

INTRODUCTION

This unit is designed to provide support material for the teaching of Computer Systems at Intermediate 2 level. The unit may be studied as a stand-alone unit or combined with other units as part of the Computing course at Intermediate 2 level. It is also possible for the unit to contribute towards a Scottish Group Award.

There are two outcomes in the unit, requiring candidates to demonstrate:

1. knowledge and understanding of a range of facts, ideas and terminology related to the principles, features and purpose of computer systems
2. practical skills in the context of computer systems using contemporary hardware and software.

Knowledge and understanding and practical skills are to be demonstrated in the following contexts:

1. data representation
2. computer structure
3. peripherals
4. networking
5. computer software.

Data representation provides an introduction to the methods used to represent numbers, text and graphics on a modern computer system. Computer structure covers the basic internal components of computers and how they interact with each other. The section on peripherals examines the characteristics of a wide range of devices that can be connected to a computer. Networking provides a history of the development of computer networks and the advantages of networking computers. Computer software delves into the world of operating systems, application packages and computer viruses.

Satisfactory performance in Outcome 1 will be achieved when the candidate has passed the objective test for this outcome. Outcome 2

requires the candidate to exhibit the practical skills outlined in the arrangements document. These consist of:

- use of standard operating system functions
- use of the main functions and features of a standard application package
- use of standard file formats for text files
- accessing a local area network using a network client
- accessing the internet for www and e-mail.

This can be done by direct observation of the candidate while working through the course and recorded in the checklist provided in the National Assessment Bank materials provided by SQA. Evidence should be gathered from one of the activities outlined in the arrangements document.

Notes for teachers

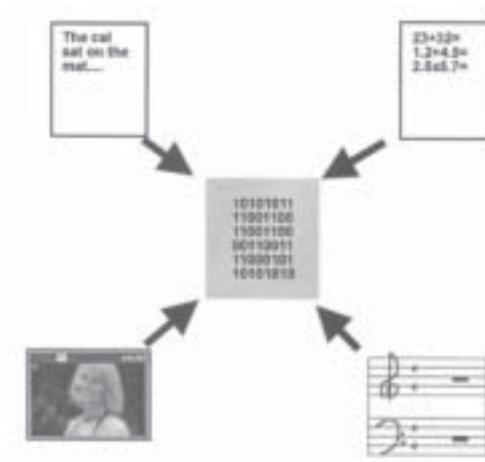
The hardware specifications given in the support materials will require updating in the course of time as technology moves forward.

When teaching the section on computer software, candidates may require to spend time learning the features of the application packages listed, i.e. word processor, database, spreadsheet and graphics. The approach taken in the notes is to identify the objects and operations available in each package. Ten hours have been nominally suggested as an appropriate time span for this part of the unit; most of the 10 hours will be needed for candidates to gain experience of using each application.

The practical tasks given in this booklet are not prescriptive and centres may decide to use their own tasks to produce evidence of satisfactory completion of Outcome 2.

SECTION 1**Data representation****Bit (binary digit)**

Computers are used to store a variety of information including numbers, text, graphics and even sound. Regardless of the type of information represented, it is all stored as *bit* patterns made up from the digits 1 or 0. In other words everything that is stored on the computer is eventually broken down into its simplest form, which is a pattern of 1s and 0s.



For this reason the computer is sometimes referred to as a ‘two-state’ machine. The two states correspond to the idea of a switch set to on (1) or off (0). There are other two-state conditions with which we are familiar: true/false, yes/no, pass/fail, black/white.

Inside the computer the 1 state is represented by an electrical signal and the 0 state by no electric signal.

Binary is a counting system that is based on using only the digits 1 and 0; as this is a two-state system itself, binary is ideal for representing data of any type.

Storage capacity

All of the data and programs that are used by a computer are represented as bits within the main memory. The storage of these bits is

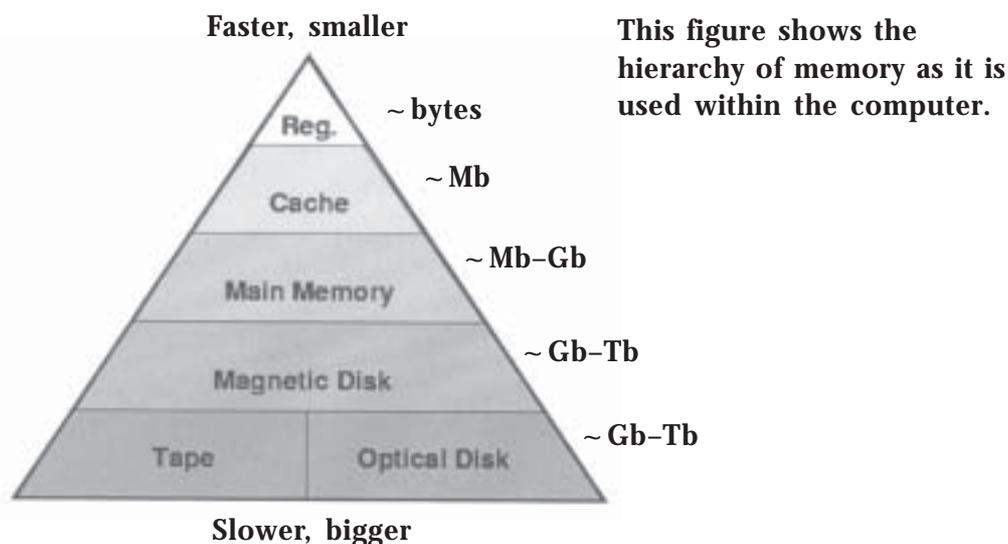
made more manageable by grouping them together in multiples of eight. In fact, the term *byte* is widely used when referring to memory size and file size rather than *bit*.

When file sizes become particularly large it becomes cumbersome to describe them in terms of bytes because the file may be in the order of, say, 2578 bytes or 456,347 bytes. As the computer is a two-state machine it is convenient to express the capacity of memory and backing store in powers of 2. Consequently, the following table represents the hierarchy of memory capacity.

Unit of memory Composed of		Typical files
1 bit	Can be 1 or 0	
1 byte	8 bits	1 character
1 kilobyte (Kb)	$2^{10} = 1024$ bytes	Half an A4 page
1 megabyte (Mb)	$2^{20} = 1,048,576$ bytes	1024 Kb 500 A4 pages
1 gigabyte (Gb)	$2^{30} = 1,073,741,824$ bytes	1024 Mb 500,000 A4 pages
1 tetrabyte (Tb)	$2^{40} = 1,099,511,627,776$ bytes	1024 Gb Enormous!

The units above are used to measure the capacity of both the main memory and the backing store. However, the capacity of backing store devices is much larger than that of main memory.

At the time of writing this unit memory is measured in terms of megabytes and gigabytes (currently up to 3 Gb of RAM), whereas a typical hard disk has a capacity in the order of 80 Gb. No doubt these figures will seem low in future years!



Positive numbers/binary

In our normal counting system we use the digits 0–9 to represent any number. For example, the number 2365 means two thousands, three hundreds, sixty tens and five units. This is called denary because we count in groups of 10 and we use the following column headings for the denary (base 10) system:

Thousands Hundreds Tens Units

$$\begin{array}{cccc}
 \textcircled{2} & 3 & 6 & 5 \\
 \hline
 2 & 3 & 6 & 5 \\
 \hline
 3 & 1 & 2 & 7 \\
 \hline
 5 & 6 & 0 & 3
 \end{array}
 \Rightarrow
 \begin{array}{l}
 2 \times 1000 + 3 \times 100 + 6 \times 10 + 5 \times 1 \\
 3 \times 1000 + 1 \times 100 + 2 \times 10 + 7 \times 1 \\
 5 \times 1000 + 6 \times 100 + 0 \times 10 + 3 \times 1
 \end{array}$$

The table above only goes as up to the thousands column but we can easily to include larger numbers like 1,345,251, which are made up as follows:

Millions	Hundred thousands	Tens of thousands	Thousands	Hundreds	Tens	Units
1	3	4	5	2	5	1

You may have noticed that all we are really doing to get the next column (heading from right to left) is multiplying by 10. This is because the denary counting system is based on powers of 10. We could show the powers in the headings for each column.

Millions	Hundred thousands	Tens of thousands	Thousands	Hundreds	Tens	Units
10^6	10^5	10^4	10^3	10^2	10^1	10^0
1	3	4	5	2	5	1

Binary numbers are grouped in a similar way to denary but the powers go up in 2s instead of 10s and we can only use the digits 1 and 0.

	128s	Sixty-fours	Thirty-twos	Sixteens	Eights	Fours	Twos	Units
	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
(a)	0	1	1	0	1	1	0	1
(b)	1	0	1	0	0	1	1	1

(a) The above binary number 01101101 using 8 bits (1 byte) is:

$$\begin{aligned}
 & 0 \times 128 + 1 \times 64 + 1 \times 32 + 0 \times 16 + 1 \times 8 + 1 \times 4 + 0 \times 2 + 1 \times 1 \\
 & = 64 + 32 + 8 + 4 + 1 \\
 & = 109
 \end{aligned}$$

(b) Similarly the 8-bit binary number 10100111 above is:

$$\begin{aligned} & 1 \times 128 + 0 \times 64 + 1 \times 32 + 0 \times 16 + 0 \times 8 + 1 \times 4 + 1 \times 2 + 1 \times 1 \\ & = 128 + 32 + 4 + 2 + 1 \\ & = 167 \end{aligned}$$

Any *positive whole number* in base 10 can be represented in this way. The same table heading can be used to convert numbers from denary into binary. We will continue to use 8 bits to represent each number.

128s	Sixty-fours	Thirty-twos	Sixteens	Eights	Fours	Twos	Units
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Consider the number 93. We can work out its equivalent in binary as follows:

The number 93 is less than 128 but more than 64 so we put 0 in the 128s column and a 1 in the 64s column. We are trying to build up the digits until we get to 93.

128s	Sixty-fours	Thirty-twos	Sixteens	Eights	Fours	Twos	Units
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
0	1						

If we add 32 to the 64 we get 96, which is too large, so we do not need a 32. Put 0 in the 32 column:

128s	Sixty-fours	Thirty-twos	Sixteens	Eights	Fours	Twos	Units
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
0	1	0					

Next we add a 16 to the 64 to give 80. This is still short of 93 so we add an 8 to get 88, which is still short. Adding a 4 gives 92. Adding a 2 gives 94, which is too much so we put 0 in the twos column. Now add a 1 in the units column, which gives 93.

128s	Sixty-fours	Thirty-twos	Sixteens	Eights	Fours	Twos	Units
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
0	1	0	1	1	1	0	1

So the number 93 in 8-bit binary is 01011101.

Complete Exercise 1 and get your teacher to check the answers.

Remember to use *all 8 bits* to represent the number, i.e. do not forget to put in the leading zeros or you will not have written an 8-bit binary number.

Why use binary?

Two-state system

One of the reasons for using binary numbers has already been described as the two-state condition (1 or 0), which has a direct correspondence to the two-state system of 'power on/power off'. The simplicity of having only two possible conditions reduces the practical problem of generating and detecting only two voltage levels.

Degradation of data

The voltage levels in a computer used to represent the 1 and 0 conditions are +5 volts and 0 volts, respectively. However, whenever electricity is used there is the possibility of interference in the signal from an outside source, e.g. a magnet. This could mean that the +5 volts becomes +4 volts. This is referred to as *degradation of data*. If we were to use our denary (base 10) counting system and the +5 volts was used to represent the number 5, this could be degraded to become 4.

Using binary avoids this problem as there is still a 'power on' source, and even though it is not quite +5 volts it can still be recognised as representing a 1.

Few rules for addition

When you were taught to add numbers in primary school it was necessary to learn the rules of addition, e.g. $1 + 0 = 1$, $1 + 1 = 2$, $1 + 3 = 4$, $1 + 5 = 6$, $1 + 7 = 8$, $1 + 8 = 9$, $1 + 9 = 10$. That's only the rules for the number 1; you still needed to know the rules for adding every other digit to each other between 0 and 9. In fact there are 100 rules for simple addition in our counting system.

In binary there are only four rules for addition! They are:

$0 + 0 = 0$; $0 + 1 = 1$; $1 + 0 = 1$; $1 + 1 = 10$ (remember that's not ten it's actually two!)

This means that performing any additions in binary is easier to code than using base 10 as there are far fewer rules involved.

In summary the main advantages of using binary are:

1. binary is a simple two-state system (1 or 0) which is ideal when representing a two-state system of 'power on/power off'
2. a degraded signal can still be detected as representing 1
3. there are only a few rules for addition, making calculations simpler.

Floating point representation

Having found a method of representing positive whole numbers we now have to consider how to represent very large and very small numbers. If we used conventional binary methods then too much memory would be used just to represent numbers.

The technique used to solve this problem is similar to standard form, which you are taught in mathematics, and it is called *floating point representation*.

In standard form you are taught to write the number 341,264.89 as

$$\text{Mantissa} \longrightarrow \textcircled{3.4126489} \times 10^{\textcircled{5}} \longleftarrow \text{Exponent}$$

The rule is to place the decimal point just after the first digit and to count the number of places that it has been moved. This number is then written as the power or *exponent* of 10. In this case the point was moved five places.

We have a *binary point* in binary just as we have a *decimal point* in the denary counting system. However, the rule is to move the point in front of the digits. So the binary number

1101.001101110010

is written as

$$\text{Mantissa} \rightarrow \text{.1101001101110010} \times 2^{\text{00000100}} \leftarrow \text{Exponent}$$

Notice that we have moved the binary point four places but the exponent is written as 00000100. This is not one hundred; it is the number 4 in binary. (*Also note the leading zeros in the exponent.*)

In the example above we have allocated 2 bytes for the mantissa and 1 byte for the exponent. Computers more commonly allow 4 bytes for the mantissa and at least 1 byte for the exponent.

The computer needs only to store the value of the mantissa and the exponent to represent any real number.

As floating point representation involves using a binary point it is clear that the numbers represented are not just whole numbers but can also include fractions and decimals.

ASCII code

When you are using a program and you press a key on the keyboard the program has to have some way of identifying which key you pressed. This is true for any program whether it is a word-processing package, spreadsheet or game. Each character on the keyboard has a unique binary code allocated to it.

The code that is most commonly used to represent text is the *bit ASCII code*. The letters stand for:

A	merican
S	tandard
C	ode for
I	nformation
I	nterchange

Only 7 bits are required to store the code but we usually deal with bits in groups of 8 so an additional bit containing a zero is added to the start of the code.

The table below shows a few ASCII codes and their decimal equivalents.

Character	ASCII code	Decimal
A	01000001	65
B	01000010	66
Z	01011010	90
a	01100001	97
2	00110010	50
Beep	00000111	7
&	00100110	38

Character sets

The complete set of characters that is represented on the keyboard is called the *character set*. This includes all the letters of the alphabet (upper and lower case), the digits 0 to 9, punctuation marks, special symbols, such as %, £, & and #, and *control characters*.

If you study French or German you will realise that our standard English character set does not contain some of the symbols that are used by these languages. This is even more obvious when you consider Chinese or Japanese! Different character sets are used for different languages and it is possible to change the character set used on a desktop computer.

Control characters

Most ASCII characters are either displayed on the screen or can be printed on a printer but there are some that serve a different purpose. Control characters include keys such as RETURN, TAB and DELETE. These are used to send a control signal to a printer, e.g. BACKSPACE or NEW LINE. There is even a character that causes the computer to emit a beep! Sometimes control characters are referred to as 'non-printable characters'. They are the first 32 characters in ASCII.

Data transfer

The simplest form of text document is ASCII. It contains only the character information without any formatting, styles or fonts. Many application programs, such as word processors and spreadsheets, allow you to save a document as plain text, otherwise known as ASCII. Once the document has been saved it can be loaded into other packages that can read the data. ASCII can therefore be used to transfer data from one package to another.

ASCII table

Code	Character	Code	Character	Code	Character	Code	Character
0		33	!	66	B	99	c
1		34	"	67	C	100	d
2		35	#	68	D	101	e
3		36	\$	69	E	102	f
4		37	%	70	F	103	g
5		38	&	71	G	104	h
6		39	'	72	H	105	i
7	beep	40	(	73	I	106	j
8	backspace	41	)	74	J	107	k
9		42	*	75	K	108	l
10	new line	43	+	76	L	109	m
11		44	,	77	M	110	n
12	new page	45	-	78	N	111	o
13	return	46	.	79	O	112	p
14		47	/	80	P	113	q
15		48	0	81	Q	114	r
16		49	1	82	R	115	s
17		50	2	83	S	116	t
18		51	3	84	T	117	u
19		52	4	85	U	118	v
20		53	5	86	V	119	w
21		54	6	87	W	120	x
22		55	7	88	X	121	y
23		56	8	89	Y	122	z
24		57	9	90	Z	123	{
25		58	:	91	[	124	|
26		59	;	92	\	125	}
27	escape	60	<	93	]	126	~
28		61	=	94	^	127	
29		62	>	95	-		
30		63	?	96	`		
31		64	@	97	a		
32	space	65	A	98	b		

Using 7 bits it is possible to store $2^7 = 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 128$ different characters in ASCII. However, the English language requires fewer than 128 characters.

Complete Exercise 2

Graphics

Computers need to have some way of storing graphical images in memory on backing storage devices (e.g. the hard drive) and also of displaying them on a monitor.

Pixels

A *pixel* is the most basic component of any computer graphic. Pixel stands for picture element. It corresponds to the smallest element that can be drawn on a computer screen. Every computer graphic is made up of a grid of pixels. When these pixels are painted onto the screen, they form an image.



(a) A bit-mapped image

(b) Enlarged version of the same image showing individual pixels

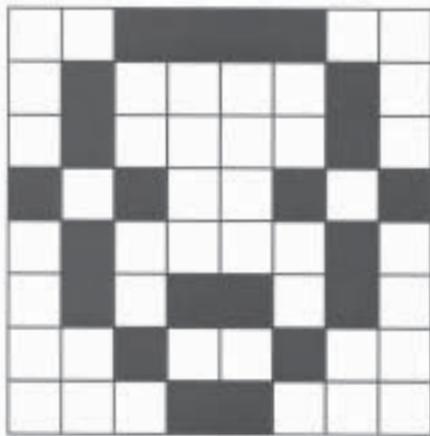
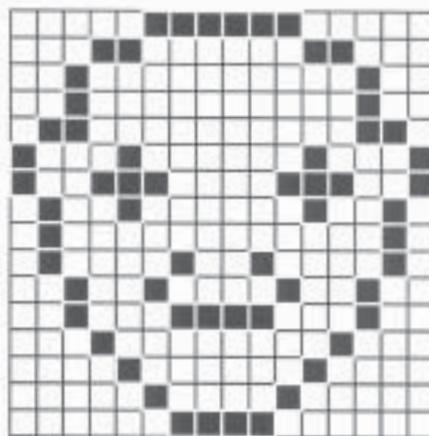
In black and white, each pixel can be represented by 1 bit: 1 if the pixel is black or 0 if the pixel is white. The computer represents the image in memory as a file of 0s and 1s. The computer opens this file then starts looking for numbers that describe image information. Every time it comes to a 0 it draws a white pixel. When it comes to a 1 it draws a black pixel. The file is known as a *bit map*.

