

Computing theory

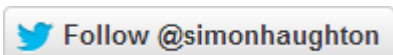
for 7-11 year olds

**An essential companion for the
new national curriculum**

By Simon Haughton

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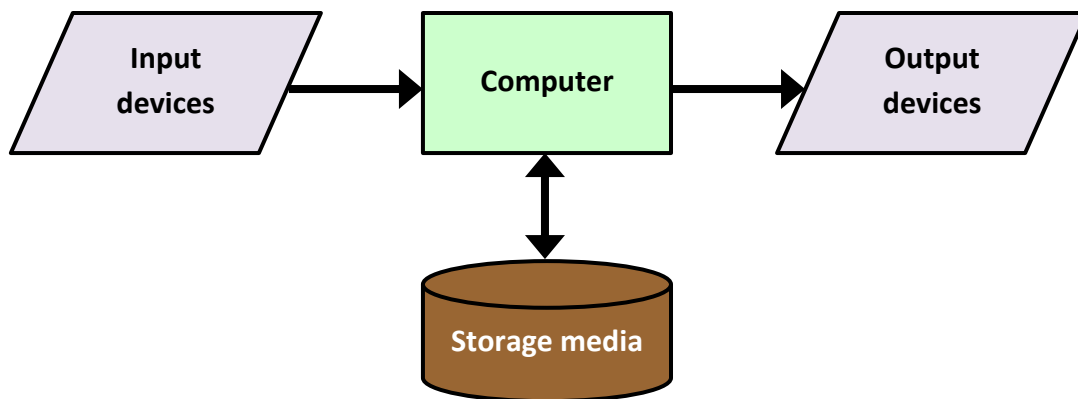


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1. What are the parts of a computer system?

A computer system will input, process and then output data.



All of the electrical or mechanical parts of a computer are called hardware.

Input devices let you put information from the outside world into a computer.	Output devices get information out of a computer and present it in a way you can understand it.
Popular input devices include a: keyboard, camera, microphone, mouse, touchpad, touch screen, game controller and biometric device (e.g. fingerprint identity sensor)	Popular output devices include a: monitor or screen, speaker, printer, projector, flash light and a wide variety of control devices such as motors and buzzers.

An image displayed on a computer screen is made up of lots of tiny dots called pixels. Its resolution is the number of pixels that can be displayed in a set area. Displays with lots of pixels have a high resolution.

Essential hardware devices are located on the motherboard inside a computer and include:

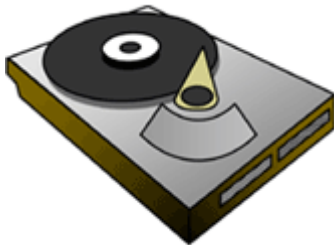
- The **power supply unit** which supplies power to the computer system for it to work.
- The **processor** which performs all the calculations that the computer does. The faster the processor is, the faster your computer will work.
- The **main memory** which stores the programs and data that the user is currently working with so it can be immediately accessed.
- A **network interface card** which allows the computer to connect to a network, such as the Internet.

The internal components of a computer are linked together by wires called busses which are used to send electronic signals down.

Extra devices called peripherals can be connected to a computer externally, such as a printer. These can be connected wirelessly or using sockets known as ports.

Storage media are used to keep data when a computer is switched off. Data is read from or written to a storage medium by a drive. Popular storage media include:

- hard disks;
- flash memory (e.g. SD cards and USB flash drives);
- optical disks (e.g. CDs and DVDs).



