c** OCR
- **d** OMR.

10 Which of the following holds the temporary operating instructions for the computer, its programs and the data?
- **a** ALU
- **b** CPU
- **c** RAM
- **d** ROM.

11 The process of starting a computer is known as:
- **a** memory management
- **b** software control
- **c** booting
- **d** crashing.

12 The MPEG file format compresses which type of data?
- **a** graphics
- **b** music
- **c** text
- **d** video.

13 Software that is made for use in specific organisations is called:
- **a** customised
- **b** custom-written
- **c** integrated
- **d** specialised.

14 The type of interface that allows a user to interact with a computer or device using a touchscreen is:
- **a** graphical
- **b** hardware
- **c** menu-driven
- **d** software.

Short answer questions

15 Explain the meaning of the term 'IPOS cycle'.

16 Complete the following sentences by using the most appropriate device from the list:
- **a** A _____ records voices for presentation software.
- **b** A _____ controls multimedia projectors.
- **c** A _____ is used to type data for a document.
- **d** A _____ reads information from a smart card.
- **e** A _____ is used in flight simulators.
  - **i** remote control
  - **ii** microchip reader
  - **iii** joystick
  - **iv** graphics tablet
  - **v** keyboard
  - **vi** microphone.

17 Categorise each of the following examples as either (D) a storage device or (M) storage media:

a **b** **c** **d**

18 Circle the most appropriate term in each of the following statements:
- **a** When data is retrieved from sequential/direct access storage devices, the device will start from the beginning of the data to be read from, and proceed in a sequence, until it reaches the required data.
- **b** An example of a direct/sequential access storage device is a hard disk drive.
- **c** Direct/Sequential access storage devices access data immediately without having to read data from the beginning through to where the data is located.

19 Figure 1.35 illustrates an access device. Data is stored at each position on the device.

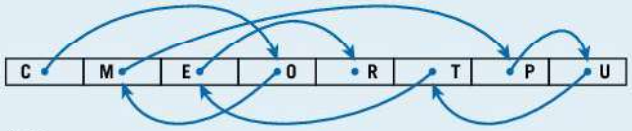


Fig 1.35

- **a** Starting from the first position at the left and moving to the right, write the letter found in each position.
- **b** If the data is accessed from the first location (**C**), follow the arrows and write the output in each position.
- **c** If the positions were numbered from 1 to 8, what would be the output if the data was accessed in the following order:
  - **i** 6783
  - **ii** 82567.
- **d** Circle the appropriate response:
  There is no order/a specific order to how the data is stored on the device.
  The diagram is illustrating serial/random access or sequential/direct access to the data.
  The speed to access data on this device would be fast/slow.
  A DVD/magnetic tape is most suitable for this type of access.

2.1 Data and information

Data is raw, unprocessed facts. For example, the numbers 26, 29 and 30 represent data. We do not know what the three numbers represent – they could mean just about anything – such as the temperature in degrees Celsius, the dates of interschool sports events or even the number of students in three classes. **Information** is processed data. The three numbers can therefore indicate what type of clothing to wear to keep cool based on the temperature, how close the exams are, or how many exam papers to print for each class.

Data processing is the manipulation of data to obtain information. So, taking one of the examples above, finding the average of the three numbers gives an indication of how warm the days have been.

The term **information system** is given to any record-keeping system. We come across information systems all the time. Common examples of manual information systems are dictionaries and telephone directories. What these examples have in common is that data has been collected (input), processed and displayed (output) in order to provide useful information.

Information is collected for the purposes of culture, leisure, work, research and everyday life. In organisations, however, it is mainly used for planning and decision making. There are many sources of information, including, for example:

- measurement: sales, productivity output, cash receipts
- formal and informal communication: word of mouth, meetings, announcements, interviews
- publications: hurricane-preparedness tips, research, daily newspapers, media reports and trends in chronic diseases
- questionnaires: opinion polls and market research
- products: labels containing ingredients, quantities, contents origin and dosage.

The value of information can include the cost of production, the cost of distribution and the value to the purchaser. The more valuable the information is to the customer, the more the organisation can charge for it. Also, customers may be willing to pay more to get information quickly.

With the rise of the Internet, two elements in this value chain have changed. The cost of distributing information has been reduced dramatically for web providers. Also, 'free' information may have additional value. An online newspaper story may include graphs or pictures and links to other stories on the same topic.

Once information is collected, it is often communicated directly to the person who wishes to use it. In order for it to be useful, information must be:

- relevant: it must be what the user needs to know, and be up-to-date
- accurate: it must be as correct as possible
- timely: information should be provided for problem-solving before a critical stage is reached and opportunities are lost
- complete: it must represent a 'whole' picture of a problem or solution

- in an appropriate medium: it should be delivered using an appropriate communication medium, whether by printed material or storage device
- cost-effective: the value of information should be more than the cost involved in its collection.

Information as a commodity

An information commodity is an item of information that can be bought or sold. For example, with online information you may have to pay a charge every time that you access that information.

The major types of information for sale are:

- databases, especially banking and other financial information that give demographic, tracking and buying trends
- information retrieval systems such as abstracting and indexing services
- full text databases and reference materials such as encyclopaedias
- other, less formal, publications such as subject-specialised bulletin boards, which in some cases may replace the more traditional journals.

Questions

1 Explain what is meant when data is said to be relevant.

2 Name two characteristics of data, other than relevance, that would determine if it is useful.

3 What is the term given to an item of information that can be bought or sold?

A common problem with manually entering data into a computer system is that it is very easy to input incorrect data. Examples include users mistyping a name or address in a database so that letters are sent to the wrong person. However, it is also possible for a device to misread a barcode and therefore not provide any information to the user.

Errors

Errors occur in any computer information system. There are several approaches to dealing with the problems that errors cause, specifically preventing errors (so that they do not occur) and detecting when errors do occur (so that they can be corrected). Below a few approaches are considered.

Data entry errors

Sometimes data cannot be automatically scanned into the system for storage, so a common way is to type the data directly into the computer system. Data entry errors, such as transposition errors, would then occur when an operator enters data using a keyboard and mixes up digits and/or letters. For example, the number 32 may be entered as 23. Other errors occur when data entry requirements are not clear. Do you interpret 07/01/2019 as July 1 2019 or 7 January 2019? These data entry errors can be either accidental or deliberate.

- Accidental errors occur unintentionally: data is entered or a command is issued by mistake, in good faith, but in error.
- Deliberate: if errors are made deliberately, then the user probably knows enough to get around any validation checks. Examples include a disgruntled employee entering fictitious data into a company's database. Possible solutions to this problem include file access permissions imposed by the operating system, better vigilance of the administrator and the cross-referencing of data with other supposedly reliable sources.

Software and hardware errors

There are two types of error here. Software might malfunction, erasing or corrupting previously entered data. Hardware may develop a fault (often intermittent) that corrupts data. Examples include bad sectors on a hard disk, bad memory or a power surge. The application may appear to accept data correctly but when that data is retrieved it is corrupt.

Transmission errors

Transmission errors occur when data received is not the same as that transmitted by the sender (Fig 2.1).