There is a one-to-one relationship between the pixels and the bit pattern.



Resolution

The quality of a graphical image is directly related to the number of pixels used to produce it. An image with a large bit map that contains many small pixels will be clearer and sharper than a similar image with a smaller number of pixels. The concentration or density of pixels is called the **resolution** of the image.

(a) Pixel pattern using an 8×8 grid(b) Pixel pattern using a 16×16 grid**Storage**

As each pixel requires 1 bit of storage, clearly an image that is high resolution will have many pixels and consequently will take up more storage space than a low-resolution image.

In the 8×8 bit-mapped grid above each pixel requires 1 bit of storage. There are 64 pixels so this means the image needs 64 bits or 8 bytes of storage (8 bits = 1 byte).

In the 16×16 bit-mapped grid there are 256 pixels. The storage requirements are 256 bits or 32 bytes.

In both of the above examples the resolution is very low and the images appear jagged and crude but you can still see that the 32-byte image has more detail than the 8-byte one.

Calculate the storage requirements for the happy face image given on the previous page.

Dots per inch (dpi)

When purchasing a printer or scanner you may have noticed that one of the features often listed is the dpi. This means *dots per inch* and is a measure of the density or concentration of pixels in a linear inch. By purchasing a device with a high dpi your images can be scanned or printed to a higher resolution and consequently be of high quality. The down side is that storing these images will take up a lot of RAM when the image is loaded and a great deal of disk space when the image is saved.



This compact, lightweight and stylish yet power-packed for rugged, mobile use printer delivers uncompromised desktop printing: photo-quality printing with up to 4800 by 1200 optimised dpi on premium photo paper and print speeds of up to 9 pages per minute in black and up to 8 pages per minute in colour.

HP DeskJet 450Cbi: inkjet printer, 1200 × 1200 dpi (black), 4800 × 1200 (optimised color), 9 ppm black and 8 ppm colour (draft mode), 16 Mb RAM. Connects via Parallel, USB and Fast Infrared. Comes with lithium-ion battery, direct storage card/compact flash card printing, Mac & PC compatible

- Product description - HP DeskJet 450Cbi - printer - colour - ink-jet
- Printer type - personal printer - ink-jet - colour
- Dimensions (W × D × H) - 13.3 in × 7.4 in × 3.3 in
- Printer output - 9 ppm - black draft | 5 ppm - black normal | 1.6 ppm - black best | 8 ppm - colour draft | 2 ppm - colour normal | 1 ppm - colour best | 0.5 ppm - photo draft | 0.3 ppm - photo normal | 0.1 ppm - photo best | 1.1 ppm - photo draft - 4 in × 6 in | 0.7 pp
- Max resolution (b&w) - 1200 × 1200 dpi
- Max resolution (colour) - 4800 × 1200 dpi

The maximum black and white resolution of the above printer is 1200×1200 dpi. Consider the image below.

5 inches



4 inches

$$\text{length} = 1200 \times 5 = 6000 \text{ pixels}$$

$$\text{breadth} = 1200 \times 4 = 4800 \text{ pixels}$$

$$\begin{aligned} \text{total no of pixels} &= 6000 \times 4800 \\ &= 28,800,000 \text{ pixels} \end{aligned}$$

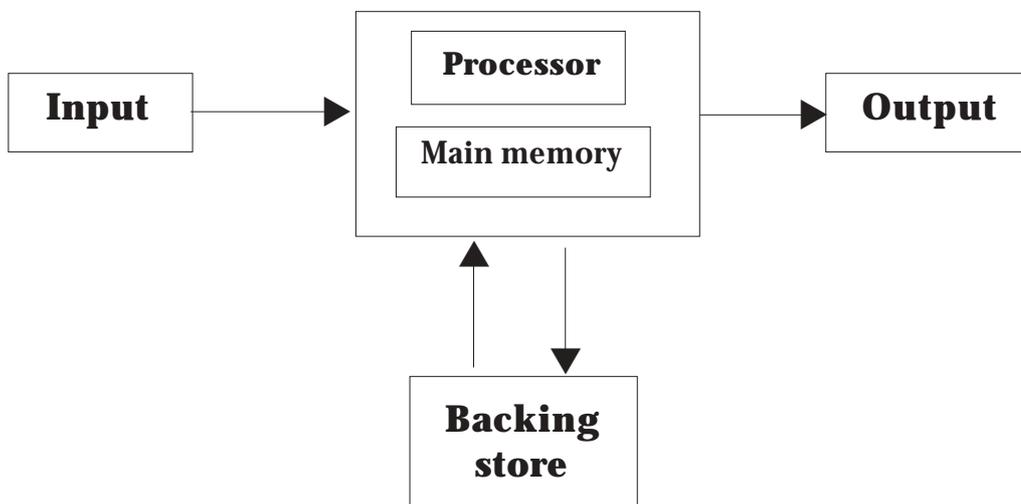
$$\begin{aligned} \text{1 pixel needs 1 bit of data} \\ \text{storage} &= 28,800,000 \text{ bits} \\ &= 3,600,000 \text{ bytes} \\ &= 3515.625 \text{ Kb} \\ &= \mathbf{3.43 \text{ Mb}} \end{aligned}$$

Complete Exercise 3



SECTION 2**Computer structure**

The diagram below shows the components used in a typical computer system. It is a simple representation of how a computer works and is often referred to as the 'four box diagram'.

Four box diagram

When your computer is switched off all programs and data are held on backing store media such as hard drives, floppy disks, zip disks and CD-R/W. Once the computer is switched on, the operating system is loaded from the backing store into main memory (RAM). The computer is now ready to run programs.

When the user opens a word processor file both the application program and the file itself are loaded into the main memory. The user may then edit the document by typing on the keyboard. It is the processor that controls the timing of operations and runs the word-processing program, allowing the user to add new text.

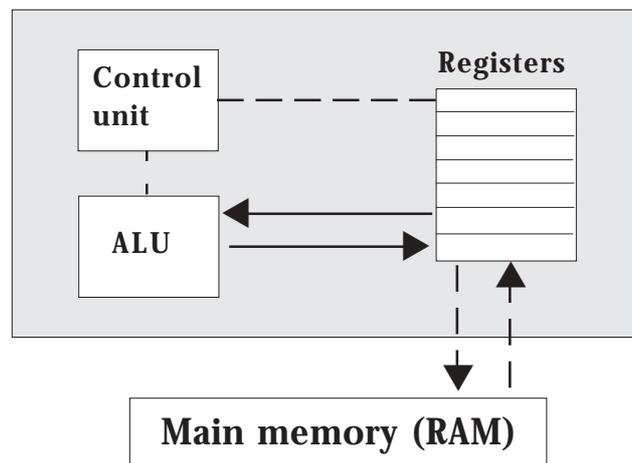
Once the editing is complete, the user saves the file to the backing store and this over-writes the original file (unless a new file name is used). If there is a power failure or the user does not save the document to the backing store then the file will be lost forever.

Throughout this process the document is outputted to the monitor so that the user can see what is happening. The user may wish to obtain a hardcopy of the document by using the mouse (input) to instruct the processor (process) to make a printout (output).

This example shows the relationship between the backing store, the main memory and the processor.

The processor

The processor is at the heart of the computer system and forms the main component of the computer itself. Within the processor are the *control unit*, the *arithmetic and logic unit (ALU)* and *registers*. Together they are responsible for the overall operations that make the computer work.



Computer programs are simply a list of instructions that have to be carried out in a particular order. The control unit sends signals that fetch each of these instructions in turn from the main memory (they are held in registers within the processor). It then decodes and executes them. The ALU is involved from time to time where it is necessary to perform arithmetic calculations or make logical decisions. This is far removed from the games and application programs with which you are familiar but all programs are run in this manner.

Control unit

The main functions of the control unit are:

1. to control the timing of operations within the processor
2. to send out signals that fetch instructions from the main memory
3. to interpret these instructions
4. to carry out instructions that are fetched from the main memory

In general the control unit is responsible for the running of programs that are loaded into the main memory.

Arithmetic and logic unit

The main functions of the ALU are:

1. to perform arithmetic calculations (addition, subtraction, multiplication, division)
2. to perform logic functions involving branching, e.g. IF...THEN

Registers

These are temporary storage areas within the processor that are used to hold data that has been fetched from the memory or produced during a calculation.

Main memory

The main memory of a computer is composed of ROM and RAM.

Read Only Memory (ROM) is used to store a small part of the operating system called the bootstrap loader. When your computer is switched on, the bootstrap loader examines the backing store devices to find the operating system. Once found it is loaded into RAM.

ROM has the following features:

1. data in ROM is permanently etched onto a microchip
2. ROM is read-only so it cannot be changed
3. data on ROM is not lost when the computer is switched off.

Random Access Memory (RAM) is the largest part of the main memory. This is where the operating system is stored; it also holds all programs and data. You can purchase additional RAM chips and install them in your desktop computer.



RAM chips: to improve system performance they can be added to your computer, increasing the ram from, say, 256 Mb to 512 Mb.



RAM has the following features:

1. the data in RAM is read/write so it can be changed
2. all data stored in RAM is lost when then computer is switched off
3. RAM is sometimes referred to as primary storage.

Storage refers to the media and methods used to keep information available for later use. Some data will be needed right away while some won't be needed for extended periods of time. Different methods are therefore appropriate for different uses.

The main memory holds the data that the processor needs immediately and for this reason it is sometimes called *primary storage*. However, the main memory is not as large as the backing storage devices and there has to be some way of saving data when the computer is turned off (remember that all the contents of the main memory are lost when the power is switched off); this is where the backing store comes in. By saving your files and programs onto the backing store they will still be there even after the computer is switched off. As any data saved to the backing store must first be stored in the main memory, the backing store is sometimes called *secondary storage*.

Descriptions of different computer systems

The details of the specifications included in this section are accurate at the time of writing. It will be necessary to update them as technology advances by consulting the latest magazines.

This section covers:

- desktop computers
- portable systems, including laptops and palmtops
- mainframe computers
- embedded computer systems.

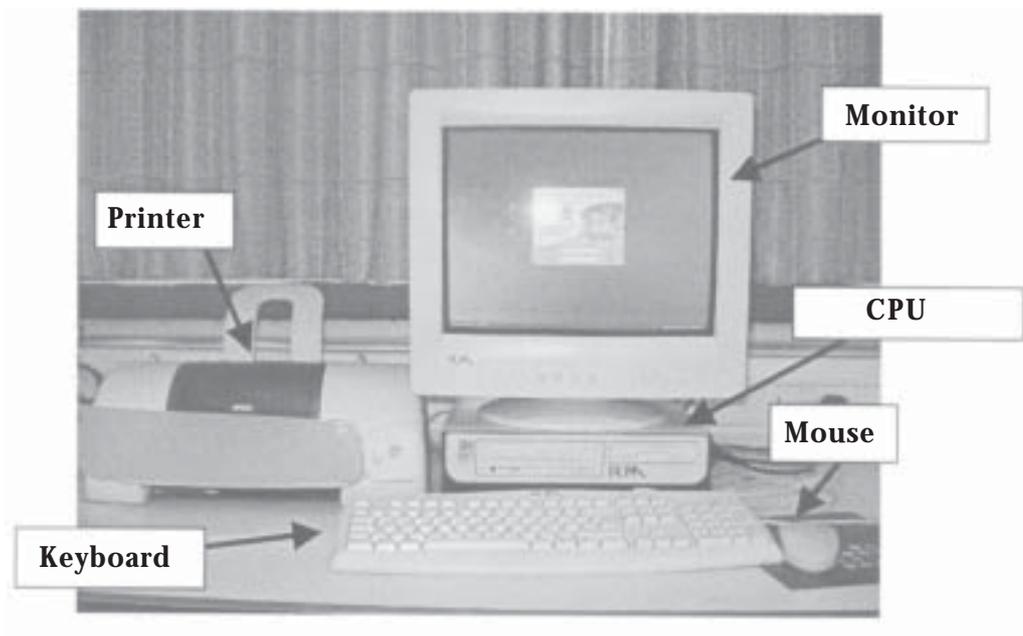
A computer system is described by reference to:

- its processing power
- the size of its memory
- its backing storage
- its input and output devices.

In the following section, these topics are discussed for each type of computer system listed above.

Desktop computer

Sometimes known as a personal computer, this is a computer system that can fit on your desk at home, work, school or college. The individual elements of a desktop computer vary according to the needs of the user. Some users need a general-purpose desktop computer to run a range of applications; others need a desktop computer that will form a workstation on a network. A typical desktop computer comprises a central processing unit (CPU), a monitor, a keyboard, a mouse and a printer. The CPU includes the processor, the main memory and other important electronic circuits.



Processing power

To judge the processing power of any computer system accurately is a complex task that takes into account a range of factors beyond the scope of this unit. It is dealt with in depth in the Computer Systems unit at Higher. For the purposes of this unit we will use the clock speed of the processor as the main indicator of the processing power of a system. The clock in a computer system is a regular stream of electronic pulses in the control circuit that keeps everything working in time. The speed of the clock is measured in MHz (MegaHertz) or, more recently, in GHz (GigaHertz). A processor working at 900 MHz sends out 900 million clock pulses per second. The most recent desktop computers have processor speeds of up to 3.2 GHz. These processors have the ability to handle complicated graphics, text, number, and data processing tasks and are ideal for video editing.

Memory size

Recent desktop computers commonly have 256 Mb of RAM, usually expandable to 3 Gb (depending on the motherboard and processor). Memory of this size is used for graphics, multimedia applications and to meet the needs of ever-expanding operating systems.

Backing storage devices

All desktop computers are fitted with a variety of backing storage devices. These may include:

- a large-capacity hard disk, which is commonly in the region of 80 Gb but can be up to 200 Gb. This is necessary to hold digital images, particularly video; 30 s of video can take up to 20 Mb of disk space.
- a CD ROM drive or DVD drive, used to store software and data files that do not need to be updated. Rewritable CD drives may be added to the system if needed.
- DVD-RW drives are now becoming very popular both as back-up devices and to store digital video images.

Input devices

Most desktop computers have a standard keyboard and mouse. Depending on the use made of the system, additional specialist devices may be required. These include:

- a microphone for speech input
- a webcam for video conferencing
- a graphics tablet for artists or graphic designers

- a scanner to capture ready-made graphics or images from a page, or to input text and convert it to an editable text file using optical character recognition (OCR)
- a joystick for game playing.

Output devices

All desktop systems can produce printed output (known as hardcopy) and screen output (known as softcopy). Most can also produce sound output. Output devices include:

- an inkjet or laser printer: a standard requirement of all desktop systems. Both inkjet and laser printers are capable of producing quality hardcopy output.
- a screen or monitor: many desktop systems have 17" monitors as standard, 1600 × 1200 pixels, which enable desktop systems to produce high-quality graphical images. Thin-film transistor (TFT) monitors (using liquid crystal display (LCD) technology) have also become popular.
- speakers: a desktop system used to run multimedia applications should have a pair of good-quality speakers attached.
- modem: used to transfer data across a public communications system.
- network interface card (NIC): home networking is now a reality, with computers sharing devices, data and internet access.

Typical applications

Typical applications that can be run on a desktop computer are:

- word processing
- database
- graphics
- communications – internet browser
- spreadsheet
- desktop publishing software
- presentation software.

A multimedia desktop computer can also run multimedia authoring software (for editing videos) as well as multimedia information systems such as Grolier (a multimedia encyclopedia).

Computers that are intended for game playing will usually have a graphics card installed with 256 Mb of onboard RAM. This can process 3D graphics.

Computers communicate with external devices such as printers and modems using parallel and serial ports. However, faster ports have now been developed and are common on most desktop computer systems. They include universal serial bus (USB) and Firewire. In fact, USB 1.0 is now being superseded by USB 2.0, which has a much faster data transfer rate.

Portable systems: laptops

Processors

Processors for laptops are very powerful; in many cases just as powerful as those used on desktops. A current top of the range system is 2.4 GHz, with 512 Mb of RAM. Some manufacturers produce specially designed processors that work at a lower voltage than ordinary processors. These systems reduce the amount of power used, an important factor in a small portable system.



Backing storage devices

Laptops employ a range of different types of backing storage. A laptop might be fitted with some of the following:

- a 40 Gb hard drive
- a removable 3.5" floppy drive
- a combination 8× DVD-ROM and 8×/4×/24× CD-RW drive.

Input devices

Common input devices are:

- a pointing stick or touchpad: these devices take the place of a mouse, which is bulky to store and carry and also needs space for its mouse mat
- a keyboard: laptops often have the full set of 89 characters found on standard keyboards.

Output devices

Common output devices include:

- **LCD screens:** these are used because they are light, compact and can run on the low power provided by small batteries. LCD screens can be quite large, around 12 or 13" in size, and they generally have high resolution (1024 × 768 pixels)
- **small built-in speakers**
- **infrared communications facility** for sending or receiving data to and from a desktop computer
- **modem**
- **NIC**
- **USB or Firewire interface** to allow other devices to be connected to the laptop.

Uses

Mainly used as a portable computer system between the user's place of work and home.

Portable systems: palmtops and portable document assistants (PDAs)***Processing power***

Palmtops have less powerful processors that run at slower speeds than desktop processors, often between 200 and 500 MHz.

Memory size

Installed memory is the amount of available memory that comes with the PDA. This is much less than a laptop or desktop. You can usually add more memory through an expansion slot. Even the newer, colour Palm models come with only 64 Mb of memory.

Backing store

Unlike other computers, the RAM is used as a backing store device in a PDA. This means that a constant current has to be applied to preserve the data. Additional backing store can be purchased and plugged into the PDA (often the same type used by digital cameras). Sizes range from 32 Mb to 2 Gb.