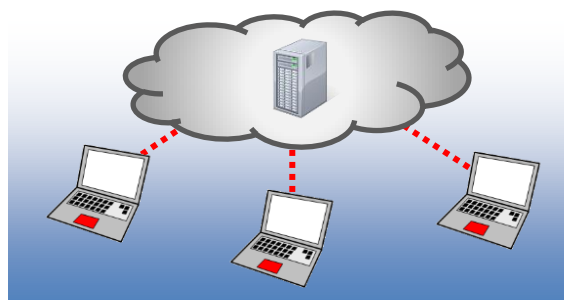
Computers are digital devices because they can only store data as binary numbers (0s and 1s). How much space data takes up on a storage medium is measured in these units:

Unit	The same size as...
1 Bit	A single storage location which can hold either a 0 or a 1.
1 Byte	8 Bits - Enough memory to store 1 letter.
1 Kilobyte (Kb)	1,024 Bytes – Enough memory to store a few sentences of text.
1 Megabyte (Mb)	1,024 Kilobytes – Enough memory to store a couple of images.
1 Gigabyte (Gb)	1,024 Megabytes – Enough memory to store lots of music, some computer programs or half a film.

It is important you check that there is enough memory space on a storage medium to save your data. You can delete or remove any files no longer needed to free up space.

Sometimes data saved on a storage medium can get lost. This might be because of: a computer virus, accidental deletion, a hardware fault or simply leaving it lying around. It is therefore a good idea to save more than one copy of your work in case the original gets lost. This is known as making a backup.

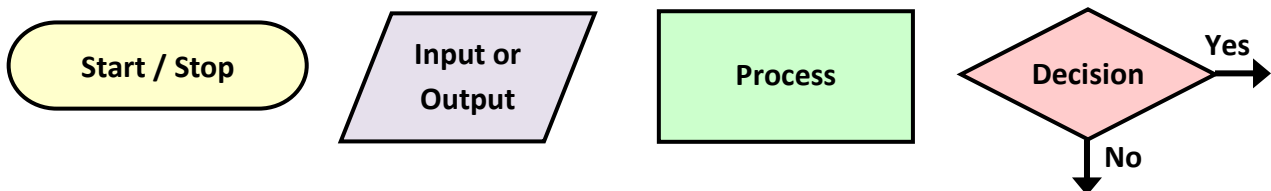
Cloud storage involves uploading data to a remote file server or computer via an Internet connection. Online data storage is secure (as long as passwords are kept private) and ensures protection against physical damage, such as fire or theft.