Fig 2.1 Illustration of transmission errors

Validation

Data validation is the computerised checking of input data for errors (data that may be unreasonable or incomplete) before it is processed. It does not confirm the accuracy of data. There are different methods of validation. The most appropriate method(s) to use will depend upon what data is being entered.

Range check

Range check ensures that the data entered is within a certain range. For example, when you enter a number corresponding to a month of the year, the range of acceptable numbers is 1 to 12.

Reasonableness check

This check tests whether the data obeys specified criteria. For example, the age of a child at preschool could be about 4 years old, but not 14 years. Reasonableness checks are therefore used to detect doubtful data.

Data type check

This is also known as a character or alphanumeric check. When a database is created, each field will

accept a specific type of data. Whenever data is entered into a field the database will check that it is of the correct type, for example alphabetic or numeric. If it is not, then an error message will be displayed, and the data will have to be re-entered.

Table 2.1 *Examples of valid and invalid data types*

Field name	Type	Valid data	Invalid data
Date of birth	Date	19/10/1994	19/19/94, or 23
Percentage mark	Numeric	56, 99	A+, Pass, 125, –15

Notice that a type check is not a very good validation check. There are many entries you could put in the 'Valid data' column in Table 2.1 that would pass the type check but are clearly incorrect.

The data type check is particularly important if a fixed length field is defined to store the data. Any extra characters that exceed the maximum length would be lost. Length checks are usually only performed on alphabetic or alphanumeric data.

Table 2.2 *Examples of valid field lengths*

Field name	Maximum length	Valid data	Invalid data
Student ID	6	826025	82–60–45
Grade	2	B+, C	A++, Fail

Consistency check

A consistency check compares the contents of two or more fields to make sure that they make sense. It is also called an inconsistency check, since it mostly identifies errors and discrepancies in the data. This check compares new data with previously entered data. For example, checking that the age entered corresponds to the age calculation from the date of birth. Consider the following employee record:

Employment Status Form	
Are you unemployed?	No
Unemployment benefits claimed?	Yes
Number of years working	12
Current occupation	Foreman

It would be useful to have a consistency check to cross-check the information in the 'Are you unemployed?' and 'Unemployment benefits claimed?' fields, since you should not claim for unemployment benefits if you are still working. In this example, therefore, either an error has been made on input or this is a deliberate attempt to claim benefits while still working. Other examples of consistency checks are:

- Single mothers with children can claim for childcare allowance. Check that the number of children is not zero.
- Only full-time employees are paid overtime. Check that these fields correspond.

Presence check

This type of check ensures that the data is actually entered. It can be used on any field in a database. For example, every person in a particular database must be assigned to a department. Therefore, a presence check on each employee's record could ensure that a department is entered in the form.

Format check

This check verifies that the data has been entered in the correct format. For example, a national ID number may have the format 999-9999-X999, where 9 represents a number and X represents an alphabetic character.

Length check

This check verifies that the data entered is the correct length. For example, a password for a credit card may be four digits long, therefore entering three or five digits may result in an error.

Check digit

A check digit is an extra digit added to the end of a code. It is used to detect errors arising from transcription and also to ensure that codes originally produced by a computer are re-entered into another computer correctly. It is calculated from the other

digits in the number. Check digits are included in barcode numbers.

Fig 2.2 A barcode showing a check digit

Verification

Data verification is the checking for mistakes such as transcription errors when data is copied from one medium or device to another. Verification checks do not guarantee that the entered data is correct, it only checks that the data entered matches the source data. Therefore, you should be aware that if the original form was completed incorrectly, then the entered data may pass some verification checks despite being incorrect.

One way to guarantee that the data entered matches the source data is a procedure called **double (data) entry**. Data is entered twice using a program that checks each second entry against the first. For example, some applications require users to enter their password twice. The application compares the two passwords to confirm that they are the same. In other applications where there is more data to be entered, the program produces a list with the pairs of data that do not match so that the correct values can be re-entered.

Visual checks

Another verification method is to use on-screen prompts. After a set of data is entered, it is redisplayed on the screen. The user is prompted to read it and confirm that it has been entered correctly. If the user has entered any data incorrectly, it is re-entered.

This method of verification is not very reliable since many data entry personnel will not read the information that is redisplayed or check it carefully against the source document. Accidental errors can also be prevented by verification in asking for confirmation of instructions. For example, if you try to delete files the computer may ask 'Are you sure [y/n]?' or it may display a summary of input data and ask for verification of its validity before the data is stored.

Interpretation of coded data

Before the responses to questionnaires can be analysed, they must be edited and coded before the data entry process. The person coding these responses should have no doubt as to what should be entered. This may sound simple, but consider the following case (Fig 2.3).

Is this your first visit to the country? Yes ☒$_1$ No ☐$_2$

Fig 2.3 Coding involves assigning a label to each question

Coding involves assigning a label to each response, such as 1 for 'yes' and 2 for 'no'. Sometimes, people will write in a response such as 'can't remember' or 'unsure', and you must decide what to do. It could either be ignored, or a new code and value could be added to the question.

As another example, consider a library database where books are classified as being Fiction, Non-fiction or Reference. This information could be stored as text in a database where the corresponding field length would be 11 to store the longest classification, 'Non-fiction'. Alternatively, the classifications could be coded like this:

Classification	Code
Fiction	F
Non-fiction	N
Reference	R

Coding information reduces the amount of storage space required and speeds up the process of typing the information in. For coding to work properly everyone needs to know what the correct codes are.

Problems associated with shared data

In organisations, information is constantly sent and received among various departments. Traditionally, if two people need to use the same file, the first person

who found the file (in the filing cabinet!) made use of it; the other person waited until the first returned the file to the drawer. Computers and networks mean not only that neither person has to search through a drawer to locate the file, but also that both persons may access the data file at the same time. At least, it may appear in that way. Is this a good way to access data files?

Let us suppose that two teachers were both accessing a data record for the student Amerra Taitt (Fig 2.4). One teacher wishes to adjust the mark received in IT from the original 69% to 96%. The second teacher wishes to adjust the mark received in Geography from 18% to 81% (typo errors in both subjects!). What happens when the records are saved to the main database? Will both changes be accepted?

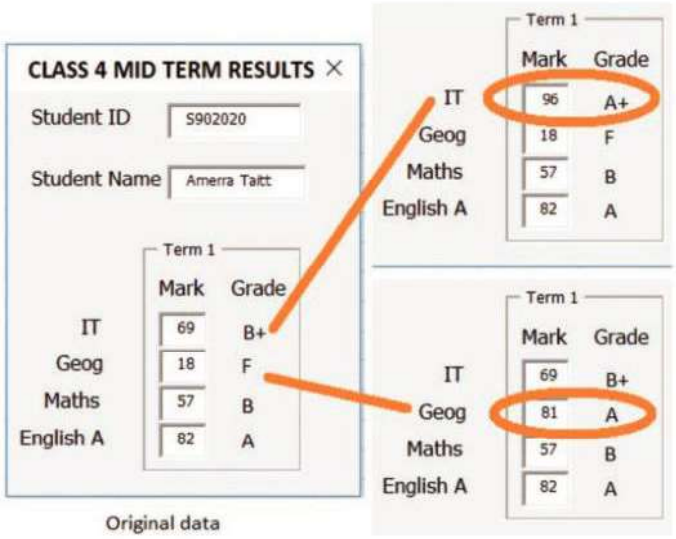


Fig 2.4 What happens if two people want to change data at the same time?