Input devices

Palmtop systems use special input devices to enter data. These include:

- touch screens that require a stylus to enter data. Some devices have a jog dial, which allows the user to scroll through pages and make a selection quickly; others use keyboards
- voice input: many palmtops have a microphone and typically can record around 16 minutes of speech per megabyte of memory available in the system
- a keyboard: some palmtops have a 61-key keyboard
- infrared receiver: many palmtops make use of an infrared receiver/transmitter to exchange data with other palmtops or with a desktop computer or printer
- some PDAs come with built-in modems for web browsing and e-mail, while others come with wireless capabilities, such as a cellular phone connection.

Output devices

Palmtop systems employ a variety of output devices including:

- LCD screens: often these are backlit for extra clarity. However, screen sizes are small, the largest being around a 6.5" diagonal. Resolutions vary, the highest being in the range 640 × 480 pixels
- a speaker
- an infrared transmitter to receive data from other compatible devices
- a wireless connection to other computers.

Mainframe computers

One of the first types of computers to be used commercially was the mainframe. This system operates by sharing a processor between a large number of 'dumb terminals'. These terminals are composed of a monitor and a keyboard, but they do not have their own processor, hence the term 'dumb'.



Large businesses, such as banks and insurance companies, use mainframes to allow their remote branches access to the processor, which is held in a central location. The processor has to be very powerful as huge amounts of data are dealt with. Imagine the number of credit card transactions throughout the country that are processed in a single day. Mainframes support *multi-access* and *multi-programming*.

Processing power

A mainframe computer will have several processors that work together, making the machine extremely powerful.

Memory size

There is usually vast amount of memory. Some modern mainframes can support more than 32 Gb of main memory!

Backing store devices

These are typically greater than 100 Gb hard disk. Tape drives are also used for back-up or batch processing.

Input devices

Keyboard.

Output devices

Line printers, page printers and monitors.

Embedded computer systems

An embedded system employs a combination of hardware and software to perform a specific function. It is often part of a larger system that may not be a 'computer' and it works in a real-time environment that is affected by time constraints.

Embedded systems come in a tremendous variety of sizes and types. An embedded system may be as small as a single 8-pin integrated circuit that performs the functions of a few logic gates, or may be as large as a system with 256 Mb of memory, a small disk (20 Gb or so), a Pentium processor and a host of intelligent peripherals. The range of physical size and computing power is huge, but all embedded systems have these features:

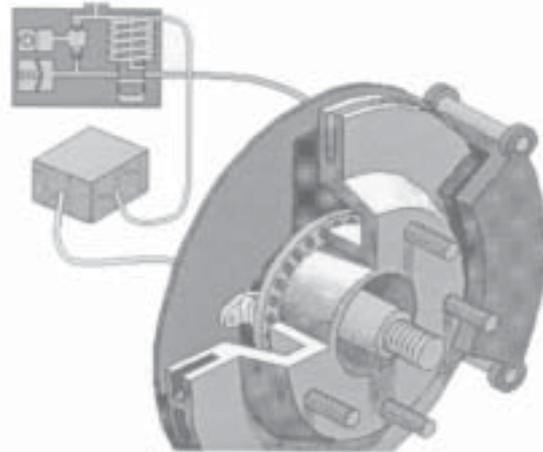
- they perform a very well-defined task for the product, equipment or system in which they are found
- they do not permit user interaction with their operation except where such interaction may be the task of the embedded system
- they are considered to be a component of the (usually much larger) product, equipment or system.

Some applications of embedded systems are:

- **consumer electronics**
 - cameras, camcorders, cellular phones, PDAs
 - CD players
 - timing and control electronics in microwave ovens, coffee makers
- **consumer products**
 - washing machines, fridges, microwave ovens
 - controllers for vacuum cleaners and washing machines for sensing dirt loads
 - cars: control of the dashboard, ignition, fuel injection, suspension stiffness and environmental temperature and anti-lock braking systems
- **industrial/communications products**
 - printers, fax machines
 - robotic devices
 - elevator, environmental and security systems in buildings
- **multimedia applications**
 - video conferencing servers,
 - interactive game boxes, TV set-top boxes
 - keyboards and other controllers for computers.

Anti-lock braking systems

An anti-lock braking system (ABS) is a system on motor vehicles that prevents the wheels from locking while braking. The purpose of this is twofold: to allow the driver to maintain steering control and to shorten braking distances.



A typical ABS is composed of a central electronic unit, four speed sensors (one for each wheel) and two or more hydraulic valves on the brake circuit. The electronic unit constantly monitors the rotation speed of each wheel. When it senses that one or more wheel is rotating slower than the others (a condition that will bring it to lock), it moves the valves to decrease the pressure on the braking circuit, effectively reducing the braking force on that wheel.

When activated, the ABS causes the brake pedal to pulse significantly. As most drivers rarely or never brake hard enough to cause brake lock-up, and rarely bother to read the car's manual, this is usually not discovered until an emergency. When drivers do encounter an emergency situation that causes them to brake hard and thus encounter this pulsing for the first time, many are believed to reduce pedal pressure and thus lengthen braking distances, contributing to a higher level of accidents rather than reduced! Some manufacturers have therefore implemented brake assist systems that determine that the driver is attempting a crash stop and maintain braking force in this situation.

The ABS equipment may also be used to implement traction control on acceleration of the vehicle. If when accelerating, the tyre loses traction with the ground (icy conditions), the ABS controller can detect the situation and apply the brakes to reduce the acceleration so that traction is regained.

ABS is typical embedded system: it forms part of a larger system, involves the use of sensors and works in real-time.

Seat-belt alarm control

Modern vehicles are fitted with a seat-belt alarm which is activated once the driver turns the ignition key. When the driver turns on the ignition key a timer is activated. The driver has 5 seconds to fasten his/her seat belt or the alarm will sound. The alarm stops if the driver fastens the seat belt within a further 5 seconds. If the driver fails to fasten the seat belt within the 5 seconds then the alarm will switch off.



The actual workings of the seat-belt system are given below.

```

IF key in THEN
  Start timer
  IF timer=5 s THEN
    Sound alarm
  END IF
  IF belt on OR key off THEN
    Alarm set to off
  END IF
  IF belt on OR key off OR timer=10 s THEN
    Alarm set to off
  END IF
END IF

```

This is another example of an embedded system:

- it has a well-defined task
- it forms part of a larger system
- it involves the use of sensors
- it works in real-time
- in this case it allows the user to interact with the embedded system as the whole point is to encourage the driver to fasten their seat belt.

In summary, we can say that:

- embedded systems are components of a larger system
- the function of embedded systems is determined by the software installed in them

- embedded systems are available in a large variety of sizes and configurations
- the advantages of embedded systems are:
 - they can be used to create many new devices and products
 - they can be easily adapted or modified
 - they are ROM based, so operate very quickly.

Processing power

This varies depending on the manufacturer but a standard computer processor can be used when installed on a compact motherboard. Processor speeds currently quoted are up to 600 MHz.

Memory size

This depends on the particular embedded system but can be as small as a single bit, or as large as the requirements of a full-scale computer, i.e. 512 Mb or more.

Backing store devices

Sometimes there may be no backing system (as in the example of a seat-belt alarm system). However, where there is a need for backing store it is usually in the form of flash memory, like the cards used in digital cameras. Their capacity is in the range 32 Mb to 2 Gb.

Input devices

As embedded systems are very versatile, there is a wide range of possible input devices:

- mechanical: strain gauges, keyboards, mouse, buttons
- electrical: field probes/sensors, network cables
- magnetic: tape heads, disk heads
- optical: wands, cameras
- sound: microphone.

Output devices

- mechanical: impact printers, card punches
- electrical: network cables
- magnetic: tape heads, disk heads
- optical: cathode-ray tubes, projectors
- sound: speakers.

Embedded systems are the fastest growing area in the field of computing.

Complete Exercise 4



SECTION 3

Peripherals

Peripherals are divided into three categories: input, output and backing store devices. Because of the ever-changing nature of computing, new devices are constantly being developed and the specifications for existing devices (particularly backing store) are soon out of date.

Input devices

The devices examined in this section include:

- keyboard
- standard mouse
- microphone
- touchpad
- digital camera
- scanner
- webcam

For each of these devices we examine their functions, uses and features. We also compare them using the criteria of resolution, speed of data transfer, capacity and cost where appropriate.

Keyboard

A standard keyboard has keys that produce the letters of the alphabet, keys to produce the digits from 0 to 9, keys to produce all punctuation marks as well as special command and function keys. Standard keyboards are often referred to as QWERTY keyboards because of the layout of their keys. Many keyboards have a numeric keypad at the side of the main keyboard, which allows easy input of numeric data.



How does a keyboard work?

The keyboard is continually scanned to see if a key has been pressed. Each individual character (remember there may be three characters on a single key) has a unique scan code, which is passed to the operating system. The operating system translates the scan code into ASCII code.

Cost

Can vary from around £12 to £30 for a wireless keyboard.

Speed of data transfer

Speed of operation is restricted by the typing skills of the operator and the limitations of the QWERTY keyboard layout. A good typist can achieve speeds of around 90 words per minute. A skilled operator using the numeric keypad can rapidly enter columns of numbers or quickly control a system by typing in numeric commands. The maximum input speed is about 10 characters per second.

***Accuracy***

The keyboard itself is an accurate device and most errors are due to the fault of the user. The sensitivity of the key presses can be increased or decreased to suit the user, so reducing the possibility of input error.

Typical uses

- Text entry in a word processor
- Keying in numbers/data to a spreadsheet
- Entering a URL for a website.

Mouse

A mouse is a small hand-held device connected to the computer by a cable. It has a ball on the underside of its cover and at least one button on the top.



How does a standard mouse work?

Movement of the mouse across the desk moves the mouse ball. The movements of the mouse ball are detected by a sensor and sent via the interface to the operating system. The operating system uses this information to control the position of the pointer on the screen. The user presses the button to perform tasks such as selecting icons and moving windows.

Other types of mouse include:

- optical: no moving parts
- wireless: no cable
- multi-button/scroll mouse: mainly for internet use.

Speed of data transfer

Although the actual data transfer rate does not change, the operating speed can be set by the user. An experienced user will set the mouse to a fast speed to open menus rapidly and make selections. A learner is more likely to slow the mouse down until they have mastered its use. Other attributes that can be configured include the function of the buttons, the size and type of pointer on the screen and the pointer trail.

***Accuracy***

Good for selecting icons and items from a menu. There are few errors using a mouse as it is generally used as a pointing and selecting tool. Errors tend to occur when the user attempts to select a small item on the screen that is situated very near other objects.

Typical uses

The mouse has become an almost indispensable tool for the modern computer as it forms an integral part of the GUI¹/WIMP system. It is commonly used to provide a means of communication between the user and the operating system as well as being used in application packages.

¹ GUI: graphical user interface; WIMP: window icon menu pointer

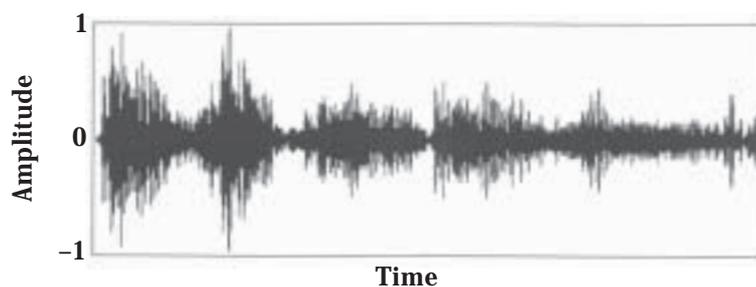
Cost

For a standard two-button mouse this can be as little as £3. An optical mouse costs around £16 and a scroll mouse about £7. Wireless/scroll mouse prices start at around £15.

Microphone

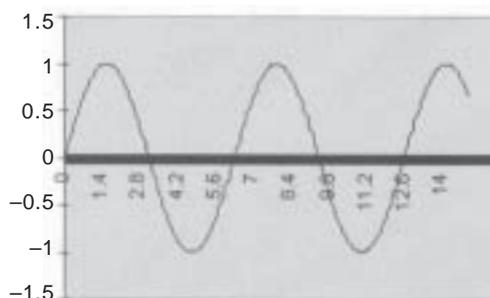
The purpose of a microphone is to allow sound to be inputted to the computer. Naturally occurring sound is analogue and this must be converted into digital form for the computer to make sense of it. The microphone itself is used only to take a sound and convert it into an electrical signal, which is then inputted to the computer. The process of converting this analogue electrical signal into a digital signal that can be understood by the computer is called analogue to digital conversion (ADC).

As the purpose of the microphone is limited we really have to look at the hardware and software that interprets the signal to understand how sound is inputted to the computer.

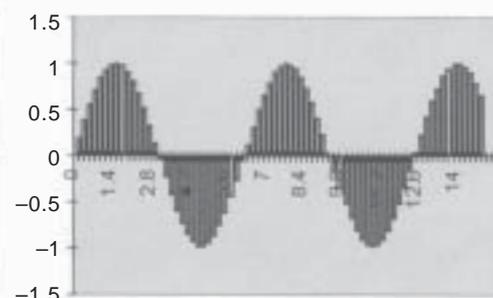


graph of typical sound signal output by a microphone

Computers and other hardware systems record sound by a process known as sampling. The sampler 'listens' to its audio input repeatedly at fixed intervals and stores a number each time. This number or sample represents the amplitude (volume or amount of sound) at that point in time.



analogue output signal from microphone



sampled (digital) signal

Sampling

This is the number of times per second that the sampler listens to the audio input. For instance, if the sample rate is 22 KHz then the sampler listens 22,000 times a second and stores a number each time. The more often you sample, the better the quality of the final result. This is similar to resolution in graphics.

Sample size

This is the number of bits stored for each sample. The two most common sample sizes are 8-bit and 16-bit. The sample size affects the 'granularity' of the sound; 8-bit numbers can only have a range of 0 to 255 whereas 16-bit samples can range from 0 to 65,535 and so can represent the sound with greater definition. This is similar to bit depth in graphics.

If you record a sound at 11 KHz 8-bit mono for 1 second it will take up about 11 K of disk space (plus a little for the file header and other things) whereas 1 second of sound recorded at 44 KHz 16-bit stereo will take up about 172 K of disk space.

Accuracy

The sound card used is the main constraint on the accuracy of the sound sampling. The number of bits used to store the data is typically a measure of this.

Capacity

A sound input device, e.g. a microphone, is unlikely to have much of its own cache. It will generally depend on fast access via the sound card to hard disk space to store the sample.

Speed of data transfer

The speed of conversion from analogue to digital depends mainly on the processor and amount of RAM in the machine as these are the factors that determine how quickly the sound will be processed.

Cost

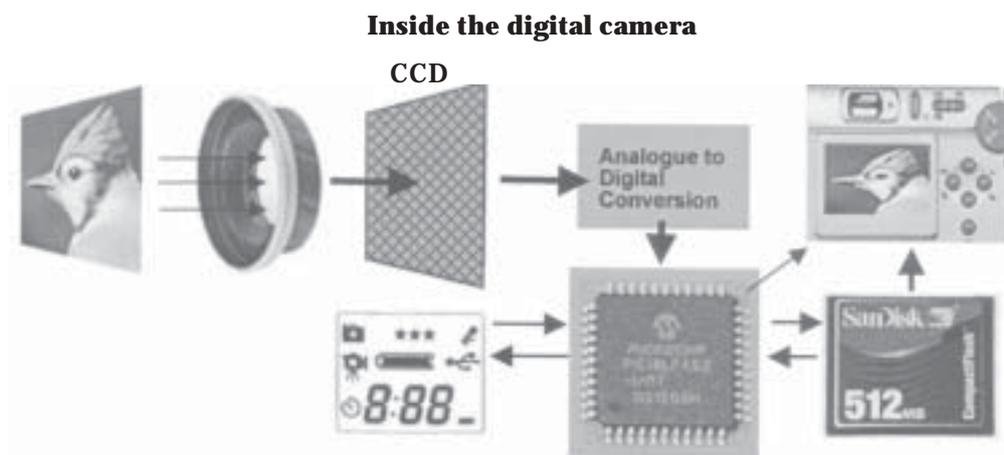
The cost of a microphone ranges from around £10 to above £40; however, there can be a significant difference in quality. The more expensive devices tend to be used by commercial users, e.g. telesales and call centres.

Typical uses

- As a means of issuing commands to the operating systems or applications.
- To record music.
- To use the computer as a telephone.

Digital camera

The digital camera is an input device that looks similar to a conventional camera in that there is a lens and a viewfinder. An image is created of the object being photographed. In a conventional camera, the lens causes this to be generated upside down on the back plate of the camera where the film is situated. The main difference in a digital camera is that the film has been replaced with an array of image sensors and a storage device.



The image sensor is made from an array of photosensitive cells. Each cell converts the light that strikes it into an electrical signal that is proportional to the intensity of the light.

Accuracy/resolution

This refers to the quality of the image: how real does it look? There are a number of factors involved but the main one is the resolution. This is the number of pixels that can be represented in the CCD. The camera is often referred to as 2 Megapixel or 5 Megapixel; this is the maximum number of pixels that can be supported.

There are often three settings in digital cameras: the lowest is 480×640, ideal for web images; 1024×768 is good for desktop publishing; and 1600×1200 is for high-quality pictures. These figures are based on a typical 2 Megapixel camera.

Speed of data transfer

The speed really refers to the download time of an image to the computer. The main factors affecting the speed of transfer are the type of connection (e.g. USB) and the size of the image itself. Clearly a larger image will take longer to download. Typical USB transfer rates are 12 Mbit s⁻¹ for USB 1.0 and 480 Mbit s⁻¹ for the more recent USB 2.0.

Capacity

This is determined by the size of the removable flash card on which the images are stored and the image size itself. Flash cards vary from 16 Mb to 2 Gb. Many modern desktops have a flash card reader installed, which allows the removable card to be plugged in directly.

The following table indicates the number of images that can be stored on a 128 Mb card.

Image size	640×480	1024×768	1600×1200
Size of one image	79 Kb	155 Kb	302 Kb
No. of images	577	271	128

(The capacity is also affected by other factors, including compression, but we restrict ourselves here to the main factor.)

Cost

This depends on the make and quality of the camera and ranges from around £100 for a decent 2 megapixel camera up to £3000 or more for a professional digital camera.

Additional features

- Special effects:
 - black and white
 - rotation of image
 - sepia
 - redevye flash removal.
- Zoom (optical and digital):
 - digital zoom simply magnifies the pixels without improving the resolution so the magnification can appear jagged.
 - optical zoom is based on the lens within the camera and is a true magnification of the original image.