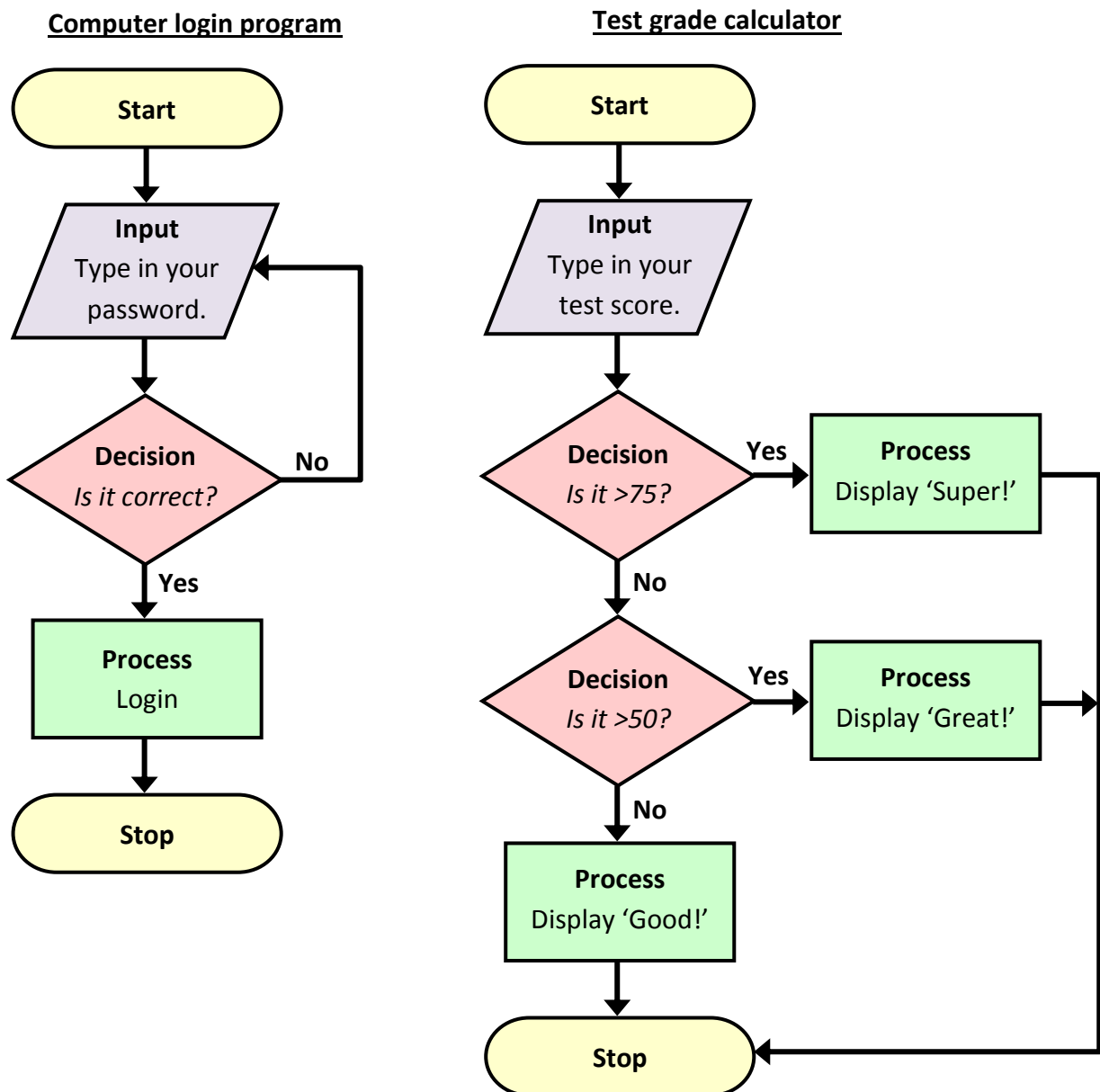
2. What is an algorithm?

An algorithm lists the steps that must be followed to do a task.

A flowchart shows how these steps are linked and the order in which they happen. Each step is put into a different shaped box depending on what it is:



Flowcharts are often used to describe how algorithms will be carried out by a computer.


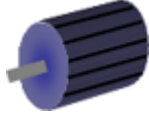

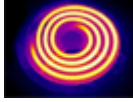



Tracing an algorithm means to carry out an algorithm on paper before it is programmed onto a computer.

3. What is computer control?



Computer control is using a computer to control the action or movement of an object:



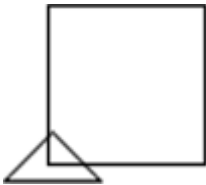
1. An input device transfers information from the outside world into the computer. Sensors are input devices because they measure different conditions.
2. Computers will process the information entered from different input devices using a control program.
3. A control program will respond by controlling devices called actuators:

Actuator		Action produced
Bulb		Lights up.
Motor		Rotates a shaft.
Buzzer		Makes a beeping sound.
Heater		Produces heat.
LCD display		Displays a graphic.

A control box is usually used to connect many input devices and actuators to a computer.