Data-sharing in this manner can lead to problems of data accuracy when the data records are saved. The teacher who saves the changes first will have the marks overwritten by the teacher who saves the changes last, which of course will erase the changes made by the first teacher. How can this problem be avoided?

Fig 2.5 A well-structured database will prevent simultaneous access to the same database record

Good databases avoid this problem by allowing only one user or system to access a data record at a time. When an attempt is made by a second person to access the same record, a message may be provided (Fig 2.5).

Computer systems that provide shared access to data must have security features in place. This prevents users from gaining access to data which they are not authorised to view or modify. The users of the computer system should be provided with their own usernames and passwords for the login process. There are also access privileges depending on the user's level. For example, a student at the school will be allowed access to certain software such as word processing, perhaps email facilities and limited Internet access. A clerk will have access to student records, personnel records, Internet access, email, and payroll programs. The network administrator will have the highest level of access, including data records of usernames and passwords and the network administration and security software.

Questions

1. Explain the difference between data validation and data verification.
2. Give an example of a data-related hardware error.
3. Copy and complete the table below by giving an example of valid data for each item:

	Field name	Acceptable values	Example of valid data
a	Opening hours	8 am to 4 pm	
b	Bulk orders	>250	
c	Standard shipping	3 to 5 days	
d	Centre number	999999 where 9 represents a digit	

Many of the output devices discussed in Chapter 1 are human-readable, meaning that a hard copy of the output is printed as reports, graphs, charts and so on. Other devices are machine-readable, meaning that the output is in a form that only a computer can process. An example is output to a monitor. This is called soft-copy output since it is not printed on paper or other physical material.

Data-capture forms

These forms must be designed so that their instructions are clear and concise, leaving no doubt as to how to enter the data onto the form. For example, the format for dates could be specified as 'dd/mm/yyyy' so that the format 'mm/dd/yy' is not used in error.

The responses from the forms are called human-readable since data entry personnel manually enter the responses written on the forms. This method of data capture is liable to transcription and other errors when the data is entered into the computer. One method of avoiding transcription errors is double (data) entry, where the data is entered twice by two different people and the computer will only accept the data if the two versions are identical.

Turnaround document

A turnaround document is a machine-readable document that has some information printed on it by a computer but has more information added to it by a human. It is then fed back into a computer to transfer this newly added information. These documents serve two purposes. They are used to:

- verify the accuracy and completeness of information that has already been entered
- update information already entered with additional data.

Optical mark recognition and optical character recognition are often used together in a turnaround document. Figure 2.6 shows an example of a turnaround document used to record the reading on an electricity meter.

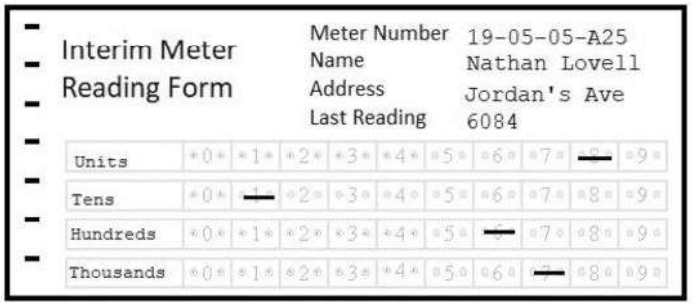


Fig 2.6 The meter reader has marked the reading as 7618 on this turnaround document

Another example of a turnaround document is the multiple-choice sheets used in examinations. Information such as the candidate number, subject and school code is printed on the multiple-choice answer sheet by the computer. The student takes the test and fills in the answer grid by making marks in the appropriate boxes using a pencil or ballpoint pen. The form is then returned to the examination council to be fed into a special reader.

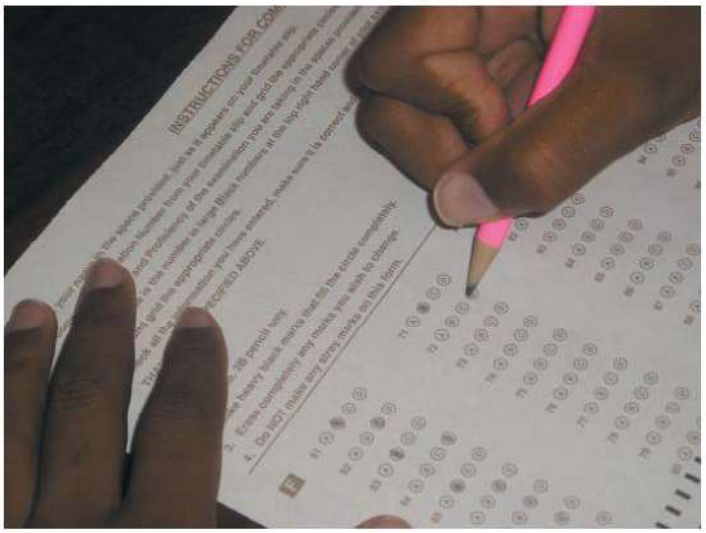


Fig 2.7 Multiple-choice exam sheet

Optical character recognition (OCR) is used to read the student's pre-printed information from the form, whereas optical mark recognition (OMR) is used to read the answers that have been added. All the information can be read into the computer automatically. The sheet is marked, and the total mark is printed without any need for human intervention.

Turnaround documents allow cheap, fast input of information into a computer system. Data can also be printed on turnaround documents in barcode format.

Alternatives to turnaround documents

In some industries, turnaround documents are being replaced by small handheld computers, including mobile devices. These pocket-sized devices have a display screen and touchscreen keyboard. For example, many local utility companies now issue their meter readers with handheld computers. At the start of the day the names and addresses of the customers to be visited are downloaded into the computer. As the meter reader visits customers' homes, he or she types the meter readings into the computer. At the end of the day the readings can be transferred automatically onto the main computer to issue bills. Another example involves courier services that equip drivers with these devices. As the courier delivers a package, the recipient uses a stylus to sign the delivery document on the device. This signature is captured digitally and uploaded to the database as proof of delivery.

Fig 2.8 Turnaround documents are being replaced by small handheld computers

Data logging

Computers are often used by companies and scientists to automatically measure and record changes in conditions such as the temperature, the speed at which a ball is travelling in sports such as cricket and baseball, the amount of light or oxygen in a room or even the level of noise being made by vehicular traffic near a hospital.

Data logging is a method of automatic data capture where a reading from a sensor is input at regular intervals. This data can then be processed to provide analysis of the environment (Fig 2.9).