Consequently, when making comparisons between similar digital cameras, the optical zoom factor is more important than the digital zoom.

- Photo imaging software
 - download/preview software

- photo stitching software (to make a panoramic image): this examines adjacent images, finds overlaps then creates a new wide image (see below)
- edit photos
- direct printing (straight to a compatible printer) without using a computer



Four images stitched together to create a panorama.

Scanner

A scanner is an input device that allows graphical data to be captured by the computer. This data can be in the form of photographs, line drawings or even text. To capture the data, the scanner reflects light off a paper image that is placed on a sheet of glass. The reflected light is gathered by photosensitive cells. The electrical current representing the reflected light intensity passes through an analogue-to-digital converter to create a bit map of the original image. This digital image is then sent through an interface to the computer.

A typical flat-bed scanner comprises an A4 glass plate underneath which a scan head is moved down the length of the glass in small steps.



The control software for the scanner usually allows a number of image characteristics to be altered. It is important to be aware of these as the file size created for a single A4 page can be as high as 20 Mb. OCR software, which comes with most scanners, enables the conversion of a graphical representation of text into a word processing file, database, spreadsheet or other text format.

Resolution

The resolution of a scanner is a measurement of how close together the scanned pixels are located. It is usually measured in dpi. Images scanned for display purposes on a monitor (e.g. for use in a multimedia presentation) should normally be scanned at 72 dpi as this will match the resolution of most monitors. Flat-bed scanners can give a resolution of up to 2400×4800 dpi. The number of colours in the scan is also a major factor affecting the resolution of the image; this is called the bit depth. A scan of 24 bits means 24 bits are allocated to each pixel in the image; this is also known as true colour, as millions of different colours can be represented.

Speed of data transfer

The scanner itself does not have any RAM so the data is sent directly to the computer. This means that the speed of data transfer depends on the connection to the computer and the computer specifications. A modern USB 2.0 scanner has a transfer rate of 480 Mbit s⁻¹.

Cost

Like the digital camera this depends on the make and model of scanner. Prices range from £40 up to £300 or more.

Uses

Converting photographic prints into digital form. Scanning documents for OCR.

Touchpad

A small, touch-sensitive pad used as a pointing device on some portable computers. By moving a finger or other object along the pad, the pointer moves on the display screen. Tapping the pad or pressing the side button is the same as clicking a mouse.



Beneath the surface there are two layers that together create an electromagnetic field. When an object such as a finger touches the surface the properties of the electromagnetic field change and the details are input to the computer.

Accuracy

The touchpad can be as accurate as a mouse but is susceptible to errors if the user is inexperienced. It is unsuitable for high-definition graphics work but ideal in a portable computing environment where only basic selection and pointing are required.

Speed of data transfer

As far as the user is concerned the data is transferred immediately as there is virtually no time delay between activating the touchpad and viewing the result on the screen. Figures based on USB 1.0 give a top speed of 12 Mbit s⁻¹.

Cost

As touchpads are usually a component of a systems and not a separate device, costs are not available. However, it is possible to purchase a touchpad device for a standard computer that uses a stylus for input for around £175.

Webcam

A simple webcam consists of a digital camera attached to a computer. Cameras like these are easy to connect through a USB port. A piece of software connects to the camera and grabs a frame from it periodically. A purpose-made webcam is shown below.



The software turns the image into a normal graphic and uploads it to the web server. The image can be placed on any web page.

Accuracy/resolution

This is based on the number of pixels. The maximum number of pixels is usually in the range of 640×480.

Speed of data transfer

With USB 2.0 the top speed is 480 Mbit s⁻¹. However, a more common measurement is the number of frames per second, which is normally about 30.

Typical uses

- Video chat
- Video conferencing
- Live streaming internet webcam
- Still image capture
- Video e-mail.

Cost

From as little as £12 for a very basic webcam up to around £50 for one with more sophisticated software.

Activity

Using the internet or magazine sources, complete the first seven lines of the Peripherals Exercise Sheet (page 99).

Output devices

The output devices covered this sub-section include:

- cathode-ray tube (CRT) monitors
- LCD panels
- inkjet printers
- laser printers
- loudspeakers

CRT monitors

CRT monitors comprise a sealed glass tube that has no air inside it. An electron gun at one end fires a stream of tiny electrons at the screen located at the other end. The image is made by illuminating particles on the screen.



Accuracy

The main factors are the refresh rate, the number of pixels and also the physical size of the monitor. What is really important is what the refresh rate will be at the maximum desired resolution. To keep it simple, every pixel or dot on the screen is refreshed or redrawn many times every second. If this flicker can be detected it can cause eyestrain and image quality is simply not the same as if it were flicker-free. The industry standard for flicker-free images is 75 Hz as very few people can detect flicker at or above 75 Hz. Most flicker-free monitors offer a refresh rate of 85 Hz. Those that use higher rates do not offer any additional advantage and could even be considered counter-productive.

Resolution

A monitor image is made up of pixels, or picture elements. Pixels are either illuminated or not; the pattern they show is what makes up the image.

A 17" monitor may have a maximum resolution of 1280×1024 . Not only does this ratio (5:4) cause image distortion but text is simply too small to read at this high a resolution on this size of monitor. A 17" monitor should use either an 800×600 or 1024×768 resolution, which are the desired (4:3) ratio. A 15" monitor should use 640×480 (4:3) or 800×600 resolution.

Cost

This is related directly to the size and make of the monitor. A typical 17" monitor is about £80. A larger 25" monitor can cost up to £1800.

LCD panels

Applying a voltage across an LCD material changes the alignment and light-polarising properties of its molecules so that they can be used in conjunction with polarising filters to create an electronic shutter that will either let light pass or stop it passing. Thus, the LCD display works by allowing different amounts of white backlight through an active filter. The red, green and blue of each pixel are achieved by filtering the white light that is allowed through.

LCD stands for Liquid Crystal Display. LCD is also known as TFT (Thin Film Transistor).



An LCD monitor

Accuracy

The main factors are the refresh rate, the number of pixels and the physical size of the LCD monitor. The refresh rate is set at an industry standard of 75 MHz.

Resolution

Like the CRT monitor this is based on the pixel array. Different screen modes can be selected but the maximum resolution is often 1280×1024.

The number of bits allocated to represent each pixel is called the colour depth. The colour depth can be as high as 24 bits, which allows more than 16 million different colours to be represented. It is difficult to imagine any more than 16 million colours so 24-bit colour depth is often referred to as true colour.

Cost

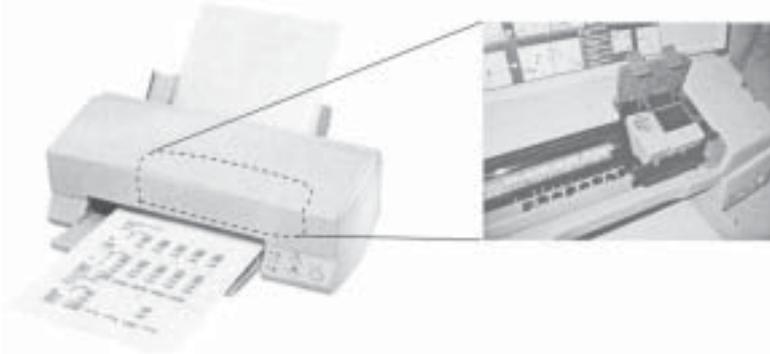
A 17" LCD monitor currently costs about £300.

Typical uses

LCD monitors are lightweight, compact and can require little power to run compared to CRT monitors. They are ideal for use in laptops, tablets and palmtops. Full size LCD monitors for desktop systems are becoming very popular.

Inkjet printers

These work by spraying a fine jet of ink, which is both heated and under pressure, onto paper. Most have a black cartridge and either a single colour cartridge or separate red, yellow and blue cartridges.



Accuracy

The quality of the printed image is measured by the number and spacing of the dots of ink on the page. The image resolution is generally measured in dpi. The higher the dpi, the better the quality or sharpness of the printed image. The vertical and horizontal resolutions may, therefore, be different depending on the number of nozzles on the print head and the distance moved. Typical resolution is 2880×1440.

Speed

The major factor here tends to be the mode of communication with the computer. Often this figure is given in terms of pages per minute for black and white or colour, e.g. black and white 10 ppm and colour 6 ppm.

Cost

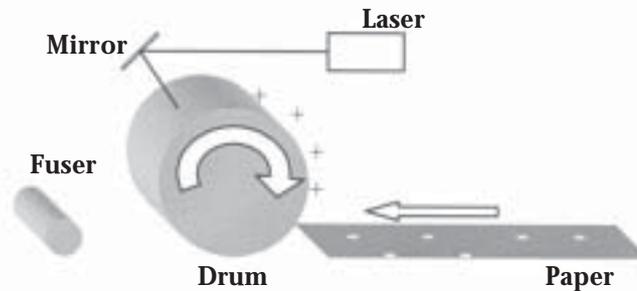
The real costs of the printer are in the consumables, i.e. ink cartridges and photo-quality paper. Some manufacturers have reduced the price of a good inkjet printer to around £25 as the profit will come from the sale of replacement inkjet cartridges which can cost about £20 for a single-colour cartridge. This typically means costs of around 5p per page of text and more for graphics. At the top of the range modern printers can accept flash cards from a digital camera and some even support wireless technology. Prices for these are around £220.

Typical uses

Home, office and business. These printers are ideal for that occasional presentations and livening up mostly text documents with some colour. They are also good for creative home projects such as invitations, birth announcements and personal greeting cards.

Laser printers

These operate by using a laser beam to trace the image of the page layout onto a photosensitive drum. This image then attracts toner by means of an electrostatic charge. The toner is fused to the paper by heat and pressure.



Accuracy

Determined by the dpi. A typical laser printer can print from 600 to 2400 dpi, which produces very high quality images.

Speed

A laser printer needs to have all the information about a page in its memory before it can start printing. If the page has a lot of detail then it will take longer to print. One way to speed up a printer is to add more internal RAM. Once the first page has printed the rest normally follow directly. Like inkjet printers, speeds are given in terms of pages per minute, e.g. 14 ppm for black and white, 8 Mb RAM.

Cost

This ranges from around £150 to around £800. Although laser printers are more expensive to buy than inkjet printers, their running costs are much less, typically less than 1p per page of text. Replacement cartridge costs vary from around £40 to around £100.



Typical specifications

Brother HL 5040 (around £150):

- A4 mono laser printer
- Up to 16 ppm print speed
- 1st page in 12 seconds
- USB 2 and parallel interface as standard
- 8 Mb memory expandable to 136 Mb
- 2400×600 dpi resolution
- 18 seconds warm-up time
- 10/100 network interface optional
- 250 sheet universal paper cassette
- 133 MHz RISC processor

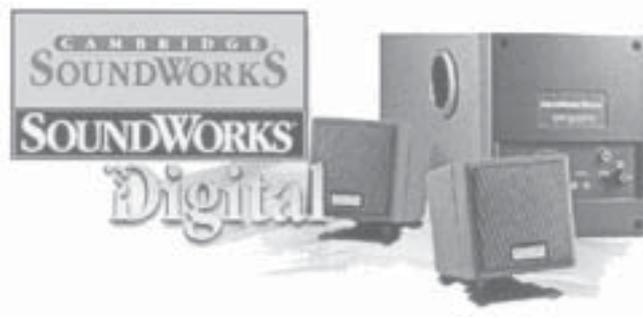
Colour laser printers

These are becoming more common and cheaper. A colour laser printer is really four printers in one: black, red, yellow and blue. Typical cost is from £550 to £2000.

Loudspeakers

There are two types of speaker systems used on computers: those that are inbuilt and those that are external. Most computers will have a speaker (or two) incorporated in the case or perhaps the monitor. The purpose of inbuilt speaker systems is limited to producing a sound from the computer and nothing more; the quality is poor.

Multimedia computers are intended to produce good sound quality that is comparable to hi-fi systems. They include 'active speakers', which have their own power supply and usually have an amplifier. A good quality system will include a sub-woofer and five speakers to produce surround sound.



Accuracy/quality

This can be measured as the comparison between the original sound and that produced by the computer. Speakers are only one component of sound quality; the formats of the sound tracks and type of soundcard also have a significant effect.

If we consider the sound produced from a pre-recorded CD or DVD movie then active systems can be as good as a professional hi-fi system.

Cost

This varies depending on the quality and make but the price range is typically from around £100 to around £300.

Complete Exercise 5

Complete the monitor, printer and loudspeakers sections of the Peripherals Exercise Sheet on page 99.

Backing store devices

When a computer is switched off the data has to be stored on a secondary storage device so that it can be loaded back in at a later date. Current backing store devices fall into two categories: magnetic and optical. We will examine the following devices in turn:

magnetic storage devices/media:

- floppy drive
- hard drive
- zip drive
- magnetic tape

optical storage devices/media:

- CD-ROM
- CD-R
- CD-RW
- DVD-ROM
- rewritable DVD
 - DVD-R
 - DVD-RW

Random (direct) and serial access devices

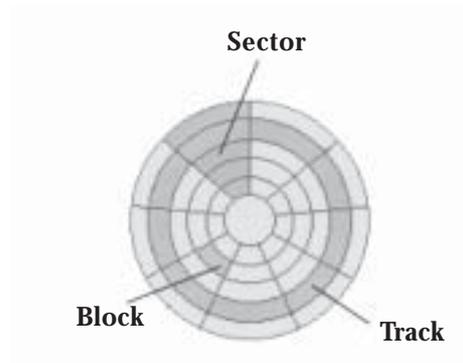
Random access is where the system can go straight to the data it requires. A disk is a random-access medium. To read data stored on the disk, the system simply has to have the address on the disk where the data is stored, and the read head can go directly to that location and begin the transfer. This makes a disk drive a faster method of data storage and data access than a tape drive, which uses serial access.

Magnetic and optical storage

Data is stored by magnetising the surface of flat, circular plates that constantly rotate at high speed (typically 60 to 120 revolutions per second). A read/write head floats on a cushion of air a fraction of a millimetre above the surface of the disk. The drive is inside a sealed unit because even a speck of dust could cause the heads to crash.

Floppy drive/disk

A floppy disk is a small disk that the user can remove from the floppy disk drive. The disk is made from circular plastic plates coated in ferric oxide. When the disk is formatted or initialised, the surface of the disk is divided into tracks and sectors on which data is stored as magnetic patterns.



The disk itself is floppy but is covered in a hard plastic case to protect it. The standard size is 3.5".

Type of access

Direct/random

Speed of data access

Floppy disks are relatively slow to access because they rotate far more slowly than hard disks, at only six revolutions per second, and only start spinning when requested. The access speed is about 36 Kb per second.

Capacity

High-density disks hold 1.44 Mb of data (enough to store about 350 pages of A4 text). A floppy disk needs to be formatted before it can be used but most disks are now sold already formatted.

Cost

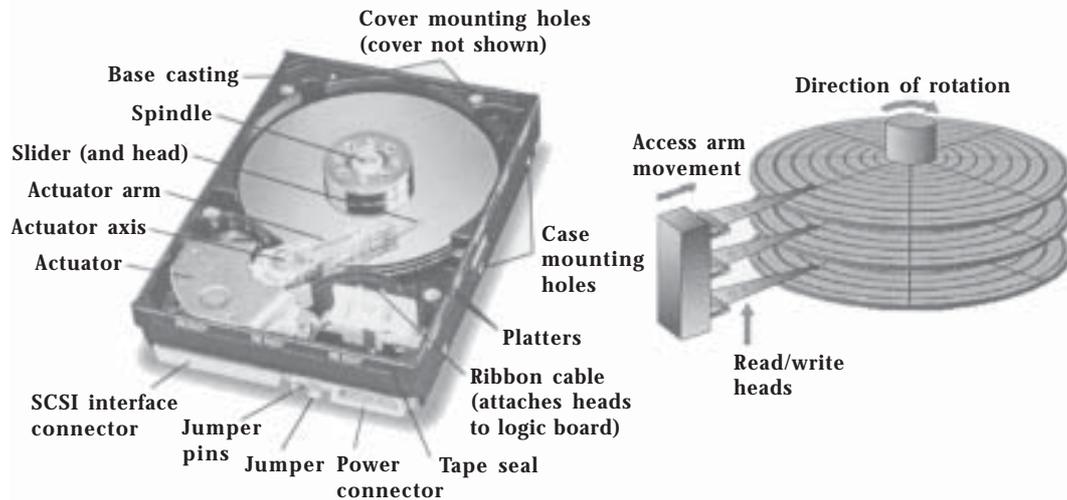
The cost of an internal floppy disk drive is around £7. External USB drives cost around £20. The media cost varies slightly depending on the brand but 14p is a typical price per disk.

Functions

Floppy disks used to be a convenient means of storing small files and of transferring files from one computer to another. Many single files are now larger than 1.44 Mb, mainly due to graphics and video (jpeg and mpeg) making the floppy disk an unsuitable medium for anything but small files.

New USB flash drives (32 Mb to 2 Gb), which can be inserted into a USB port, are making the floppy disk drive redundant to the extent that some computers are now sold without a floppy disk drive.

Hard drive



A hard disk is a rigid disk with a magnetised surface. The surface is divided into tracks and sectors on which data is stored magnetically. The data is read by a read/write head fixed to an arm that moves across the surface of the disk. Hard disks are usually sealed in a protective container to prevent dust corrupting the data.

Type of access

Random/direct

Speed of data transfer

Hard disks rotate at much higher speeds than floppy disks, reaching speeds of up to 7200 rotations per minute. This means that the fastest hard disk can transfer data from disk to computer at the rate of 22 Mb per second. Some can even manage higher transfer rates in short bursts of up to 33 Mb per second.

Capacity

Measured in gigabytes, the standard amount for a desktop computer is currently 80 Gb but it is possible to purchase hard disks with a capacity of 250 Gb.

Cost

An 80 Gb hard disk is currently priced at around £65.

Functions

The hard drive is used in all computer systems: stand-alone, network and mainframe. It has become an essential component of the modern computer, particularly with the increase in video editing, which demands a great deal of storage space. A typical hard disk will store:

- the operating system
- applications
- user files.

Zip drive

A zip drive is a removable storage device that securely stores computer data magnetically. It is durable and portable, and a 100 Mb zip drive can hold the equivalent of 70 floppy disks.