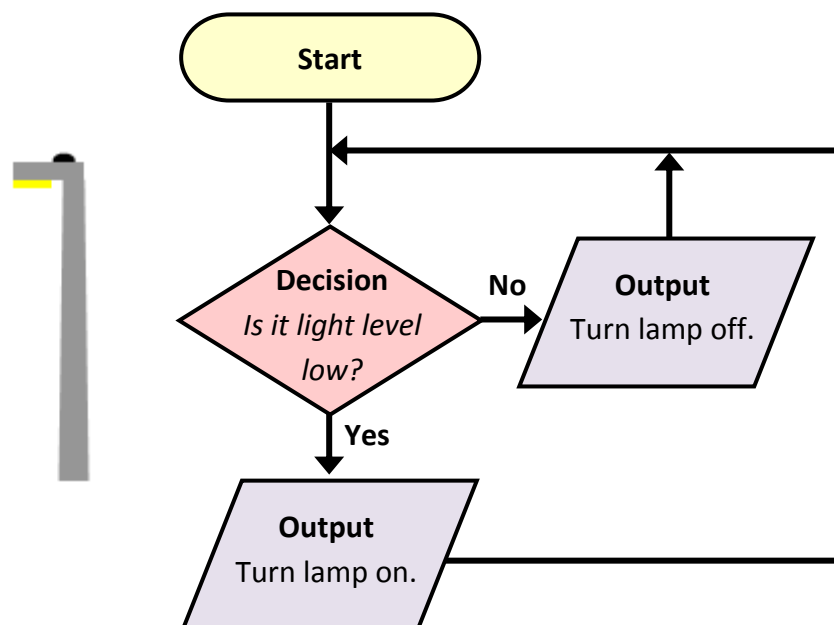
Examples of real-life control systems include:

Situation		Decision to make
Microwave		If the 'start' button is pressed, heat the food inside for 30 seconds.
Door bell		If the button is pressed, buzz a bell for five seconds.

Situation		Decision to make
Lamp		If the switch is pressed in, turn the lamp on. If the switch is pressed out, turn the lamp off.
Television set		Turn the television on or off when the standby button is pressed on the remote control.
Screen turtle		Move the turtle in the direction of the arrow key that is pressed.

Computers can take readings from sensors automatically. This can be helpful in control systems where responses need to be triggered due to changes in environmental conditions, such as:

- **street lamps** coming on when a light sensor detects it is dark;
- **greenhouse heaters** coming on when a temperature sensor detects it is cold;
- **burglar alarms** sounding when a passive infra-red (PIR) sensor detects movement in a room.



Control systems like this are useful because they can:

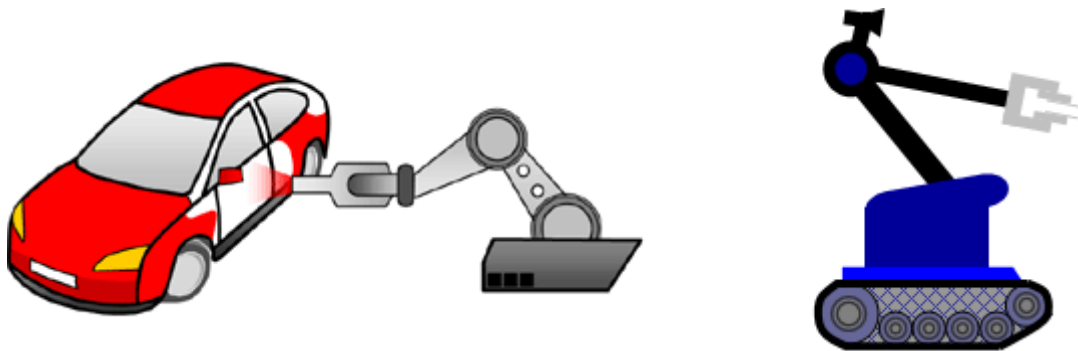
- respond more quickly than humans to changes in environmental conditions;
- work continuously without making mistakes – they are very accurate and won't get tired.

4. What are robots?

A robot is a computer-controlled device that can move about and carry out tasks:

- they take in information from their surroundings using sensors;
- they are programmed to respond automatically by moving or acting, usually using electrical motors.

There are lots of different robots that come in different shapes and sizes. Although some use artificial intelligence to behave like living creatures on their own, most are used in industry to carry out specific tasks over and over again.





Task	Reason robots are used
Robot buggies are used to defuse bombs.	They can carry out tasks too dangerous for people.
Robots on a car production line weld parts together or spray paint onto the bodywork all day long.	They don't get bored or tired by repetitive tasks.
In hospitals, robots sometimes help perform surgery during operations.	They can make much more accurate movements than humans can.