Fig 2.9 This student is checking water quality using a sensor connected to a data logger. This data can then be processed to provide analysis of chemicals in the water

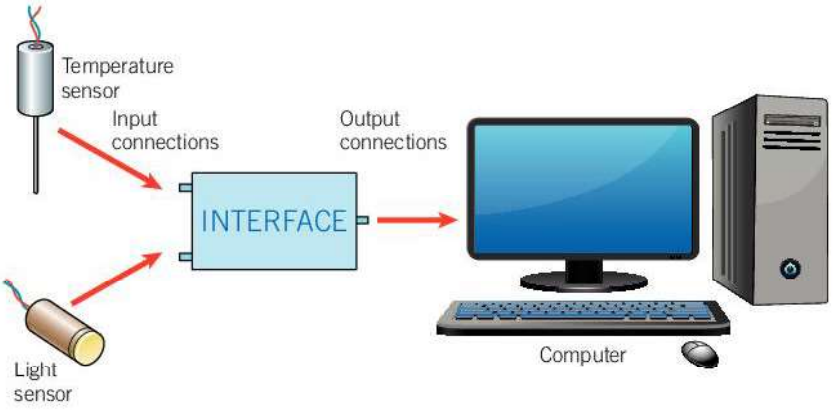


Fig 2.10 Components of a data logging system

A data logging system consists of sensors connected via an interface to a computer and some data logging software (Fig 2.10). The sensors will take measurements and at required intervals the software will record the data. The results can then be displayed as a graph or a table.

Microfilm

Microfilm is often used as an alternative to the printer. The output is 'printed' on a roll of film (computer output microfilm) or sheet of film (computer output microfiche) rather than paper. In addition to being faster, this method also condenses large stacks of paper into small amounts of microfilm or microfiche with no special programming. The drawback of computer output microfilm or microfiche (COM) is that it takes a special device to print the microfilm and a special viewer to read it.

Questions

1 State which of the following output is hard-copy output or soft-copy output:
   a human-readable
   b machine-readable.

2 Give an example of a document that is machine-readable.

File organisation and access relates to the use of records, fields and files.

- A **field** contains a single data item, and many fields comprise a record. Each field has a name and one is the key field used to identify the record.
- A **record** is a collection of related data fields (possibly of different data types) and treated as a single item for processing.
- A data file is a collection of records holding the same type of information but about different objects or individuals.

A file has three important characteristics:

1 It can be permanent or temporary.
2 The records of the file are specially organised on the secondary storage device. This is called file organisation.
3 Records are accessed (or located) using different methods.

Master and transaction files

Many businesses and organisations regularly access, modify and store large amounts of files. These files are given special names to identify their purpose. A master file is a permanent file which is kept up-to-date. It stores the main information, summary data and key fields in the data.

The master file contains two types of data:

- permanent data, such as employee personal data, payroll data employee status and job title
- temporary data, which is updated on a regular basis, such as hours worked and taxes deducted.

A **transaction file** is a temporary file which is used to update the master file after a certain time (at the end of each day or week, for example). The transaction file updates the master file. The records in the transaction file are used to perform three important operations:

- add: put a new record into the master file
- update: change the contents of a record or a field that already exists
- delete: remove a record from the master file.

Record matching

A **primary key** is normally used to identify the record you want to update or delete. It is a field in the record whose value is unique to that record. For instance, in a student record, the Student ID is normally used as the key field. Without a key field to identify the record you want you cannot delete or update records.

To delete or update records in a master file, compare the primary key in the transaction record with that in the master file record. If there is a match, you can update or delete the master file record. If both files are ordered (sorted) on the key field, then this record matching operation functions correctly, but if either the transaction or the master file is unordered, record matching cannot work.

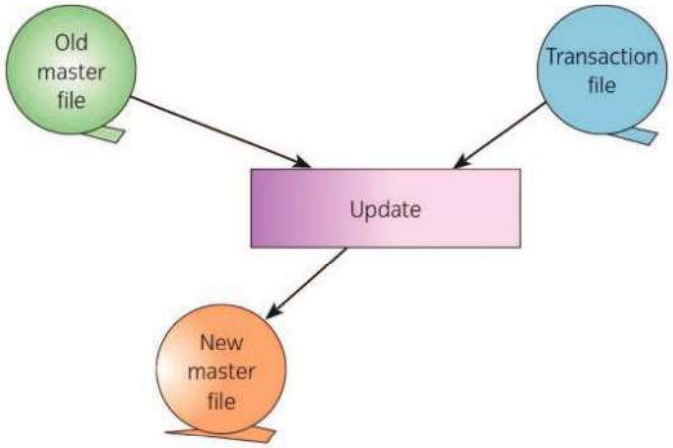


Fig 2.11 Updating a master file with a transaction file

There are three possibilities when updating a master file:

1 Transaction record key is *less than* the master file record key.
The transaction record is added to the master file.
Next transaction record is read.

2 Transaction record key is *equal to* the master file record key.
The master record is deleted or updated.
Next transaction record is read.
3 Transaction record key is *greater than* the master record key.
No more transactions for this master record.
Write master record to new master file.
Read next master file record.

Processing errors

Table 2.3 lists some errors or situations which can occur during processing.

Table 2.3 *Error messages during file processing*

Situation	Error
If the master file encounters an 'end of file' marker in the transaction file, then there is no data on which to update the master file	No data found
If you are searching for a record to update or delete in the master file, and it is not found	Record does not exist or invalid primary key in the transaction record. If you reach the end of the master file before the end of the transaction file, then either you are adding new records in the transaction file to the master file, or you are not updating the most current master file, or your master file may be corrupt
If you are searching for a location to add a record in the master file, and you find the record	Trying to add a record that already exists

Serial and sequential file organisation

Serial file organisation is the simplest type of file organisation. The records are arranged one after another, in the order in which they were added. That is, they have not been sorted into any particular order. Examples of serial files (also called unordered files) include unsorted invoices for customers for the day, and a typical shopping list. Serial files can be stored on tape, disk or in memory. A serial file is used mainly for backup purposes. Recording data in the order in which transactions are made is also useful if you need to restore transactions that have been lost from the master file through hardware or other problems.

Unordered file	Ordered file
Record M	Record A
Record H	Record B
Record B	Record G
Record N	Record H

A sequential file is one in which the records are stored in sorted order on one or more key fields. Examples of sequential files include invoices for customers sorted on customer number, and class registers sorted on last name. Magnetic tape is sequential by its very nature, just like listening to a cassette tape or watching a movie. To access a particular section or continue from where you left off, you must start at the beginning and scan forward until you reach the specific one.

Searching for a record

To search for a particular record, all the preceding records must be read. The main drawback to inserting, deleting or amending records in both serial and sequential files is that the entire file must be read and then the records written to a new file. Since disk access is slow, computer time is wasted even if only a few records are involved. For instance, if 10 records are to be added into a 1000-record file, then 1000 records will have to be read from the old master file and after the 10 insertions from the transaction file, 1010 records are written to the new master file. It therefore takes a long time to insert a new record with serial organisation. To maximise efficiency of processing, use sequential organisation, where the records are arranged in order by the value of the key field common to all records.

Summary of reading, writing and sorting for sequential files

Read access

- Records are read from the beginning of the file until the desired item is found
- If accessing a record, access time is increased to read the entire file or many records but decreased if few records are to be accessed

Write access

- Adding records to the end of the file is easy (may require sorting). However, it is difficult to add or delete data in the middle of the file.