**Type of access**

Direct/random

Speed of data access

This depends on the connection type. The USB 1.0 transfer rate is 0.9 Mb s^{-1} , the USB 2.0 transfer rate is 7.3 Mb s^{-1} and the Firewire rate is 7.3 Mb s^{-1} .

Capacity

Older zip drives take 100 Mb disks, but 250 Mb has become the standard and the latest devices hold a massive 750 Mb. The newer drives can also read all previous zip media.

Cost

An internal 250 Mb zip drive costs around £55, an external USB 250 Mb zip drive costs around £49 and an internal 750 Mb zip drive costs around £65.

Media prices

A 100 Mb disk costs around £9, a 250 Mb disk around £12 and a 750 Mb disk around £15.

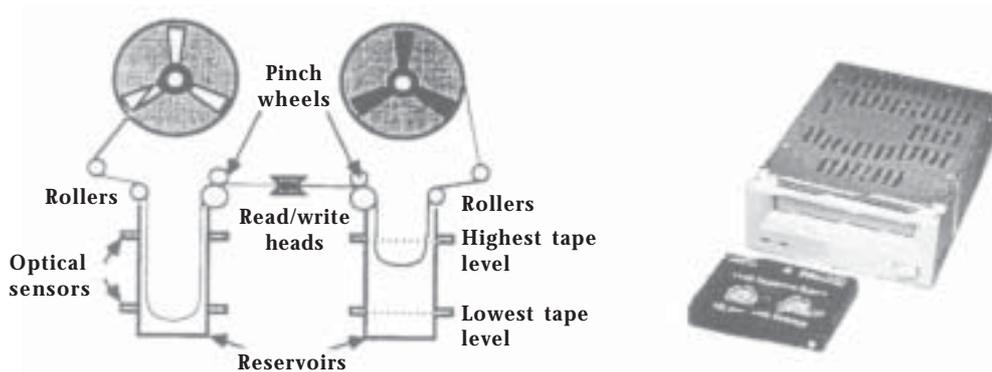
Functions

Good for storing large files on a portable medium, particularly photo images, which tend to be large, desktop publishing files and video. Often used to back up data.

As with floppy disks, USB flash drives are likely to make zip drives (especially the smaller capacity ones) obsolete.

Magnetic tape

For almost as long as computers have existed, magnetic tape has been the back-up medium of choice. Tape is inexpensive, well understood and easy to remove and replace. But as hard drives grew larger and databases became massive data warehouses, tape had to change to store more data and do it faster. From large reel-to-reel mainframe tape, focus shifted to the speed and convenience of digital audio tapes (DATs). Tape is a sequential medium so data has to be read from it in order.



Modern systems use cassettes. Some of these are even smaller than an audio cassette but hold more data than the huge reels.

Type of access

Serial

Speed of data access

Access speeds have been traditionally slow due to the serial access to the data; however, a data transfer rate of between 0.92 Mb s^{-1} and 30 Mb s^{-1} is possible.

Capacity

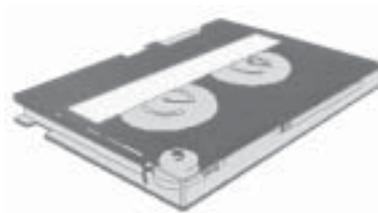
Magnetic tape comes in a wide range of sizes, from 10 Gb to 500 Gb. Compressed data tapes can hold up to a massive 1300 Gb of data on a single tape.

Cost

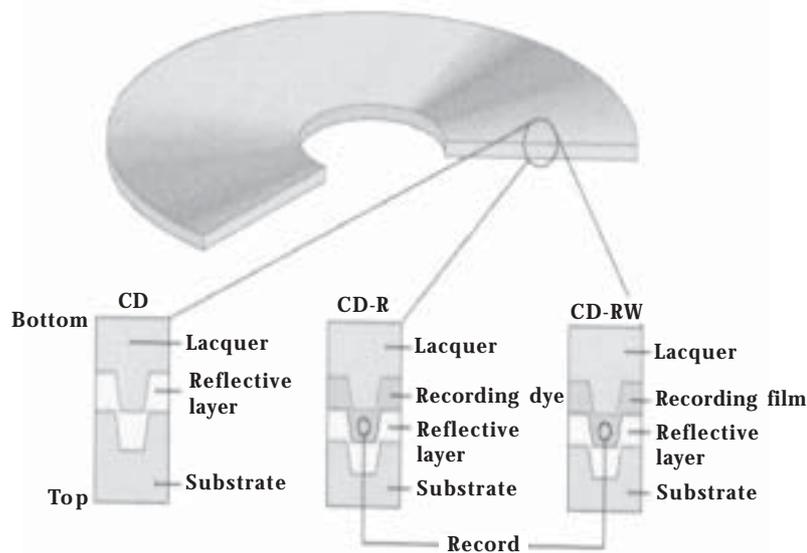
A tape drive that uses a 35 Gb tape with a transfer rate of 8 Mb s^{-1} can cost about £650 whereas a 100 Mb tape drive with a data transfer rate of 12 Mb s^{-1} is about £2500. Data cartridge prices range from £10 to £100.

Functions

Magnetic tape can be used for permanent storage. Tapes are often used to make a copy of hard disks for back-up (security) reasons. This is automatically done overnight and is suitable for network or mainframe backups.

Digital Audio Tape**Optical storage devices**

Optical disks are more secure than tapes as they cannot be erased by magnetic devices. Data is written into the disk by burning a permanent pattern on the surface using a laser beam. Data is read using a laser of low intensity.



Layers of light-sensitive chemicals on the surfaces of CD-R and CD-RW media create shiny and dull spots along the groove that the laser reads. CD-Rs use a dye that works much like photographic film, but CD-RWs contain a chemical that can switch between being clear and opaque hundreds of times. Mass-produced CDs are stamped with microscopic pits that produce the same effect.

CD-ROM drive

The term CD-ROM is short for *compact disk read-only memory*. CD-ROM disks can only be used to read information stored on them – the user cannot save data to a CD-ROM disk. CD-ROM writers use a high-powered laser to store data by making tiny pits in the surface of the CD-ROM disk. The pattern of these pits is read by a sensor in the CD-ROM drive that detects light reflected off the surface of the disk. The patterns are then turned into binary numbers.

Type of access

Direct/random

Speed of data access

The speed varies from drive to drive. The original CD drives read data at a rate of 150 Kb per second. Rather than quoting speed in Kb s^{-1} the norm has been to relate the speed as multiples of 150 Kb s^{-1} . The latest 56-speed drives read data at a rate of $56 \times (150 \text{ Kb s}^{-1})$, i.e. 8.4 Mb s^{-1} . Manufacturers quote the highest speeds achieved by their drives during tests in ideal conditions but these speeds are often not achieved during typical use.

Speed	1×	24×	32×	48×	52×	56×
Transfer rate	150 Kb s^{-1}	3.6 Mb s^{-1}	4.8 Mb s^{-1}	7.2 Mb s^{-1}	7.8 Mb s^{-1}	8.4 Mb s^{-1}

Capacity

The capacity of CD-ROM disks ranges from 650 Mb to 700 Mb of data. With compression the capacity can be up to 1.3 Gb.

Cost

Typically, a CD-ROM drive can cost as little as £15.

CD-RW drives



CD-Rewritable (CD-RW) drives let you burn, or write, CD-R and CD-RW media with your favourite music or photos or just to back up data. The most important feature to look for is the drive's record speed, which tells you how long you'll spend waiting for it to finish burning a CD.

Type of access

Direct/random

Speed of data access

Three numbers are usually used to rate drive speed: record speed, rewrite speed and read speed (usually in that order). The highest number listed is often for reading; the lowest is rewriting. Recording frequently is the same as or less than reading. Note that a drive with a 48× record speed theoretically could burn a CD in half the time a 24× drive requires, but in reality the speed difference is less pronounced.

A typical specification is given below.

P5 Model USB2 CD-RW 52×32×52×, inc. CD Rec Cost £68.00

Item	Value
Device type	Disk drive – CD-RW
Compatibility	PC, Mac
Type	1 × CD-RW – external
Interface type	Hi-speed USB
Read speed	52×
Write speed	52×
CD/DVD rewrite speed	32×
Supported CD formats	CD extra, CD-DA (audio), CD-I, CD-ROM XA, video CD
Supported recording modes	Multisession, disk-at-once, track-at-once, packet writing, session-at-once
Software included	Drivers and utilities
Operating system required	Microsoft Windows 98 Second Edition/ Windows ME, Apple MacOS 9.1 or later, Microsoft Windows 2000/XP
System requirement details	Windows 98SE/2000/ME/XP – Pentium II – 350 MHz – RAM 64 Mb | MacOS 9.1 or later – PowerPC G3 – RAM 64 Mb

There are some issues with burning disks at fast write speeds in excess of (48×): the high spin speeds have caused disks to shatter during tests. This is why manufacturers are now warning the public not to use deeply scratched disks in drives.

Costs

As can be seen in the above specification, the cost can be as little as £68.

There are two types of recordable CDs: CD-R and CD-RW.

CD-R (media)

Compact disk recordable (CD-R) is also known as *write once read many*. This is a bit of a misnomer as it is in fact possible to write to a CD-R in different sessions until the disk is finalised. Once finalised the disk cannot be written to again. There are several different formats of CD-R and some formats will not work in standard CD-ROM drives. The write process is irreversible.

Type of access

Direct/random

Speed of data access

These disks are burned for the CD-ROM drive so access speeds are measured in multiples of 150 Kb s⁻¹. The latest speed is 56× read.

Capacity

Normally 700 Mb but up to 1.3 Gb with compression. The capacity can also be given as the time to record music onto the CD until full, e.g. 80 minutes.

Typical uses

- Distribution of a finished product/program
- Permanent backing storage and archiving
- Encyclopaedias

Cost

CD-Rs are often sold in packs rather than as single disks. A disk pack of 50 currently costs around £14, giving a unit price of 28p per disk.

CD-RW (media)

These are the same size and shape as other CD media but you can write and rewrite a CD-RW.

Speed of data access

This is really the read speed, which is the same as for a CD-R. However, we also have to consider the initial write speed to a blank CD (given as 52× in the above example) and the re-write speed to a used CD (32× in the above example). Generally the re-write speed is the slower of the quoted speeds.

Capacity

Same as a CD-R, i.e. 700 Mb.

Cost

Depends on the manufacturer but the cheapest is currently priced at around 80p.

Typical uses

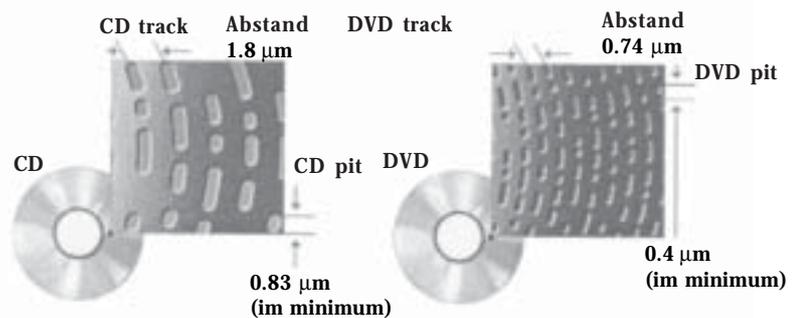
- Portable media for transferring large files to another computer
- Back-up of hard drive (drive image)
- Storing photos/movie files (large size)

DVD-ROM drive (digital versatile disk)

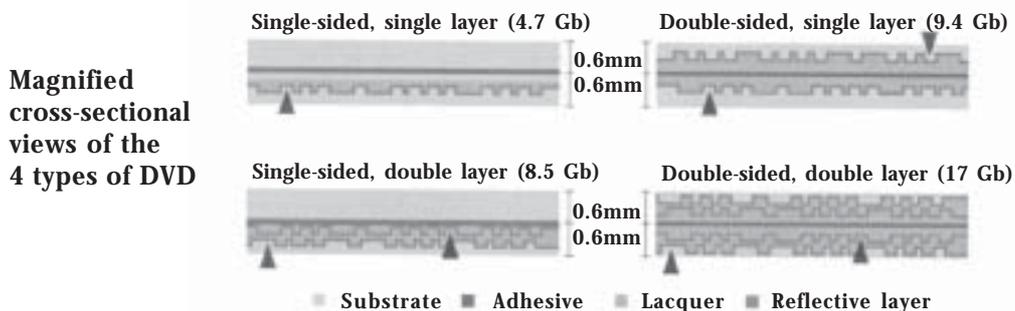
These disks are the same size (12 cm) and composition (polycarbonate) as CDs, but store more information as a consequence of smaller track spacing and smaller 'lands and pits' (bits).

Magnified views of

- (a) CD
(b) DVD



In addition, they can be recorded on both sides, and in two layers on each side. There are four types of DVD:

**Type of access**

Direct/random

Capacity

Depends on the type of DVD, as shown in the following table.

Format	Capacity	Approx. movie time
Single-sided/single-layer	4.38 Gb	2 hours
Single-sided/double-layer	7.95 Gb	4 hours
Double-sided/single-layer	8.75 Gb	4.5 hours
Double-sided/double-layer	17 Gb	Over 8 hours

In general, any DVD can store more than a CD.

Speed of access to data

The data transfer rate from a DVD-ROM disk at 1× speed is roughly equivalent to a 9× CD-ROM drive (1× CD-ROM data transfer rate is 150 Kb s⁻¹, or 0.146 Mb s⁻¹). The DVD physical spin rate is about three times faster than that of a CD (that is, 1× DVD spin = 3× CD spin). A drive listed as ‘16×/40×’ reads a DVD at 16 times normal speed, or a CD at 40 times normal speed.

Cost

A DVD-ROM drive can be purchased for around £23.

Typical uses

- Encyclopedias
- Games
- Movies

DVD-RW combination drive

There are currently two main versions of rewritable DVDs: DVD-RW and DVD+RW. There is little difference between the two other than speed of access to data. Modern DVD-RW drives allow access to both types of disks. DVD-RW drives write DVD-R, DVD-RW, CD-R, and CD-RW disks. The example below can also read and write to CDs.

Plextor PX-708A	Dual DVD-R/RW – DVD+R/RW
Format	Speed
Read speed, CD	40× (6 Mb s ⁻¹) CAV
Read speed, DVD	12× (16.2 Mb s ⁻¹) CAV
Write speed, CD-R	40× (6 Mb s ⁻¹) P-CAV
Write speed, CD-RW	24× (3.6 Mb s ⁻¹) CAV
Write speed, DVD-R	4× (5.4 Mb s ⁻¹) CLV
Write speed, DVD+R	8× (11 Mb s ⁻¹) Z-CLV
Write speed, DVD-RW	2× (2.7 Mb s ⁻¹) CLV
Write speed, DVD+RW	4× (5.4 Mb s ⁻¹) CLV

As can be seen from the above table, with a combination drive there are quite a few figures to compare!

Speed of access to data

The time it takes to burn a DVD depends on the speed of the recorder and the amount of data. The playing time of the video may have little to do with the recording time, since half an hour at high data rates can take more space than an hour at low data rates. A 2× recorder, running at 22 Mb s⁻¹, can write a full 4.7 Gb DVD in about 30 minutes. A 4× recorder can do it in about 15 minutes.

Cost

A combination drive can cost as little as £42.

Comparing storage devices			
Storage capacity	1 CD-ROM (650 Mb) = 451 floppy disks (1.44 Mb)		
	1 DVD (4.7 Gb) = 7 CD-ROMs (650 Mb)		
Access speed	Hard drive	CD-ROM	floppy disk
	22 Mb s ⁻¹	100 Kb s ⁻¹	36 Kb s ⁻¹

DVD-R (media)

There are six different formats of DVD and this one allows the user to record in a single session or in multiple sessions until the disk is complete. DVD-R is compatible with most DVD drives and players.

Speed of data access

This depends on the drive being used but a typical speed is 40× (CD), i.e. 6 Mb s⁻¹.

Capacity

Normally 4.7 Gb

Cost

Prices vary depending on the quality of the media and in this case quality is an issue as some poorer makes will not be read properly on DVD drives. Purchasing in batches of 25 reduces the cost to 70p per disk.

DVD-RW (media)

Can be used over 1000 times to write and re-write data onto the RW disk. As previously mentioned, there are two different types of media: DVD-RW and DVD+RW. The capacity and speed of access depend on the drive rather than the DVD itself.

Cost

About £1.59 per disk.

A major problem with DVD is the format of data. There are several different data formats that are not compatible with each other. In other words, a DVD+R/RW drive cannot write a DVD-R or DVD-RW disk, and vice versa (unless it is a combo drive that writes both formats). Very roughly, DVD-R and DVD+R disks work in about 85% of existing drives and players, while DVD-RW and DVD+RW disks work in around 70%. The situation is steadily improving.

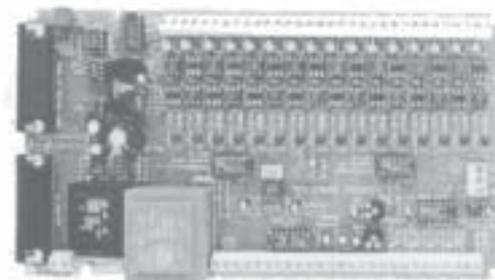
Complete Exercise 6

Interface

An interface is a hardware device that is needed to allow the processor to communicate with an external or internal device such as a printer, modem or hard drive. Sometimes the interface is a board in the computer and sometimes it is a connection to a port.

The reason that an interface is required is that there are differences in characteristics between the peripheral device and the processor. Those characteristics include:

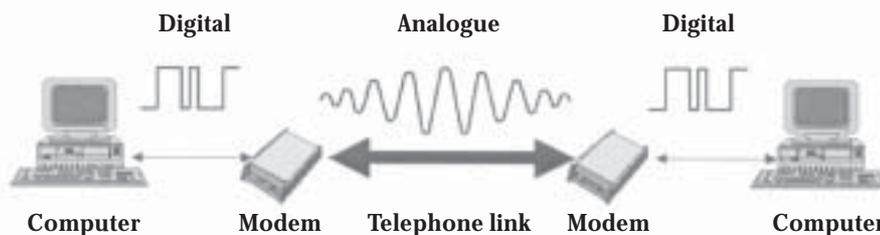
- data conversion
- speed of operation
- temporary storage of data.



Interface card for a PC

Data conversion

The commonest example of data conversion is when the peripheral accepts an analogue signal that must be converted into digital for the processor to comprehend it. A modem is typical of this, as shown below.