5. What are computer simulations?

Simulations are computer programs that pretend to copy a real-life event. They usually let you explore what happens when you make choices.

A variable is something that can change in a simulation.

A flight simulator	A virtual pet
	
<p>You can choose:</p> <ul style="list-style-type: none">• how high to fly;• how fast to fly;• what angle to turn. <p>These things can change how well your plane flies.</p>	<p>You can choose:</p> <ul style="list-style-type: none">• what to feed it;• when to play with it;• how often to clean the cage. <p>These things can change how well your pet grows and how happy it is.</p>

Simulations let you try things out that could be too difficult, dangerous or expensive to do in real life. If you crash a car in a simulation for example, nobody will be put in any danger and no car will need repairing.

Problems with simulations are that they can be too simple and can be very expensive to run. Sometimes a simulation is used at first but the results are then tested out by using the real system.

6. What is computer programming?

A computer program is a sequence of commands that are followed in order to tell the computer hardware what to do to carry out a task. Computer programs are also known as software.

The most important piece of software that a computer system must have to function is an operating system. Examples are *Window* and *iOS*. An operating system controls the entire operation of a computer by:

- providing a user interface;
- managing communication between different hardware devices;
- organising data on storage media.

A computer program is produced using a programming language, with the commands or instructions in them usually closely related to words in the English language.

A processor can only execute (carry out) commands that are in machine code so a program must be translated by the computer using a compiler before it can be run. The original sequence of commands is known as source code and the file containing the machine code is known as an executable file.

Computer programs process data that has been inputted by the user to produce an output so they are made up of:

- data structures which store the data that is being processed;
- the commands that must be followed to process the data;

A program stores data that it is using in variables. Programming languages have at least five built-in types. They are:

Type	What can be stored	Example values
Integer	A whole number	76, -365
Real or float	A number which includes a decimal part.	3.14, 0.05214
Char	A single character.	S, t, 4, %
String	A sequence of characters such as a word or sentence.	Hello, Tom Jones
Boolean	The value TRUE or the value FALSE.	TRUE, FALSE

Some languages will have other built-in types such as date or time.

Other components of programming languages are:

Component	Purpose	Example in <i>Python</i>
Variable assignment	This sets the value of a variable to a specified value.	<code>number = 100 area = height * width</code>
Arrays	An array stores a set of values. An array that stores a list of data uses one index number and is known as one dimensional.	<code>colours = ['red', 'green', 'blue']</code>
IF statements	These decide which commands to run depending on whether certain things (conditions) are true or false.	<code>if score > 80: ... elif score > 50: ... else: ...</code>
Iteration	A way of repeating or looping commands multiple times.	<code>for i in range(4): print 'Hello world' for i in range(1,10): print (i*10)</code>

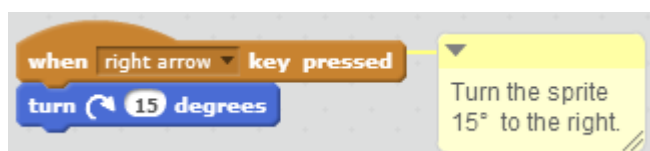
A small sub-program called a procedure or function can be declared (placed) at the start of a bigger program and then called many times from different parts of it. This means that the code within the procedure or function only has to be written out once in a program instead of several times. Decomposing a program into smaller parts like this also makes it easier to understand and edit.

```
import random

def cointoss():
    options = ['heads', 'tails']
    result = random.choice(options)
    print result

cointoss()
cointoss()
cointoss()
```

Many programmers like to add comments beside their code. These are notes which explain what commands do to remind them. They are not run.



```
name = raw_input('What is your name? ')
# The user types in their name and it is saved
# in a variable.
print 'Hello', name # Display this variable
on-screen.
```

Programmers also regularly test their programs during development to check they work as expected. Finding and correcting mistakes in a program's source code is known as debugging. Common errors include commands being spelt incorrectly and punctuation marks like brackets or speech marks being forgotten.