Sorting

- Sequential files are often sorted on the record key to make processing simpler. However, sorting can be time consuming for large files.

Adding a record

For serial files, you simply add the new record to the end of the file. However, the major purpose of sequential files is to preserve the ordering of the file. This means that the record must be inserted into the file in the correct position and not at the end of the file as with serial files. Also, you cannot just insert all changes to records in sequential files into the existing file – you must create a new file that contains the inserted records.

The algorithm for adding a record is:

1. All the records with a key value less than the record to be inserted are read and then written to the new file.
2. The record to be inserted is written to the new file.
3. Finally, the remaining records are written to the new file.

Updating a record

Updates are normally done using magnetic tape in batch mode. All the updates are gathered together into a transaction file, and then applied to the master file together. Updating, therefore, is again accomplished by creating a new file which contains the updated records. Sorting the master file and transaction file records in the same order improves the efficiency of the updating process.

To amend a record in a sequential file:

1. All the records with a key value less than the record to be amended are read and then written to the new file.
2. The record to be updated is read, any changes are applied to it and the updated record is written to the new file.
3. Finally, all the remaining records are written to the new file.

Deleting a record

With both types of files, the only way to delete records is to create a new file which omits the records marked for deletion.

To delete a record in a serial file:

1. Compare each record with a key value of the record to be deleted (since the transaction file is not sorted).
2. If it is not the record to be deleted, then write that record to the new file.
3. When the record to be deleted is encountered it is not written to the new file.
4. Finally, all the remaining records are written to the new file.

To delete a record in a sequential file:

1. All the records with a key value less than the record to be deleted are written to the new file.
2. When the record to be deleted is encountered it is not written to the new file.
3. Finally, all the remaining records are written to the new file.

Direct access file organisation

A direct access file, also called a random access file, allows access to a particular record in the file using a key. This makes it much easier to find, read, delete, update and insert records. The file is organised like a one-dimensional table on disk where each record is a

part of the table. The record number acts like a table index to allow you to find the records.

You can access a record directly or randomly by calculating its location using a mathematical formula and going directly to the record. For example, when you input an ID number, the mathematical formula uses it to produce a value that points to the storage location on disk where the record can be found.

Direct access files also support sequential access by allowing the records to be read one after another. The records in a direct access file are not sorted in ascending or descending order, but are stored in random order.

With hard disks, direct access is possible. With an audio compact disk, for example, you can play the songs in random order or go directly to the track you want to hear. However, not only must the medium allow for random access to records, but the file itself must be organised so that you can go directly to the record you want to retrieve. This can be compared to sequential organisation, as on a magnetic tape. You have to start at the beginning and run the tape forward until you get to the song you want to hear.

Summary of direct access file organisation

This organisation is best for:

- files which seldom change in size
- files which require frequent updates
- single record enquiries and updates
- processes which require fast access to records
- storage of master file records on direct access media only (such as hard disks)
- accessing disk file records sequentially or directly.

If processed directly, they need not be processed in order.

Index sequential file organisation

An **indexed file** is used to speed up the key search in a file. You can think of it as a one-column table organised in ascending order and stored on disk. The primary key in the table is used as an index to the record. It is just like the index of a book where the key value (topic) has a pointer to the storage location (page number) where the information is stored.

Many applications require a mix of sequential and direct processing of records. Consider a file containing customer accounts with three fields: 'Account Number', 'Credit limit' and 'Balance'. Every time a customer wants to make a purchase, his or her credit limit and balance must be checked; this requires individual access to his or her record. Every month, a statement must be produced for each customer; this requires sequential access to the whole file.

An index is a special file of records with two attributes: record key and the storage address of the corresponding record in the indexed file. A partial index containing the highest or the lowest key value in each block of records is useful when the index itself is organised sequentially. Ideally, you want to have the index in main memory. Then you can search the index quickly to obtain the storage address, and then retrieve the required record in a single disk access.

Searching for a record

The search key is compared with the index keys to find the highest index key that comes before the one you are searching for. Then a linear search is performed from there onward, until the search key is matched or until the record pointed to by the next index entry is reached.

For example, suppose you are in a supermarket where the items are stored on the shelves in alphabetical order (Fig 2.12). You wish to find forks. Instead of walking up and down each aisle, you look up at the listing (index) of what is in each aisle. This tells you which aisle to walk down to find the forks. You know to stop looking once you have found forks on the listing (Fig 2.13).

In spite of the double file access (index + data) needed by this kind of search, the decrease in access time with respect to a sequential file is significant.

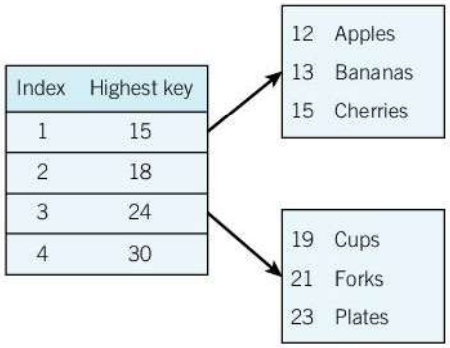


Fig 2.12 Index sequential file access

Fig 2.13 Supermarket aisle signs are similar to index sequential searches

Summary of index sequential access file organisation

- Instead of having an index entry for each record, have an entry for each block of records starting from the lowest or highest record.
- Leave spaces in each block to allow for easy insertions.

Table 2.4 summarises methods of access to a record for a variety of file structures.

Table 2.4 *Searching for a record can be achieved through various file organisations*

File structure name	Structure details	Access method
Serial file	Unordered records	Sequential access
Sequential file	Ordered records	Sequential access
Partially indexed file	Ordered records	Sequential access to index, followed by direct access to first record in the group, then sequential access to find the desired record
Fully indexed file	Unordered records	Sequential access to the index, followed by direct access to the data file
Direct access file	Unordered or ordered records	A calculation provides the address (location) of a record, followed by direct access to the record

Questions

1. Write the connection between a field, record and file.
2. Why are master and transaction files needed in most businesses?
3. What is the special name given to the field that normally identifies a record?
4. State the type of file organisation for each of the following descriptions:
   - **a** records arranged one after another, in the order in which they were added
   - **b** records stored in sorted order
   - **c** records stored in random order
   - **d** records stored with directory-type listings to denote location.

The processing of data into information occurs when a machine or processor acts on the input it receives. An example of this is an electric kettle which senses when the water temperature reaches boiling point and switches off. A car production line can sense when a car body is in a certain position and then act to weld together the relevant parts of a car. **Information processing** is only valuable if the information can be stored and retrieved quickly, accurately and efficiently and cannot be changed accidentally.

Setting up an information processing system

Before setting up an information processing system, a business should consider the following questions:

- Will computerisation really solve the particular problem?
- Is it cost-effective in the long term?
- How large is the amount of data to be handled?
- Is high processing speed really important?
- Can the present staff manage the system?
- Will the changes caused by computerisation lower the morale of staff?
- How can the loss of jobs be handled properly?
- What can be done to help staff adapt to computerisation?