Speed of operation

The speed of operation of peripheral devices tends to be in terms of pages per minutes, frames per second or megabytes per second; however, the processor works at a rate in line with its internal clock, which is much faster. The speed of the internal operations is measured in gigahertz and a processor will typically work at 2.8 GHz, i.e. 2800,000,000 cycles per second. This difference in the speed of operation between the processor and devices requires an interface between the two devices as the processor can deliver data much faster than the peripheral device can handle.

Data storage

In older computer systems the processor would stand idle while the printer was finishing a print job. One way around this problem is to have the data held temporarily in transit between the processor and the printer. Interfaces are used to hold this data, thus releasing the processor; the data is held in a 'buffer'. Keyboard characters entered by the user are stored in the keyboard buffer while they are being processed.

One of the important considerations when purchasing a portable CD-RW drive is the type of interface it uses. There are four interface options for portable drives: parallel port, PC card, USB 2.0 and IEEE 1394 Firewire. Most users favour USB 2.0 and Firewire because of their high connection speeds and flexibility.

Types of interfaces include IDE, SCSI, serial, parallel, PCI, USB and Firewire.

SECTION 4

Networking

A network can be described as a number of computers that are interconnected, allowing the sharing of data and peripherals. There are two types of networks: LAN and WAN.

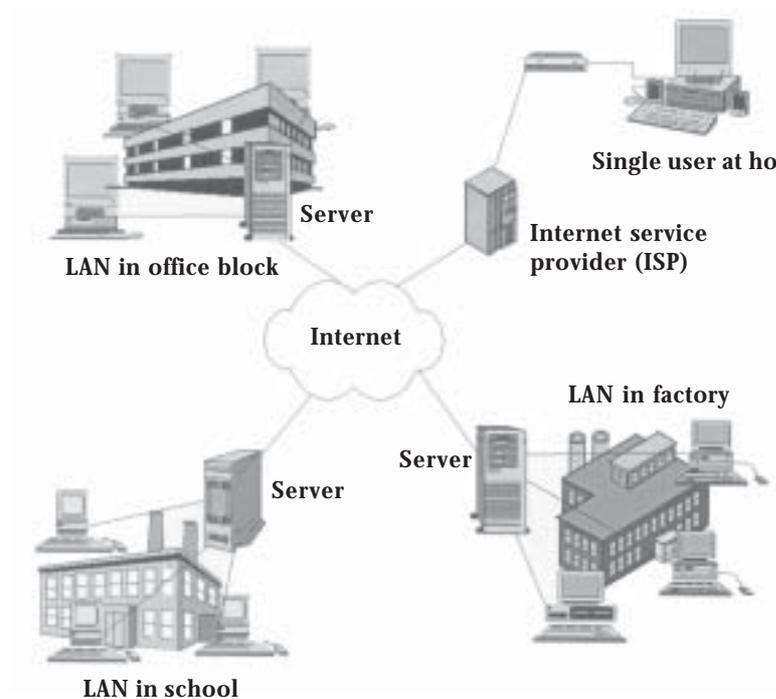
Local area networks (LANs)

LANs provide networking capability to a group of computers in close proximity to each other, such as in an office building, a school or at home. LANs are useful for sharing resources such as files, printers, games or other applications. A LAN, in turn, often connects to other LANs, and to the Internet to allow global e-mailing.

Wide area networks (WANs)

A WAN spans a large geographic area, such as a state, province or country. WANs often connect multiple smaller networks, such as LANs.

The internet is a global network of networks where many LANs and WANs are interconnected. $1 \text{ Gb s}^{-1} = 1000 \text{ Mb s}^{-1} = 1,000,000 \text{ Kb s}^{-1} = 1,000,000,000$ bits per second.

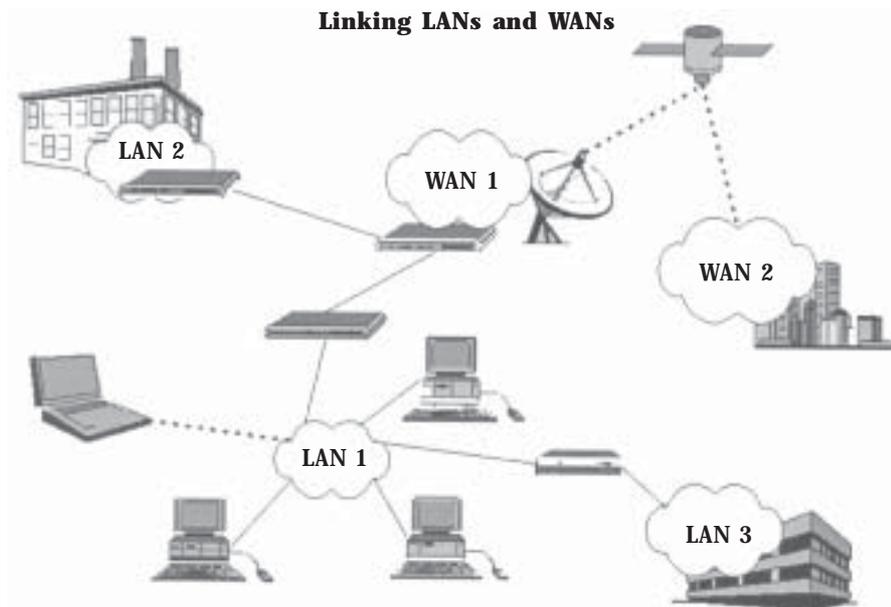


Features	LAN				WAN		
Transmission media	Twisted pair	Coaxial cable	Fibre optics	Wireless	Microwave	Satellite	Radio
Bandwidth	10 Mb s ⁻¹	500 Mb s ⁻¹	30 Gb s ⁻¹	54 Mb s ⁻¹	100 Mb s ⁻¹	100 Mb s ⁻¹	2 Mb s ⁻¹
Geographical spread	Can be in a single building or a site linking buildings together				Spread throughout a country or the world		
Functions	<ul style="list-style-type: none"> • A LAN allows users to share data files, applications and peripherals • Users can access their work from any station on the network • Different levels of access can be granted to users • Users can communicate through e-mail 				<ul style="list-style-type: none"> • Allows users to share data, files and equipment • Permits 'live' chat • Allows users to e-mail each other • Allows video conferencing • Allows access to databases • E-commerce • Entertainment 		

The development of networks

The field of computer networking and today's internet trace their beginnings back to the early 1960s, a time when the telephone network was the world's dominant communication network. Computers were expensive mainframes linked to remote terminals that were very expensive and could only be afforded by large companies. During the 1970s a network linking universities together was developed so that they could share research material; it was called ARPAnet. By the end of the 1970s approximately 200 hosts were connected to ARPAnet. Several similar networks were also created and before long researchers wanted some method of connecting them all together. This presented a problem because they all used different data transmission methods.

In 1973, Robert Metcalfe's PhD thesis laid out the principle of Ethernet, which would later lead to a huge growth in LANs that operated over a small distance based on the Ethernet protocol (TCP/IP). The attraction of LANs in the office environment throughout the 1980s and 1990s was mainly due to the advantages of sharing data files, peripherals and e-mail. In 1983, the new protocol suite TCP/IP was adopted as a standard, and all ARPAnet hosts on the network were required to use it.



When ARPAnet finally grew into the Internet (with ARPAnet itself passing out of existence in 1990), the use of TCP/IP had spread to networks beyond the internet itself. Many companies had built corporate TCP/IP networks, and the internet had grown to a point at which it could almost be considered a mainstream consumer technology.

The way was clear for LANs to expand their horizons; all the networks could communicate with each other using the Internet as a backbone.

Companies could now use the public telecommunications infrastructure to create their own WANs through a leased line and in some cases a dedicated line. This acted as a catalyst for large organisations to expand their businesses on a national and global scale.

Finally in 1991 access to the internet was made public. At this stage the communication was still text based and mainly used by enthusiasts. The real revolution happened when hypertext mark-up language (HTML) was developed; this laid the format for web pages, which are still in use today.

During the mid-1990s private commercial companies such as AT&T, MCI, Sprint, UUNET and other telecommunication companies connected to each other and created the modern backbone of the internet. This was accompanied by increased machine performance at a reduced cost, which in itself allowed more users to be connected.

The growth in home computers and the demand for up-to-date information fuelled the desire of individuals to connect to the internet; members of the public were encouraged to purchase a dial-up connection using their phone line. The rapid expansion of private access to the internet overwhelmed some internet service providers and some subscribers found themselves faced with restricted usage. The number of internet users recorded on May 6, 2002 was over 778 million.

At the turn of the millennium the telecommunication companies began to offer broadband. This meant a permanent connection to the internet at a much faster bandwidth from 128 Kb s⁻¹ up to 2 Mb s⁻¹. The proportion of internet users connecting by broadband is climbing each year.

Desktop computers now come with a NIC as standard. This is an acknowledgement from manufacturers that many desktop machines will find their way onto a network. With the emergence of wireless technology, home users can share peripherals, data and their broadband connection between machines, without the need for cables. Home networks are now a reality.

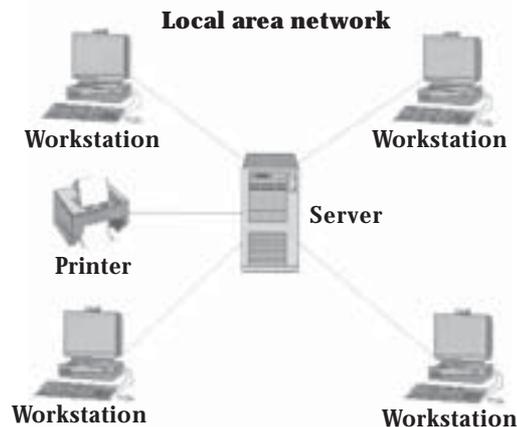
The convergence of the telecommunications and computing industries is drawing even closer as users can now send e-mail via their mobile phones and even access web pages using general packet radio services (GPRS) technology.

Computer networks started in isolation but over the years the backbone of the internet has widened to the extent that we now have a global communication network that can be accessed from any point in the world. The main factors leading to the development of computer networks are:

- the falling cost of telecommunication technologies and services
- shared access to expensive equipment
- the geographic spread of organisations
- demand for up-to-date information.

Client/server networks

In client/server networks one computer acts as a central resource for the others. The central computer (server) will normally have a faster processor, more RAM and a greater amount of backing storage (hard drive) than the stations on the networks (clients).



The server stores programs and data files that can be accessed by the client stations. Users will normally log on to the network with a user name and password. A list of users and their passwords is kept on the server along with the user's files. When the user loads a file from their user area the file will be sent from the server's hard drive to the client station. After the user has edited the file and saves it to their user area, the file is sent back to the server and stored on the hard drive. Software on the server will ensure that only the user has access to their files and that they are kept secure.

The client station runs programs with its own processor but has to contact the server for access to any files or shared resources. Shared resources can include printers, CD-ROMs, a database or access to the internet.

Client/server networks originated as a type of LAN but it is now possible to share resources through the internet from remote locations. This allows people to work at home rather than in an office.

The benefits of networks include:

Security

- tampering with programs and files is prevented through restricted access rights
- personal work is saved in private spaces on hard disks that are

password protected from inadvertent or malicious copying and/or deletion.

Communication

- data files, programs and peripherals devices can be shared
- communication is improved via e-mail/chat/bulletin boards.

Management

- centralised back-up of files
- stations can be managed remotely.

The world wide web (www)

The internet is made up of server computers distributed across the world. One server will provide some unique information of its own but it will also point at information on other servers. These other servers point at still more servers (and possibly back to the original server). This compilation of hardware is collectively known as the internet. The internet is *hardware* and the www is *software*.

In the 1990s a method was proposed whereby data could be shared more easily, including video and sound. The result was a standard system of displaying information using protocols that could be understood by any computer. To access the information on the www you need a client browser application. A *browser* is a program that allows a user to read and navigate web pages. Two of the most common browsers are Internet Explorer and Netscape Navigator. Safari is rapidly replacing Netscape, particularly on Macs.

A web page is a document that usually contains text, images and perhaps multimedia files containing additional formatting information in HTML. It is possible to create a web page in a simple text editor or a word processing application; all you have to do is add the extra HTML code to the document so that the web browser knows how to display the page.

HTML code for web page

```

1 <!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN" "http://www.w3.org/TR/html4/loose.dtd">
2 <html>
3 <head>
4 <title>For Sale</title>
5 <meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
6 </head>
7
8 <body>
9
10 <div align="center">
11 
12 <img alt="Ford Escort" />
13 <img alt="Ford Escort" />
14 <p>Only 22,000 Miles</p>
15 <p>click to see more details</p>
16 </div>
17 </body>
18 </html>
    
```

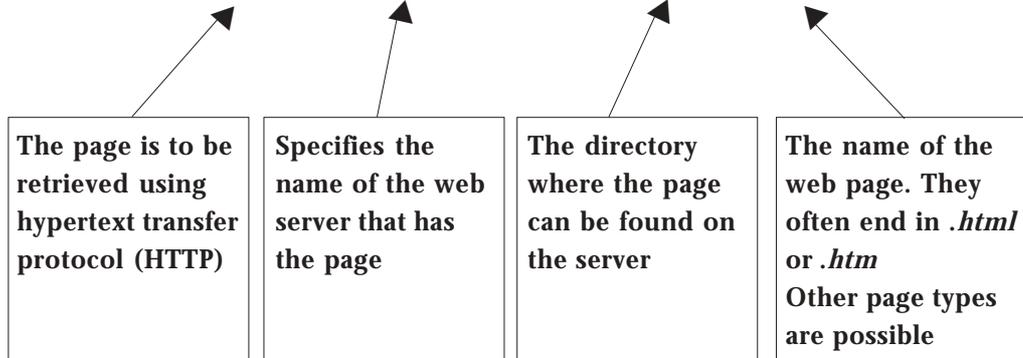
Page as viewed in browser



Note the additional formatting information that defines the layout of the page. The <head> sections are called 'tags'.

Each web page is stored on a web server and is identified by its unique location, commonly known as its URL (uniform resource locator). The URL given in the address bar above is:

[HTTP://www.computing.com/int2/car.html](http://www.computing.com/int2/car.html)



Hyperlinks

The sample page has text, an image and a *hyperlink*. It is hyperlinks that allow any page on the web to connect to any other. Hyperlinks are normally identified in blue and underlined when they are text links. If the user clicks on the link then the browser will load the URL of the page it is seeking and try to find it on the web. Sometimes a page will not be retrieved as it has been removed from the server by the owner; this is known as a 'dead' link.

In the example on the previous page the text here is a link to another page on the same website. Hyperlinks can be to a page within the same website or anywhere else on the internet.

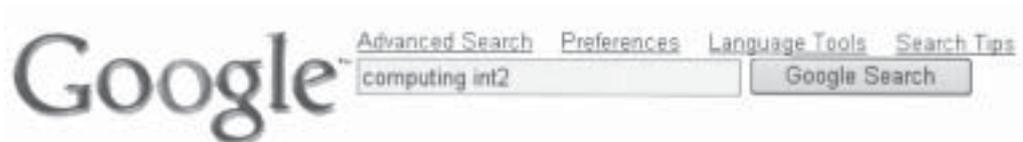
Hyperlinks can be associated with images as well as text and normally the pointer turns into a hand with a pointing finger when placed on an image that has a hyperlink attached to it.

The browser has forwards and backwards buttons that allow the user to navigate ahead, or back to pages that were previously viewed. It is also possible to store your favourite pages in the browser; this creates a library of hyperlinks.

You can 'surf' the web by typing a URL into the address bar, clicking on a hyperlink or using the browser to view favourites or previous pages.

Search engines

Websites such as Yahoo and Google include a search engine that regularly runs programs called *web crawlers* to gather information about what pages are on the internet. When the web crawler comes across a document it sends the URL along with extracts of the content back to the site, where it is stored on a database.



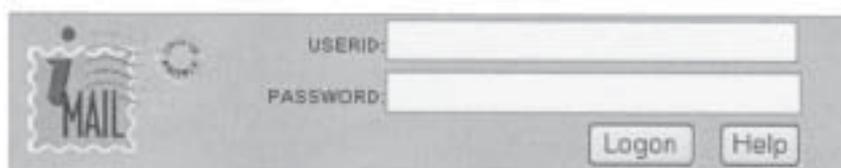
When you enter a search (see above) you are really searching the database for words that match your entry. Advanced searches can include operators such as AND and OR to help narrow the search. The results of the search are placed on a web page that is composed of hyperlinks and brief extracts from the original web page. To visit the actual page all you have to do is click on the hyperlink.

E-mail

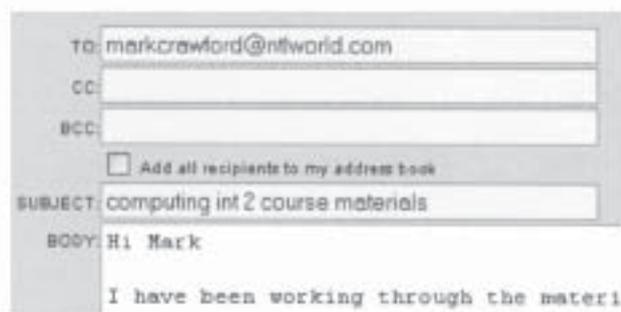
Electronic mail (e-mail) is the exchange of computer-stored messages by telecommunication. E-mail messages are usually encoded in ASCII text.

However, you can also send non-text files, such as graphic images and sound files, as attachments.

Many e-mail systems are now web based. This means that a user can access their e-mail from any computer that has a connection to the internet. The software used to access the e-mail may vary, but basic principles and functions apply. The user logs on to an e-mail server with a username and password before access is granted.



To send an e-mail message to someone you must first have their e-mail address. This is the location of the server on the internet where the person's mailbox can be found. An example is given below.



The part before the '@' symbol is the user name of the person on that server and the 'ntlworld.com' part is the *domain name*. Together they make up the e-mail address of the person to whom the message is being sent.

Sending a message

After entering the e-mail address of the recipient it is usual to enter a subject. This will appear to the recipient as a short line of text telling them what the message is about. It is possible to send a message without a subject but it is not good etiquette. The body of the message is entered in the box below the subject heading. Attachments can be added to the e-mail in the form of documents, files, pictures or even

video. Once the message has been composed the user clicks on the send button and the message is delivered.

Reading a message

In the e-mail software there is a send/receive button that will send any unposted e-mails and at the same time download any that are waiting on the server. On web-based systems any new mail is automatically made available when you log on to the server.