7. How can you select software appropriately?

A generic software application is a package that can be put to a wide variety of uses, such as:

- **word processors** for creating printable text-based documents such as stories or letters;
- **presentation packages** for creating on-screen slideshows to present information;
- **spreadsheets** for doing data calculations and drawing graphs;
- **databases** for collecting and analysing data (e.g. from a survey or questionnaire);
- **graphics packages** for painting pictures and manipulating images.

In contrast, an application specific package is produced to perform one particular task.

Developers usually distribute their software:

- as an online service which runs in a web browser;
- as a downloadable file which needs to be installed on a computer;
- on an optical disk which contains a file that need to be installed on a computer.

When choosing the best software to complete a task in, consider:

- *What is the purpose of the task?*
- *Who is the intended audience?*
- *What digital devices are available for you to create and share your work on?*
- *Do you need to produce a hard copy (e.g. on paper) or soft copy (e.g. on screen) output?*

Sometimes different software applications need to be combined to complete a task – photos might need to be edited before they are inserted into a presentation, for example.

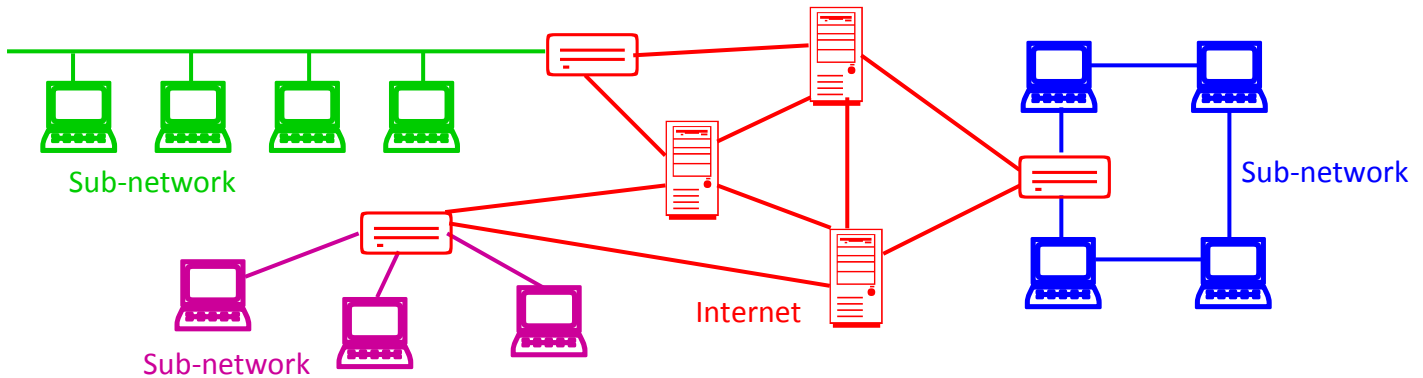
When evaluating software to decide whether to install it, consider these factors:

Factor	Questions to consider
Description	<i>Does it offer any new or interesting tools? How might its tools be useful?</i>
System requirements	<i>Do you have enough storage space to install it? Does it need a certain operating system to run on?</i>
Price	<i>Is it free? Does it offer any extra add-ons to buy?</i>
Reviews	<i>What do other users think of it?</i>

Once software has been installed, it could be helpful to step through a tutorial to find out how to use the software properly or read its user guide to find out any advanced features it has.

8. What is the Internet?

A computer network is a group of computers which are connected together to allow communication between them. The Internet is an *international network* of computers connected together with copper cables and optical fibres.



It offers services like:

- the World Wide Web (information presented on websites);
- electronic mail (for sending messages);
- broadcasting (e.g. streaming multimedia content like TV shows);
- social networking (with: friends, family and people with similar interests).