Examples of information processing

Information processing can be done in almost all sectors of business. It is also becoming increasingly popular at home where bills can be paid either by phone or on the Internet. Other people use information processing for research and education through online classes where assignments and reports can be submitted electronically. In fact, anyone can use the Internet to find a wealth of information such as current affairs news, stock prices, educational materials, online banking and investments, shopping for goods and services, communication, and the exchange of information with other people around the world.

Table 2.5 *Advantages and disadvantages of information processing*

Advantages	Disadvantages
• Tasks can be completed faster because data and information can be processed at amazing speeds. • Computer storage devices can store enormous amounts of data and information for future use. • Automation can be introduced. That is, tasks can be completed with little human intervention. • Management can analyse new information and trends more quickly. • Data and information can be shared with other computers.	• It may need a high initial investment in equipment and training. • More money may be needed to employ specialised staff to operate and design the information processing system. • Some jobs may be lost as a result of computerisation, which may lower the morale of staff members. • Some staff must be trained or retrained. • Face-to-face interaction between staff may be reduced.

Health care

Information processing in health care may be used to:

- maintain patient records in hospitals and clinics
- monitor patients' vital signs in hospital, and at home
- perform computer-assisted medical tests
- research and diagnose medical conditions
- operate implanted devices such as pacemakers which allow patients to live longer
- control surgical instruments during operations that require great precision, for example laser eye surgery and heart surgery
- enable 'telemedicine' through computers with video conferencing capabilities
- train surgeons before they perform surgery.

Banking

Computers are used to keep track of all bank transactions. Customer accounts need to be updated every time a payment transaction is made whether by cheque, card or **EFT (electronic funds transfer)** at the point of sale (EFTPOS) is useful for customers in a shop. The bank card is inserted into a reader attached to the point of sale (POS) terminal. The payment is then made directly from the customer's bank account to that of the shop. The procedure is as follows:

1. The cost of all of the items to be purchased is added up, usually on a computerised cash register.
2. The customer presents his or her debit or credit card to the shop assistant.
3. The card is inserted so the chip can be read or swiped through a magnetic strip reader to input the card number and expiry date to a computer.
4. The card number, payment amount and identity of the company that has sold the goods are sent to the bank's computer using a modem and telephone line.
5. The customer types a four-digit **personal identification number (PIN)** on the keypad and presses the enter key to continue the process.
6. The bank's computer looks up the customer's account details in an accounts database.
7. If the card is valid and the customer has enough money in his or her account then the payment is approved.
8. The money is transferred electronically from the customer's bank account to the company's bank account.

Sometimes the magnetic strip reader cannot automatically read the card number from the card. If the magnetic strip has been damaged, then the sales assistant can enter the card number using a small keypad.

Payroll

A payroll system uses an information processing system to calculate the wages of each employee, print out pay-slips and record the information for accounting purposes.

Fig 2.14 Using a bank card in a reader attached to a point of sale terminal

Payroll example

Input: This may come from a database of employees' details, such as salaries, pay rates, bonus rates if employees are paid by the hour, then timesheets would be used to input and validate the number of hours worked and number of hours overtime, possibly using OMR or OCR techniques.

Processing: Using a software application such as a spreadsheet or more complex accounting software the computer then needs to calculate the gross amount earned by each employee, any bonuses, any deductions such as tax, national insurance, etc. and hence the net amount earned by each employee.

Output: The computer would need to print pay-slips. Use an impact printer if the pay-slip is required in duplicate for the employee's signature, or a non-impact printer otherwise. Update the employee database using a database integrated with the accounting software. Output details of payments to a banker's automated clearing service to pay money directly into employees' bank accounts using electronic commerce. Print summary reports.

Library

While travelling to a library to borrow books may be a regular activity for many students, libraries have been adjusting their collections, services and environments for the digital world. Most university libraries provide online access for their staff and students via an

e-information portal. This allows users to search online databases for e-journals, e-books, and articles in the online, digital or e-library. In some cases, users can also search for and request a paper-based version of the article and then travel to collect it if it is available.

Library example

Input: After logging in to the online library, the user can search for an article in an online database by entering information such as a subject, the name of an author or the title of a journal or article.

Processing: The library's online databases would have files (tables) containing details about the books, magazines and journals in the library. The system uses the key terms entered to conduct the search.

Output: The e-library may show different options to view the texts. For example, if a book is available for online reading, then you may be able to download it as a PDF document or read it in your browser, with special e-reader software or a Kindle device. Some online content offers audio features for the visually impaired or is formatted to deliver book page images. Some online libraries also provide links to other e-libraries and may indicate if a hard copy is available.

Control systems

You are surrounded by computer control systems but probably do not know it. Here are some examples of control systems.

- Traffic lights are triggered by movement sensors or the vehicle interacting with the sensor embedded in the road (Fig 2.15). A traffic light control system would not be very useful or safe if it did not respond adequately to the oncoming vehicles and stop the traffic! To do this, there has to be a computer program which is constantly looking at the data from the sensors and making decisions about what the output device (the traffic lights) should do.
- In the kitchen, microwave ovens, washing machines and tumble dryers all have control systems inside them to make them do their job at the press of a button. In the sitting room, remote-control televisions, video recorders and audio systems have built-in control systems.
- All modern cars have a management system which tells the engine what to do. This can control the flow of fuel to the engine and stops the engine from going too fast. Remote-control locks respond to a signal from the key to operate the locks on the doors.
- Buildings with air conditioning have sensors which detect the temperature and humidity inside the buildings and turn the heating or air conditioning on or off when needed.

Fig 2.15 Control systems are around us all the time

In these examples many of the sensors have digital outputs. In the traffic lights example, the embedded sensor that detects an approaching vehicle needs only to know whether a vehicle is there or not. So an on/off digital sensor is adequate. A digital temperature sensor would only be able to tell the system that the environment is hot or cold. It would not be able to tell the system how hot or how cold it is.

The processing of information is usually integrated into a control system which has sensors to input information, a processing unit (computer) which decides how to respond to the inputs, and output devices which do what is required. A control system also needs an interface unit between the computer and the input sensors and the output devices. This unit turns the signals from the sensors into something that the computer can understand, and the signals from the computer into something that will

work the output devices. The purpose of the interface is to make all parts of the system work with each other.

The processing unit in a control system may be a computer which has a program built into it. It will usually not be like the computers that you use, where you change the program by loading a new program from disk. The processing unit has a resident program in its electronic circuits. Such a system is called an **embedded controller**. Embedded controllers have only one program in their electronics to do the job they were designed to do. This makes them much cheaper to make because they do not need disk storage devices, a keyboard, a mouse or a screen. Once the system has been tested to make sure that it behaves as it should, these elements are not needed. The outputs will be the things that are being controlled, not a screen.