Replying to an e-mail

The obvious way to reply to an e-mail is to enter the person's e-mail address in the 'To' section then compose the message as normal. However, this can be tedious after a while, particularly if there is a continual dialogue going back and forth. There is a much simpler way to make a reply: every e-mail client's software has a reply button that not only enables the recipient to reply directly without having to type in the e-mail address but adds the reply to the current e-mail so that the recipient can scroll down the message to read any previous correspondence.



Reply and forward buttons on a typical e-mail package

If you wish to send the e-mail on to someone else then the forward button automatically prepares the message to be sent on. You have only to enter the new e-mail address.

Address book

When you are in the habit of sending e-mails regularly to the same people it is a good idea to store their e-mail addresses in an electronic address book. The best time to add an address to your address book is just after you have received an e-mail from someone; all e-mail software allows the option of adding a sender's e-mail address directly to the address book without having to type it in. Once the entry has been added it is possible to access it when composing a message.

Most errors in e-mail messages are due to the user typing in the wrong address, so making use of an address book is a good idea.

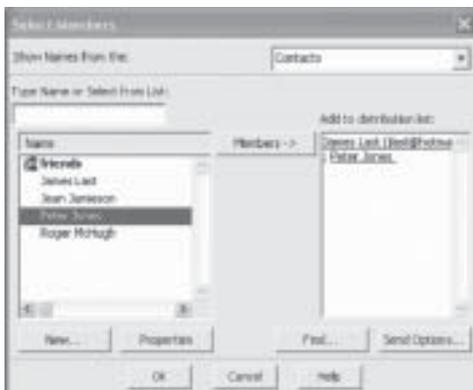
Mailing lists

When your number of contacts increases you may sometimes find that many of the messages that are sent need to go to several people at the same time. This can be done by entering all the e-mail addresses in the 'To' box or 'CC' box (see below) and separating them with a semi-colon.



Even using the address book to enter the address can be time-consuming. The solution is to use *mailing lists*. These are pre-prepared lists that include all the addresses of the people whom you wish to send the message to. You can create a list of friends or family made up of any combination of addresses from your address book.

If, for example, you name one of the mailing lists 'friends' then it can be selected from the address book in one operation.



In this example the mailing list is referred to as a 'distribution list'.

Members are added to the mailing list by selecting them from the address book and clicking on the members button.

Folders

As the number of contacts and regular e-mails increases you will find that the inbox can soon become congested with many e-mails from all sorts of people. You may also start to receive 'junk' mail from people you do not know.

One way to help manage this problem is to create a number of folders that can then be used to move e-mails out of the inbox.



Folders created within a hierarchy structure

This is similar to creating folders on your computer to store work in an organised fashion. Note that in the example above it is possible to create an entire hierarchy of folders within folders.

Once the structure of the folders has been set up, some e-mail programs allow the creation of 'message rules', which automatically move mail messages into the correct folder as soon as it is downloaded from the server. This is a major benefit for people who received many e-mail messages each day.

Practical task

Create three folders to store e-mails from other students in your class. Set up a mailing list called myfriends, add at least five students in your class to the list and send a group e-mail. When you receive e-mails from others in the class move them into one of the three folders.

Legislation

The law has struggled to keep up with the rapid pace of change that the internet has brought to society and consequently new legislation has had to be introduced. The following are three of the most common laws concerning the use of electronic information and access to networks.

Computer Misuse Act

The Computer Misuse Act was introduced in 1990 to secure computer material against unauthorised access or modification. Three categories

of criminal offences were established to cover the following conduct:

1. unauthorised access to computer material (hacking), including the illicit copying of software held in any computer
2. unauthorised modification of computer material, including
 - (a) intentional destruction of software or data.
 - (b) the circulation of 'infected' materials on-line.

Copyright Designs and Patents Act

Any uploading or downloading of information through on-line technologies that is not authorised by the copyright owner is deemed to be an infringement of their rights.

You must not make, transmit or store an electronic copy of copyright material.

Data Protection Act

The Data Protection Act 1998 is concerned with information about living individuals that is processed both manually and automatically. It basically gives new rights to those individuals about whom information is recorded.

If someone holds data electronically about an individual, then that individual has the following rights:

1. to view a copy of the data being held on them
2. to have any inaccurate data corrected
3. to prevent junk mail: by registering with the mailing preferences services you should be exempt from receiving junk mail.

The data controller who is in charge of managing the data that is held must:

1. ensure that the data is accurate, up-to-date and relevant
2. allow access to the data if requested by a data subject
3. change information that is incorrect
4. store data securely.



SECTION 5

Computer software

When a computer is switched on, the first task is to load the operating system into the memory. The *operating system* is a suite of programs that controls the hardware and software running on the computer, allowing the user to communicate with application programs and peripheral devices. Whether you load or save a file, access the internet, print a hard copy or just type on the keyboard, the operating system is involved working in the background.

An operating system is a group of programs that automatically load from your hard disk when you turn on your computer. These programs remain in RAM until you turn your computer off. There are four main types of operating systems in popular use today: MS-DOS, Windows, UNIX and MacOS. All four of these operating systems run on personal computers.

Examples of operating systems

DOS is an old (early 1980s) command-line operating system that requires the user to memorise and enter all commands from a command prompt.

A DOS window:



Windows 3.1 (late 1980s) was Microsoft's first attempt at a Macintosh-like Graphical User Interface (GUI); this interface allowed:

1. programs to be launched by double-clicking with a mouse
2. files to be copied by drag and drop
3. much easier copy and paste.



Windows 95/98/ME/2000/NT/XP are a family of Microsoft 32-bit operating systems. At the time of this writing these operating systems dominate the market and are to be found on most people's personal computers. Microsoft has come a long way since Windows 3.1 and Windows has become much more powerful and stable.

OS2 began as a joint venture between IBM and Microsoft. IBM finished and marketed this operating system. It is not used extensively today.

UNIX was originally a command-line based operating system like DOS (although it predates DOS by more than a decade). However, UNIX now incorporates all of the features of a modern GUI and more. UNIX is most popular for companies and large institutions, particularly for multi-user environments.

Linux is a UNIX-like operating system for personal computers. Its primary distinguishing feature is that its source code (basically, the text of the program) is freely distributed. A worldwide community of users work to improve Linux.

MacOS X is the current operating system for Apple Macintosh computers. Throughout the 1990s the operation systems for the Mac were quite similar to Microsoft Windows. However, in MacOSX Apple has decided to base their operating system on UNIX.

Application programs

An application program is a piece of software that is designed for a specific task or function. Some examples:

Word processing is used to create, edit, format and save documents. Popular programs include WordPerfect and Microsoft Word.

Spreadsheets are used to perform numerical calculations and accounting tasks. Popular programs include Quattro Pro and Excel.

Database management is used to organise a set of related information. Popular programs include dBase and Access.

Desktop publishing is used to produce documents with sophisticated formatting that includes text and graphics. Popular programs include Quark, CorelDRAW and PageMaker.

Presentations software is used to produce slide shows. Popular programs include PowerPoint, Harvard Graphics and Lotus Freelance Graphics.

E-mail programs are used to compose and send e-mails. Popular programs include Outlook, Eudora Pro and Pegasus Mail.

Standard file format

When application packages first became popular one of the main problems was that manufacturers made little effort to ensure that their files could be read by programs made by other manufacturers. This was particularly true of word processors, where files created in Word could not be used in Wordperfect.

Manufacturers made an attempt to address this problem by including the ability to save word-processed files as plain text or ASCII. As all word processors could now read a common file format the situation improved. However, it was soon realised that saving a document as plain text did not include the formatting of the original document (font, bold, italic, etc.). The next aim was to have a common file format that would include the formatting so that documents created in one word processing package could be totally compatible with others.

This led to the development of rich text format (RTF), which is still in use today. RTF includes the formatting codes. Many application packages can now save documents in foreign formats to aid the portability of files.

General purpose packages (GPPs)

These are application packages that are in common use and may be supplied with desktop computer systems. GPPs are widespread because the data objects contained in each package fall into the categories of text, number, data and graphics; these are the most commonly used data type in the field of computing.

The following table lists some of the objects and operations used in each of the four main GPPs:

Package	Objects	Operations
Word processor	Character Word Sentence Paragraph Table Drawing	Enter, insert, edit, delete, copy, paste, format, spellcheck, search and replace Import/export Add row, add column. Split cell, merge cell Group, scale, move forward/back
Database	Field Record File Layout	Enter, insert, edit, delete, copy, paste, format, search, sort, calculate, query Import/export Report
Spreadsheet	Cell Row Column Number Text Formula Chart	Enter, insert, edit, delete, copy, paste, set attributes Format, import/export Calculate (sum, average, max, min, if) Chart scale
Graphics	Pixel Line Circle Rectangle Polygon	Enter, insert, edit, delete, copy, paste, format, scale rotate, layer, group, ungroup, crop

Each of the above packages its own *native file format*; this means the file format in which the package would normally save data. For example, Microsoft Word normally saves data as a Word file although it could be saved as several other data types. In some operating systems (e.g. Windows) the data type can be identified by the file extension; in the case of a Word file this is *.doc*. If the file is saved as plain text then the extension is *.txt*, if saved as RFT then it is *.rtf*. In this way you can tell what type a file is by its name.

Standard file formats allow data to be transferred between different computer platforms and also between different applications. A plain text file can be read by a word processor, a spreadsheet package and a database. This makes it possible to export data from any one of these packages and import it into another.

Complete Tasks 1–4 in the Practical Exercises

Viruses

Most programs are designed to be useful; some, like viruses, are not! A computer virus is self-replicating piece of computer code that can partially or fully attach itself to files or applications, and can cause your computer to do something you don't want it to do. Virus behaviour can range from annoying to destructive, but even relatively benign viruses tend to cause harm.

Viruses enter your system via e-mail, downloads from the internet, infected floppy disks, homemade CDs and 'fun' websites. Currently the primary vehicle for transmission of computer viruses is e-mail. Viruses arrive on a computer as an attachment to an e-mail, which, when opened by the user, sends further copies of itself to everyone in the user's address book. Clearly such a means of replicating can be highly prolific.

In the case of infected floppy disks, the disk acts as a carrier spreading the virus into each machine when it is placed into the drive. Homemade CDs spread viruses in a similar fashion when the original CD has been infected during its compilation.

The popular use of programs such as Napster and Kazaa, which allow users anywhere on the internet to share files on each other's hard drives, has led to concerns about this being used as a means of spreading viruses. According to an article in the UK-based IT site, The Register, 6% of all the music downloaded from KaZaa is virus-laden.

When a virus program is executed it tends to perform four actions:

1. replication: copies itself to other files, particularly to *.com* and *.exe* files and the boot sector record
2. camouflage: attempts to disguise itself to avoid detection from anti-virus software
3. event watching: whenever the virus runs it checks for certain events, e.g. a specific date, when the virus will activate
4. delivery: this is the purpose of the virus or what it does. This may be a simple jumbling up of letters or wiping an entire hard drive.

Signs of a virus

There are a number of tell-tale signs that can indicate that your computer has been infected with a virus. They include:

- displaying unwanted messages
- strange sounds or visual effects
- computer keeps rebooting unexpectedly
- a flood of unexpected e-mails.

A common misconception is that all types of interfering programs are viruses. They aren't. Worms, Trojan horses and viruses are in a broader category of what analysts call 'malicious code.'

SECTION 6**Practical exercises****Task 1**

1. Examine the word-processed document that follows and identify the objects and operations that have been employed to create it.
2. Now, using a word processor with which you are familiar, create the document. Obtain a hard copy and hand it to your teacher. Save the file in its *native format*.
3. Save the file as a *plain text file*, obtain a hard copy and hand it to your teacher.

Annual Dinner Dance

*Mr & Mrs J MacKay
are cordially invited to attend*

*The Annual Castle Golf Club
Dinner Dance and Prize Giving*

The evening will commence with a toast to our new captain, Mr James Cutter, followed by a brief introduction to the members of the club team, who successfully retained the Major's Cup for the third year running!

The menu for the evening is given below:

Starter	Main course	Dessert
Carrot and coriander soup	Medallions of beef served on a bed of lettuce, sautéed vegetables and mashed potatoes	Devil's best chocolate excuse with cream
Blackcurrant sorbet	Chicken Mexico served with a spicy dip, rice and pitta bread	Lemon cheesecake
Chicken liver pate served with Melba toast and cranberry sauce.	Salmon steak in a hollandaise sauce, fresh vegetables and new potatoes	Profiteroles in a dark chocolate sauce

After-dinner speeches will commence at approximately 8.30pm and then the winners of the club medals will be awarded. The dance floor will be open from 10.00pm until 1.30am.



The evening's festivities will begin at 7.30 pm.

Task 2

1. Your task is to create a movie database using the following information.

Title	cat	Runtime	Plot Outline	Director
Cheaper by the Dozen	PG	98	The Baker Family of 12 move to big city.	Shawn Levy
The Perfect Score	PG	113	Group of USA College kids decide to steal exam papers	Brian Robbins
Postman Always Rings Twice	18	113	Steamy movie with murder in mind	Tay Garnett
Something's Gotta Give	12A	128	Doctor and patient vie for the attention of female	Nancy Meyers
Mindhunters	18	155	FBI psychological training programme has a killer in their midst	Renny Harlin
Cold Mountain	15	195	American civil war soldier returns home to his sweetheart	Anthony Minghella
Lord of the Rings	12A	201	Frodo and Sam approach Mount Doom in their attempt	Peter Jackson

Decide the data *type* for each of the above fields and create the data file using a database with which you are familiar.

2. Sort the file on the runtime field in ascending order and obtain a hardcopy. Hand this to your teacher.
3. Save the file in its native file format and call it *Movies*.
4. *Export* the data as a *plain text file*.
5. Open a word processor and load in the plain text file.
6. Select the text and choose the option to convert it to a table.
7. You will see that all of the data has quotation marks around each item. We want to remove this. Use one of the features of the word processor to replace all of the " marks with nothing. The quotation marks should now have disappeared.
8. We are still missing the heading for each column in the table.
 - (a) Add a new row to the top of the table.
 - (b) Enter the headings from the data file and embolden them.
9. Create a header on the document, type in your name and obtain a hard copy. Hand this to your teacher.

Task 3

A spreadsheet is used to analysis the marks that a group of pupils scored in three of their exams. The data are shown below.

	A	B	C	D	E	F	G	H
1	Test result sheet							
2	Distinction	75						
3	Surname	First name	Class	Maths	English	History	Average	
4	Harkins	Peter	4De2	73	71	67		
5	Smith	James	4Ca1	49	53	57		
6	Crawford	Peter	4Ca2	66	64	70		
7	Hussain	Shahzad	4De2	56	64	51		
8	Kazi	Jatinder	2Ca1	74	74	78		
9	Murray	Kimberly	4Ca1	71	66	79		
10	Rahman	Sanjay	4Ca2	82	90	88		
11	Melough	Joseph	4Ca1	91	88	83		

1. Enter the raw data into a spreadsheet.
2. Examine the objects and the operations that have been performed on them in the above figure. Apply the same operations to your spreadsheet so that it looks identical to the one above.
3. Complete the formulae for the average column so that the average of the three exams is displayed for each pupil.
4. Format the averages to 1 decimal place.
5. In cell H3 enter the heading Distinction and give it the same format as the other headings.
6. Cell B2 has the average that pupils must achieve (or above) to get a distinction. Enter a formula into cell H4 that will look at B2 and cell G4, decide if the pupil deserves a distinction or not and then place the word Yes or No into cell H4.
7. Replicate the formula in cell H4 down the column to show whether the other pupils will get a distinction or not.
8. Sort the data on the classes in ascending order and within each class sort the data in descending order of average.

9. **Add your name to the header of the worksheet and obtain a hard copy.**

10. **Obtain a hard copy of the formula and give both printouts to your teacher.**

Task 4

Create a table in a word processor like the one below. Copy out the questions and use the www to find the answers. Once you have completed the questions save the document and e-mail it as an attachment to the e-mail address which your teacher has given you.

1. Who was the second man to walk on the moon?
2. Who said 'Those people who think they know everything are a great annoyance to those of us who do.'
3. Who gained control of Timbuktu in 1433?
4. Which dessert that has ice-cream in the middle is named after a northern American state?
5. What is a cumquat?
6. The first computer mouse was made out of...
7. In which year did the Queen send her first e-mail?
8. What do a calico and a tortoiseshell have in common?
9. Of all grasses, which grows the tallest?
10. What is the only dog breed mentioned in the King James version of the Bible?
11. In 1861, President Lincoln appointed as Secretary of State and Secretary of the Treasury two men who had earlier been his political opponents. Name them both.
12. In *The Little Drummer Boy*, who gave him permission to play the drums?
13. What was the ELO rating system originally devised for?
14. Which dessert was named after a famous Russian ballet dancer?
15. What was a quagga?

SECTION 7**Exercises****Exercise 1: Binary representation**

Complete the table below to convert binary to denary and vice versa.

	128	64	32	16	8	4	2	Units	Base 10
(a)	1	0	0	0	0	0	1	1	$128 + 2 + 1 = 131$
(b)	1	0	0	0	0	1	1	1	
(c)	1	0	1	0	0	1	0	1	
(d)	0	1	0	0	0	0	0	1	
(e)	0	1	1	0	0	0	1	1	
(f)	0	0	0	1	1	1	0	1	
(g)	1	0	0	1	0	0	0	0	
(h)	0	0	1	0	0	1	1	0	
(i)	0	0	0	1	1	1	0	0	
(j)	0	0	1	0	1	0	0	0	
(k)	0	1	0	0	1	0	0	1	
(l)									9
(m)									25
(n)									37
(o)									111
(p)									153
(q)									92
(r)									77
(s)									213
(t)									234
(u)	1	1	1	0	0	1	0	1	
(v)	0	0	1	1	1	1	0	0	
(w)									210
(x)									171
(y)									100
(z)									

What is the largest positive number that can be represented using 1 byte?

What are the advantages in using the binary system to represent numbers?

1. _____

2. _____

3. _____

Exercise 2: ASCII code

1. How many bits are used to represent a character in ASCII code?

2. How many different characters can be represented using ASCII?

3. What is meant by the term *character set*?

4. Explain the meaning of the term *non-printable character*.

5. Give examples of two *control characters*.

6. Describe how text is represented in a computer system.

7. Explain one advantage of the fact that ASCII has been widely adopted by many program manufacturers.

Use the ASCII table on page 9 to decode the following messages, which are written in ASCII.

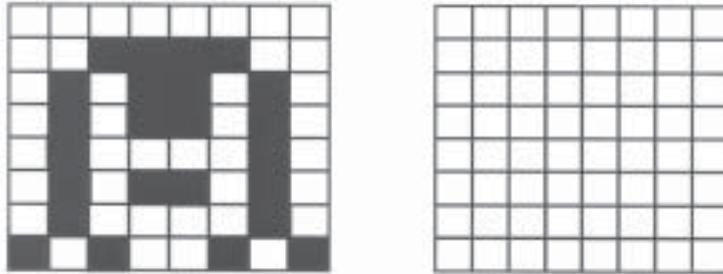
8. 77, 121, 32, 102, 97, 118, 111, 117, 105, 116, 101, 32, 115, 117, 98, 106, 101, 99, 116, 32, 105, 115, 32, 99, 111, 109, 112, 117, 116, 105, 110, 103
-

9. 67, 111, 109, 112, 117, 116, 101, 114, 115, 32, 117, 32, 65, 83, 67, 73, 73, 32, 116, 111, 32, 114, 101, 112, 101, 115, 101, 110, 116, 32, 116, 101, 120, 116
-

10. Translate your name into ASCII (remember to use a capital letter!).
-

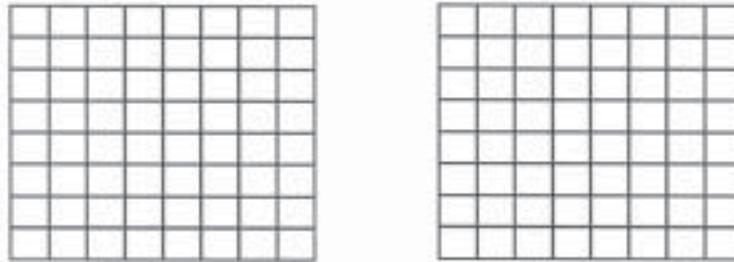
Exercise 3: Graphics

1. Complete the bit map for the 8×8 space invader image below.



2. Calculate the storage requirements for the above image.

3. Create your own image and complete the *bit map* for your image.



4. Explain the meaning of the term *resolution* when referring to a bit-mapped image.

5. What do the letters *dpi* stand for?

6. What does the term *pixel* mean?

7. A black and white image is 8" long and 5" wide with a resolution of 400 dpi. Calculate the storage requirements of the image.

Length = _____

Breadth = _____

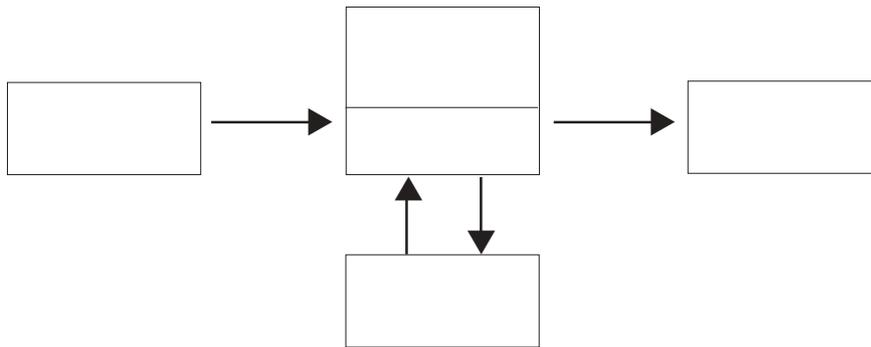
Total no of pixels = _____ 1 pixel needs 1 bit of storage

Storage = _____ bits

= _____ bytes

Exercise 4: Computer structure

1. Explain the purpose of a computer processor.
2. Complete the four-box diagram of a computer system below.



3. What is the name of the part of the processor that is responsible for the timing of operations?
4. What is the name of the part of the processor that carries out calculations and makes logical decisions?
5. If a document is in RAM and there is a power failure, what would happen to the document?
6. When the power is switched off, what happens to the contents of ROM?
7. Explain how the clock speed can be used to compare computers.
8. What is an embedded computer?
9. Name two features of embedded computer systems.
 1. _____
 2. _____

Exercise 5: Computer peripherals

1. Describe the events that occur when a user presses a key on the keyboard.
2. What is the main limiting factor with regards to the speed of entry using a keyboard?
3. What can a user do if they find that the keyboard produces *gggggggggg* when the key was only pressed once?
4. What is the purpose of the numeric keypad on the keyboard?
5. Name three types of mouse.
 1. _____
 2. _____
 3. _____
6. Name a human computer interface that uses a mouse.
7. Name one of the factors that is important when considering the accuracy of sound input when using a microphone.
8. What is the unit of measurement used in the answer to question 7?
9. What type of computer commonly has a touchpad?
10. State two ways in which a user can select using a touchpad.
 1. _____

2. _____

11. State three possible uses of a webcam.

1. _____
2. _____
3. _____

Exercise 6: Scenarios

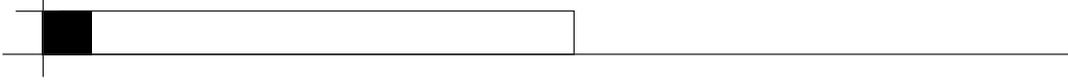
Read the following scenarios and recommend hardware and software where appropriate.

1. A geography teacher wants to prepare worksheets for his map-reading class. The sheets require diagrams, pictures and map extracts. He is on a limited budget but already has a standard computer system.
2. The art department are planning a trip to the art museum and would like to have a follow-up homework booklet for pupils. They would like to include images seen on the trip.
3. What legal problem might arise from the solution to question 2?
4. The local church intends to produce a newsletter. It should include pictures of the church gala, interviews with parishioners and news.
5. A salesman has to travel around the country and phone in his orders to the main office. He also has to call the office to check his customers' details. How could this system be improved?
6. An office has five stand-alone computers, one of which has a printer. Jobs are saved to floppy disk and loaded onto that machine for printing. How could this situation be improved?
7. An art student at university wants his brother, who lives in another part of the country and is a professional artist, to evaluate his drawings. Both have access to the internet. Suggest a possible solution.
8. A graphics designer works from home and commutes to the office twice each week. He has to be able to take his work to and from the office but the files are at least 3 Mb each. What can he do?

Peripherals Exercise Sheet

Use the internet or magazines to complete the table of peripheral devices below.

Device	Specifications					
Scanner	Cost	Resolution	Interface	Colour depth	Additional features	
Scanner 1						
Scanner 2						
Digital camera	Cost	Megapixel	Storage medium	Interface	Zoom	Other
Camera 1						
Camera 2						
Camera 3						
Webcam	Cost	No. of pixels	Connection type	Additional features		
Webcam 1						
Webcam 2						
Monitor	Cost	Size	Max. Res.	Refresh rate	Additional features	
CRT						
LCD						
Printers	Cost	PPM	Max. Res.	Memory	Interface	Other
Inkjet 1						
Inkjet 2						
Laser B/W						
Laser Colour						
Speakers	Cost	No. of speakers	Woofers	Amplifier	Other	
Systems 1						
Systems 2						
Backing store	Cost	Capacity (Gb)	Data transfer rate	Interface		
Hard drive 1						
Hard drive 2						
Zip drive 1						
Zip drive 2						
CD ROM drive						
CD-RW drive						
DVD-ROM						
DVD-RW						
CD/DVD combo drive						



APPENDIX

Data representation

Why use Binary?

- It is a two state system (on/off) which makes it simple to operate
 - Even if degradation of current occurs (ie a slight drop in voltage) it will still be detected as a 1
 - There are only four rules for addition in binary compared to 100 in decimal
- [0+0=0 ; 0+1=1 ; 1+0=1; 1+1=10]

Number Systems - Decimal

- The decimal system is a base-10 system. There are 10 distinct digits (0 to 9) to represent any quantity.
- For an n-digit number, the value that each digit represents depends on its weight or position. The weights are based on powers of 10.

4TH.	3RD.	2ND.	1ST.	POSITION
$10^3 = 1000$	$10^2 = 100$	$10^1 = 10$	$10^0 = 1$	WEIGHT

For example, $4916_{10} = 4 \times 1000 + 9 \times 100 + 1 \times 10 + 6 \times 1$

Number Systems - Binary

- The binary system is a base-2 system. There are 2 distinct digits (0 and 1) to represent any quantity.
- To express any number in base 2 we use powers much like our own decimal system.

8TH	7TH	6TH	5TH	4TH	3RD	2ND	1ST	POSITION
$2^7=128$	$2^6=64$	$2^5=32$	$2^4=16$	$2^3=8$	$2^2=4$	$2^1=2$	$2^0=1$	WEIGHT

For example: $11010010_2 = 1 \times 128 + 1 \times 64 + 0 \times 32 + 1 \times 16 + 0 \times 8 + 0 \times 4 + 1 \times 2 + 0 \times 1 = 210_{10}$

Number Systems - Binary to Decimal

- Converting binary to decimal

$2^7=128$	$2^6=64$	$2^5=32$	$2^4=16$	$2^3=8$	$2^2=4$	$2^1=2$	$2^0=1$
1	0	1	1	1	0	0	1

$1 \times 128 + 0 \times 64 + 1 \times 32 + 1 \times 16 + 1 \times 8 + 0 \times 4 + 0 \times 2 + 1$
 $= 128 + 32 + 16 + 8 + 1$
 $= 185$

Number Systems - Decimal to Binary

- We use the same table as before
- To convert the decimal number 115

$2^7=128$	$2^6=64$	$2^5=32$	$2^4=16$	$2^3=8$	$2^2=4$	$2^1=2$	$2^0=1$
0	1	1	1	0	0	1	1

115 is less than 128 so we put a zero in the 128 column
 we need a 64 to 'build' up to 115 so place a '1' in the 64 column 64
 $64+32$ is 96 so could use a 32 place a '1' in the 32 column 96
 $96+16$ is 112...just short we place a '1' in the 16 column 112
 We just need a 3 to give 115 so a '1' in the 2s column and
 a '1' in the units column gives 115
 So that 115 using 8 bit binary is 01110011

Storage of data

Hierarchy of storage



- 1byte = 8 bits
- 1KiloByte = 1024 bytes
- 1MegaByte = 1024 Kbytes
- 1GigaByte = 1024 Mbytes
- 1TetraBytes = 1024 GBytes

Floating Point Representation

- A range of very large and very small numbers can be represented with only a few digits by using scientific notation. For example:
 - $976,000,000,000,000 = 9.76 \times 10^{14}$
 - $0.0000000000000976 = 9.76 \times 10^{-14}$
- This same approach can be used for binary numbers. A number represented by $M \cdot B^{\pm E}$ can be stored in a binary word with three fields:
 - Mantissa
 - Exponent E
 - The base B is implicit and need not be stored

Typical 32-bit Floating Point Format

	Exponent	Mantissa
	8 bits	24 bits

- First 8 bits contain the exponent
- The remaining 24 bits contain the mantissa
- The more bits we use for the exponent, the larger the range of numbers available, but at the expense of precision. We still only have a total of 2^{32} numbers that can be represented.

Floating point representation

- How to represent the binary number
11010.11011011101
- This has to be converted to the form $M \cdot B^{\pm E}$
. 1101011011011101 Mantissa
- The point has been moved 5 places so exponent +5

 $.1101011011011101 \times 2^{+5}$
- Only the mantissa and the exponent need to be stored to represent this number
- Note: this assumes that all numbers are positive

Character Representation: ASCII

- Alphanumeric data such as names and addresses are represented as strings of characters containing letters, numbers and symbols.
- Each character has a unique code or sequence of bits to represent it. As each character is entered from a keyboard it must be converted into its binary code.
- Character code sets contain two types of characters:
 - Printable (normal characters)
 - Non-printable, i.e. characters used as control codes. For example:
 - CTRL G (beep)
 - CTRL Z (end of file)

Coding Methods ASCII

- ASCII
American Standard Code for Information Interexchange
- strictly speaking a 7-bit code (128 characters)
- has an extended 8-bit version
- used on PC's and non-IBM mainframes
- widely used to transfer data from one computer to another
- codes 0 to 31 are control codes

ASCII Coding Examples

An ASCII subset

Symbol	Code	"BAD" = 424144_{16} = 0100 0010 0100 0001 0100 0100 ₂
A	41	"F1" = 4631_{16} = 0100 0110 0011 0001 ₂
B	42	
C	43	
D	44	"3415" = 33343135_{16} = 0011 0011 0011 0100 0011 0001 0011 0101 ₂
E	45	
F	46	
0	30	
1	31	
2	32	
3	33	
4	34	
5	35	
6	36	
7	37	

Note that this is a text string and no arithmetic may be done on it. A postcode is a good example of the need to store numbers as text.

Representing Graphics

- There are two ways of representing graphics
 - Bit Mapped Graphics
 - Vector Graphics
- We will only study bit-mapped graphics but a brief explanation of vector graphics is included

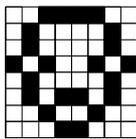
Bit Mapped Graphics

- Any graphic is made up from a series of pixels (Picture Elements).
- Each pixel is an individual point on the screen



Bit Map

- Assuming only black and white (1 or 0) for each pixel the image below would be stored as shown



Pixel Pattern using 8x8 grid

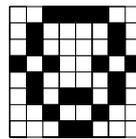


0	0	1	1	1	1	0	0
0	1	0	0	0	0	1	0
0	1	0	0	0	0	1	0
1	0	1	0	0	1	0	1
0	1	0	0	0	0	1	0
0	1	0	1	1	0	1	0
0	0	1	0	0	1	1	0
0	0	0	1	1	0	0	0

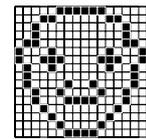
The BIT MAP of the image

Resolution

- The quality of the image depends on the number of pixels
- More pixels means higher resolution and clearer image



Pixel Pattern using 8x8 grid



Pixel Pattern using 16x16 grid

There is a one to one correspondence between pixels and bits

Memory Storage

- The image below is 4 inches x 6 inches. The resolution is 300 d.p.i. (dots per linear inch) and the image is black and white. Calculate the memory requirements

Length: 6x300 = 1800 pixels
 Breadth: 4x300 = 1200 pixels
 Total no pixels = 1800x1200
 = 2160000 pixels
 (1 or 0) means 1 bit per pixel
 Storage = 2160000 bits
 = 270000 bytes
 = 263.4 KBytes

Vector Graphics

- Each Image is made from objects (line,rect,circle)
 - Every object has ATTRIBUTES which define it

To draw the rectangle below we need to know:



Start X and Y coordinates
The length
The breadth
The thickness and colour of the lines
The type of line (dashed)
The fill colour

A Vector Image



Vector Vs Bit-Mapped

■ Advantages of vector graphics (draw packages)

- Images can be enlarged without losing resolution
- Objects can be edited by changing their attributes
- Objects can be layered on top/behind
- Images take up less disc space
- Ideal for drawing plans; use library of objects

■ Advantages of bit-mapped graphics (paint packages)

- Each pixel can be altered
- More realistic when used for photos/real life

Images

Bit-Mapped



Vector graphic



Computer structure

Components of a computer system

Hardware

- Central Processing Unit (CPU)
- Memory
- Input and Output Devices

Software

Data

Systems

Higher Computing

Components of a computer system

- Computer hardware provides the physical mechanisms to store, manipulate and input /output data.
- Software provides instructions to tell the hardware what tasks to perform
- Data in the computer may be representing numbers, characters, graphics etc but is always kept in a form that the hardware and software can manipulate.

Systems

Higher Computing

Basic concepts - Hardware

- CPU performs actual processing of data.
- Data and programs are stored in memory, and moved to and from CPU as required.
- Data travels between system components along electronic pathways, (sets of wires), called buses.

Systems

Higher Computing

We will look at:

- Four Box diagram
- CPU
- Memory
- Registers and their role
- Processing speed

Systems

Higher Computing

- Three major components of the CPU: ALU, Control unit and Registers.

- The Arithmetic Logic Unit (ALU) operates on binary data to perform all arithmetic and logical functions.

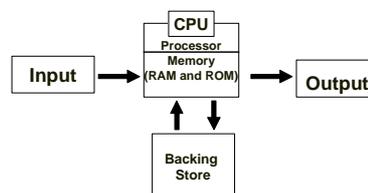
- + - * /
- < > = <>
- AND OR NOT
- Rotate Shift

- Control unit fetches and interprets instructions in memory and generates signals to control all other system components.

Systems

Higher Computing

Four Box Diagram



Systems

Higher Computing

Memory

Purpose of memory is data storage. A hierarchy of memory exists .

- data required for immediate manipulation by CPU is stored in small areas of fast access memory within CPU called registers.
- data required for active program is generally stored in primary memory, commonly called RAM.
- data which may be required at later time generally stored in secondary storage e.g. on disk, tape, or CD-Rom.

Systems

Higher Computing

Memory: characteristics

- Capacity : no of bits, bytes or words in module. Addressable unit - 1 word . Word size may be 8, 16, 32 bits ; (1 byte = 8 bits)
- Unit of transfer : RAM = 1 word ; Disk = 1 block
- access time or speed - time required to read from memory location. Tradeoff between quantity, cost and speed . As speed increases so does cost.
- Also know as Primary Storage

Systems

Higher Computing

- Registers: very fast memory internal to CPU providing temporary storage places for data being manipulated.
- System clock generates regular pulses to synchronize all system events and determine the speed at which processing can occur.
- Basic measure of system performance is clock speed, measured in megahertz (millions of cycles per second)

Systems

Higher Computing

Semiconductor main memory

Primary memory is made up of RAM and ROM

Types include:

- RAM (Random Access Memory)
- ROM (Read Only Memory)

Systems

Higher Computing

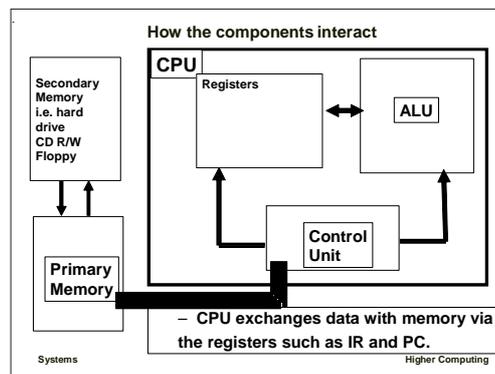
ROM- SECONDARY STORAGE

Read Only Memory

- Permanent non-volatile
- Software and data fixed during chip manufacture
- Cannot be written to
- All computers have some ROM to load the Operating System into RAM (bootstrap loader)

Systems

Higher Computing



Systems

Higher Computing