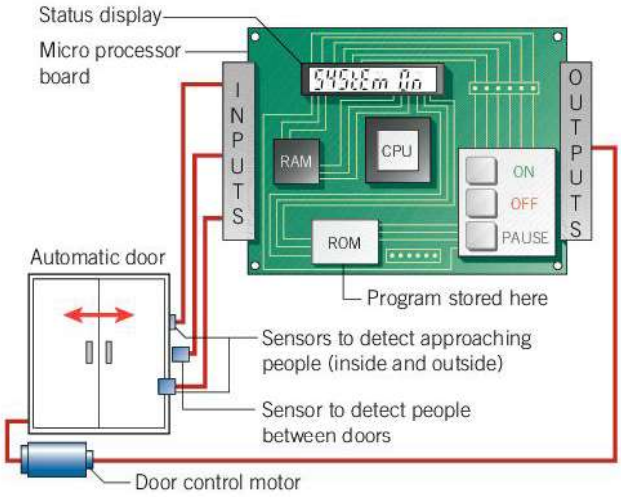


Fig 2.16 A typical control system looks like this. Note that it does not have a screen, disk or keyboard. The program is stored in ROM

Industry

Sometimes, in industry, a whole manufacturing process is controlled automatically by a computer system. Computer manufacturing systems do many tedious and repetitive tasks. In electronic circuit production, the components are automatically put in the right place on the circuit boards and then automatically soldered into position. The speed and accuracy at which these machines work are greater than those of skilled workers. The danger to the workers from the heat generated by soldering is removed by having automatic soldering systems.

The number of people needed in such areas of work has changed and usually been reduced. The skills the workers need have also changed. Rather than doing the repetitive tasks themselves, they now keep the machinery running and monitor activities.

Industry example

Input: Sensors take readings at regular time intervals and send the readings to the computer. Sensors may be measuring temperature, pressure, liquid flow rate and so on.

Processing: The computer analyses the readings and decides whether action needs to be taken.

Output: The computer sends output signals to devices which manage the process to increase pressure or temperature, for example. Some systems use an actuator, which is a device that reacts to a computer signal and operates a simple device such as a tap, motor or switch to regulate liquid flow.

Most of these systems use feedback, where the output affects the input.

Weather forecasting

Some of the world's most powerful computers are used to forecast the weather, which improves the accuracy of forecasts. People who rely on these forecasts include television companies, shipping companies, farmers, the military and outdoor sports organisations. Computer systems are also used to track hurricanes and tornados, monitor global warming, and monitor the ocean for systems of currents such as El Niño. Automatic data recording for weather forecasting has several advantages:

- It is more accurate than manual data collection.
- Computer data can be collected continuously whereas humans may get tired, and it can also be collected in situations not safe for humans.
- It is extremely fast. Computers can easily take thousands of measurements in a second. This means that events which could not be measured by a person can now be recorded for analysis later.

Table 2.6 *Sensors and their applications*

Sensor	Quantity measured	Application
Temperature sensor	How hot/cold it is	Monitoring the temperature in an oven
Light sensor	How light/dark it is	Turning street lights on when it is dark
pH sensor	The acidity of a liquid	Monitoring water pollution
Proximity sensor	Detects how close an object is to another object	Detecting how close a vehicle is when its driver is reversing near to a wall
Pressure pad	If a pad is being pressed	Detecting cars arriving at traffic lights
Button	If the button is being pressed	Obtaining a ticket to a paid car park
Light gate	Detects an object passing through the gate	Measuring the speed or acceleration of objects
Passive infrared (PIR)	Detects when a warm object moves into an area	Activating a burglar alarm if someone enters a room

Weather forecasting example

Input: Millions of pieces of data (observations such as temperature, pressure, humidity, infrared radiation) are collected from satellites, weather stations, weather balloons, aircraft, radar, weather ships and automatic weather buoys. All these readings are sent to the respective meteorological office's computer systems.

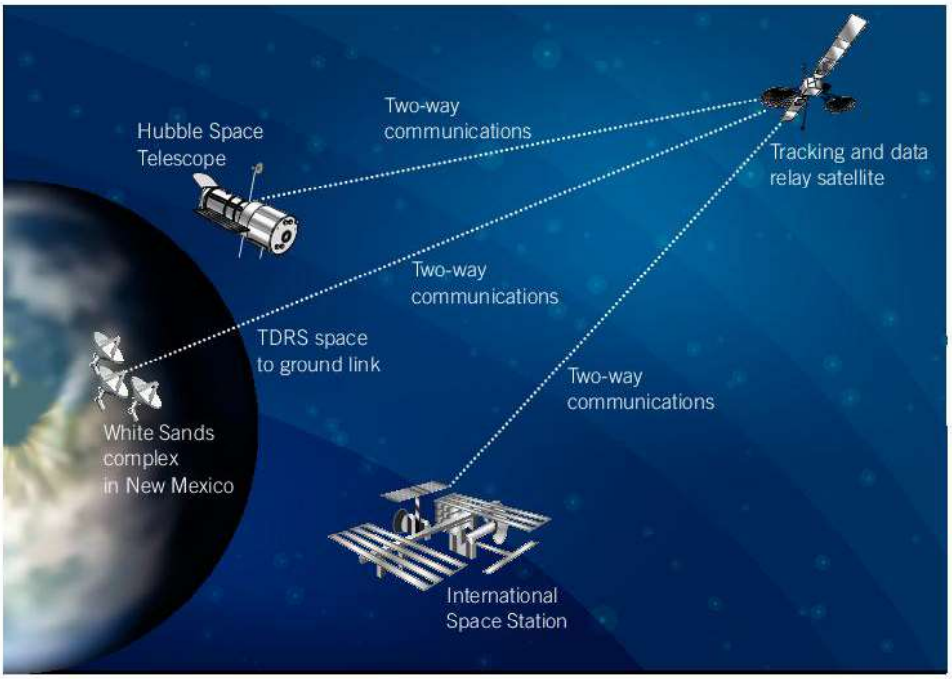


Fig 2.17 Data is collected from satellites orbiting the earth

Processing: The data is stored in a large database. The first task is to perform a quality control check on the data (validation) and to reject all invalid readings.

The data is formatted to fit in with a numerical model of readings. From this computer model, forecasts can be made. The bulk of processing is 'number-crunching' and solving thousands of inter-related equations.

Output: The forecasts are normally produced as global and local charts of weather information.

Supermarket stock control

Most businesses need to hold stocks of goods. Shops need to hold stocks of goods they sell, and manufacturers need to hold stocks of raw materials and

finished goods they make. The task of recording and maintaining stock levels is called stock control.

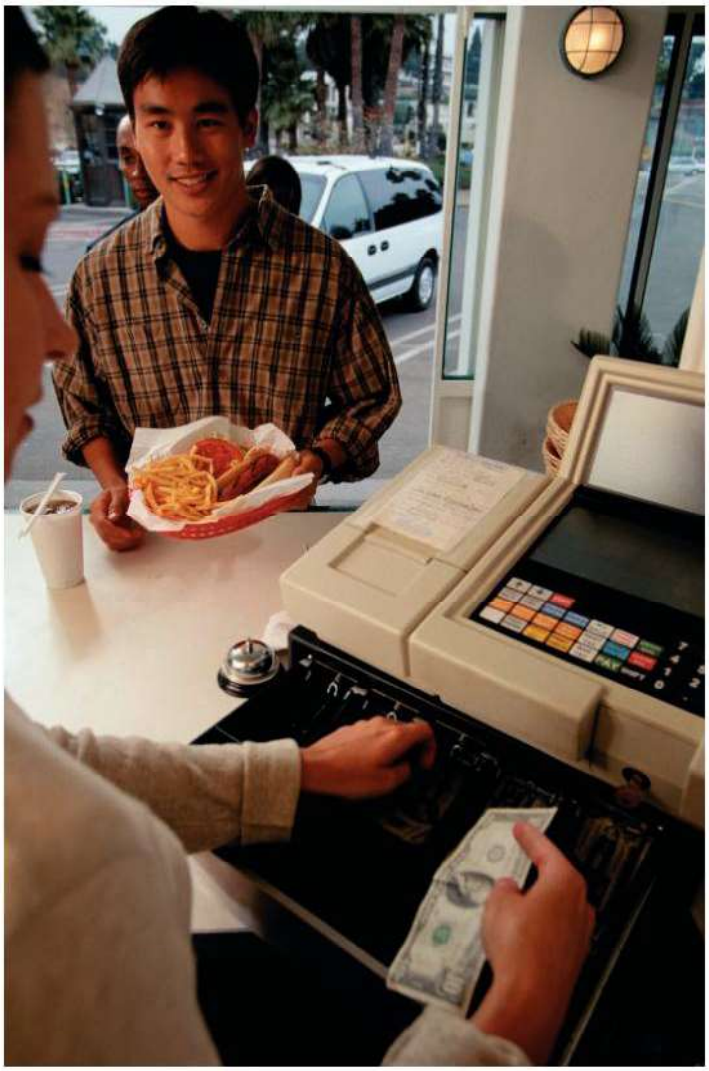


Fig 2.18 A point of sale terminal

A stock control system must keep an up-to-date record of all the stock held and place orders for fresh deliveries if stock runs low. Large shops, supermarkets and factories use computerised stock control systems.

Stock control is important as:

- Adequate stocks must be maintained to supply a customer with goods with minimum delay. If customers find goods are regularly out of stock they will go elsewhere.
- Goods must not be overstocked. By keeping stocks to a minimum, a business can limit the amount of money invested in stock and also reduce the risk of stock deteriorating before it can be sold. Minimum stock levels also reduce storage costs such as warehousing, heating, lighting and security.

A real-time stock control system

Input: The operator at a POS terminal only needs to pass the barcode on each item past a laser scanner. The scanner reads the code number stored in the barcode and sends it directly to a computer. The computer checks the code and, if it is valid, looks up the product's name and price in data files held on disk. The name and price are sent back to the POS terminal.

In this way the POS terminal can print out an itemised receipt. Note that with POS systems, prices are usually only marked on shelves and not on individual items, which can cause customer confusion. Each terminal has a keypad or keyboard that can be used if a barcode cannot be read.

Processing: As each item is sold, the stock files are updated so that customer service can be much quicker, reducing queues. Few mistakes can be made in charging customers. Prices can be changed easily. A fully itemised bill can be provided for the customer. No staff are needed for counting stock on shelves.

Output: Orders are printed when stock levels reach a re-order point. Customer receipts are printed using thermal printers.

Questions

1. Give an example of the processing required to determine if a customer's bill is overdue.
2. Give three examples of data that sensors can be used to measure.

Multiple choice questions

1 The manipulation of data to obtain information is called:
- **a** input
- **b** output
- **c** processing
- **d** storage.

2 Information that represents a 'whole' picture of a problem or solution is:
- **a** accurate
- **b** complete
- **c** relevant
- **d** timely.

3 A _____ check compares the contents of two or more fields to make sure that they make sense.
- **a** consistency
- **b** range
- **c** data type
- **d** format.

4 Hardware errors can be caused by any of the following, *except*:
- **a** bad sectors on a hard disk
- **b** corrupt RAM
- **c** power surge
- **d** program malfunction.

5 Which of the following checks is used to detect doubtful data?
- **a** length
- **b** range
- **c** data type
- **d** reasonableness.

6 An area code must contain three digits only. The following checks are suitable, *except*:
- **a** data type
- **b** format
- **c** length
- **d** range.

7 A _____ file is a temporary file which is used to _____ data in the main file.
- **i** transaction, delete
- **ii** transaction, update
- **iii** master, delete
- **iv** master, update.

8 To find a record in a file using a sequential search, repeatedly _____ a record until the required record is found.
- **a** read
- **b** save
- **c** write
- **d** update.

9 A fully indexed file contains the record key and the storage address of the:
- **a** average key value
- **b** exact key value
- **c** highest key value
- **d** lowest key value.

10 The access method that calculates the exact address (location) of a record is *most* suitable for which type of file structure?
- **a** serial
- **b** sequential
- **c** fully indexed
- **d** direct access.

Short answer questions

11 A data logging system is used to record, at specific intervals, the temperature of the water in an aquarium.
- **a** State one item of hardware that can be used to capture the temperature readings.
- **b** Explain what the logging system could output if the temperature of the water is too high.
- **c** Describe one advantage of monitoring the water using this data logging system.

12 Aaron uses a login screen as shown below:

- **a** Give two types of applications that would require a user to log on.
- **b** Describe two security measures used on the screen displayed.
- **c** Explain why the password must be entered twice.
- **d** Explain whether re-entering the password twice is an example of verification or validation.
- **e** Explain two messages that the system could show based on the information entered by the user.
- **f** After Aaron has entered his username and password, he needs to press one of the two buttons on the screen to continue. What type of screen is Aaron using?

13 A student enters the following data from an experiment on a sheet that contains the headings and instructions on what to enter:

Results sheet

Experiment number	Start temperature	End temperature	Temperature difference
1	40	50	110
b	50	65	15
3	52	68	Yes

- **a** Three errors were made in the results sheet. Explain these errors.
- **b** Explain each of the following checks as it relates to the results sheet above:
  - **i** data type check
  - **ii** range check.
- **c** Describe how the student could confirm that the data from the table is equivalent to the data on the sheet.
- **d** The four statements below show the different descriptions during the experiment when completing the sheet. Match each of the descriptions with the most suitable term from the list below:

  Terms: source document/turnaround document/ machine-readable document/soft copy/hard copy

  Statements:
  - **i** The blank sheet before the student writes in results from the experiment.
  - **ii** The sheet is scanned and saved as a PDF file.
  - **iii** Results from the data on the sheet are used to produce a set of charts which are viewed on a monitor.
  - **iv** The completed sheet and charts are printed.
- **e** A teacher needs to print 70 copies of the sheet for the next class.
  - **i** Explain which type of printer would be suitable for this task.
  - **ii** No pages are being printed, even if the teacher selects the print icon repeatedly. Explain two possible causes of this problem.

14 Consider the following illustration of a supermarket, where items are placed in aisles:

Aisle	Locator	Item #
1	35	25 – Carrots 27 – Cucumber 29 – Lettuce 32 – Sweet pepper
2	50	38 – Disinfectant 40 – Liquid soap 43 – Scrub buds 47 – Sponges

- **a** State the path taken to locate the:
  - **i** lettuce
  - **ii** sponges.
- **b** Suppose you were looking for item #30 (ginger).
  - **i** State the aisle and locator that you would choose and the item # that would indicate whether it is there or not.
  - **ii** What does the number of the locator represent?
- **c** Explain whether this is an example of direct, sequential or index-sequential file organisation.