An Internet Service Provider (ISP) is a company that lets you connect to the Internet via their computer system. They may filter unsuitable content or limit how much data can be sent at once (the bandwidth).

A wireless or WiFi connection lets devices access the Internet without having to be plugged into a connection socket. This means that they can be moved around easily without lots of wires getting in the way. A wireless router is usually used to send out radio signals to nearby computers so they can go online.



The Internet is useful because it:

- is always up-to-date;
- can be accessed across the world;
- allows multimedia to be shared quickly;
- contains a huge range of information;
- lets people contact each other easily.

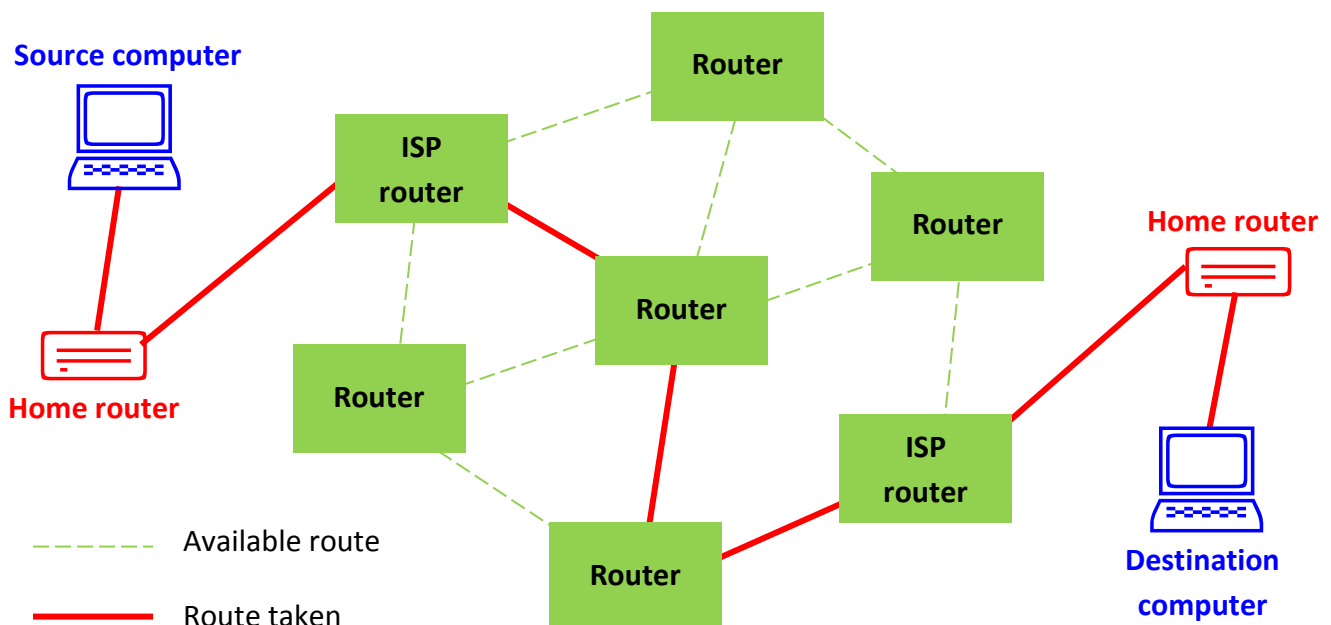
Some people worry that a hacker could illegally access their computer using the Internet and steal personal files and information from it. A firewall is a program that allows you to access the Internet but prevents other users of the Internet from accessing your computer.

9. How is data sent over the Internet?

Data that needs to be sent over a network is split up into small chunks called packets. The transmitting computer adds extra information to each packet, including its: source address, destination address and packet number (so packets can be reassembled in the correct order).

Destination address	Source address	Packet number	Data	Time To Live
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On the Internet, devices called routers identify the destination each packet of data is being sent to and choose the shortest or quietest route to send the packet down to get it closer to its destination. A set of packets may be routed along different paths if there is congestion or if a router breaks.



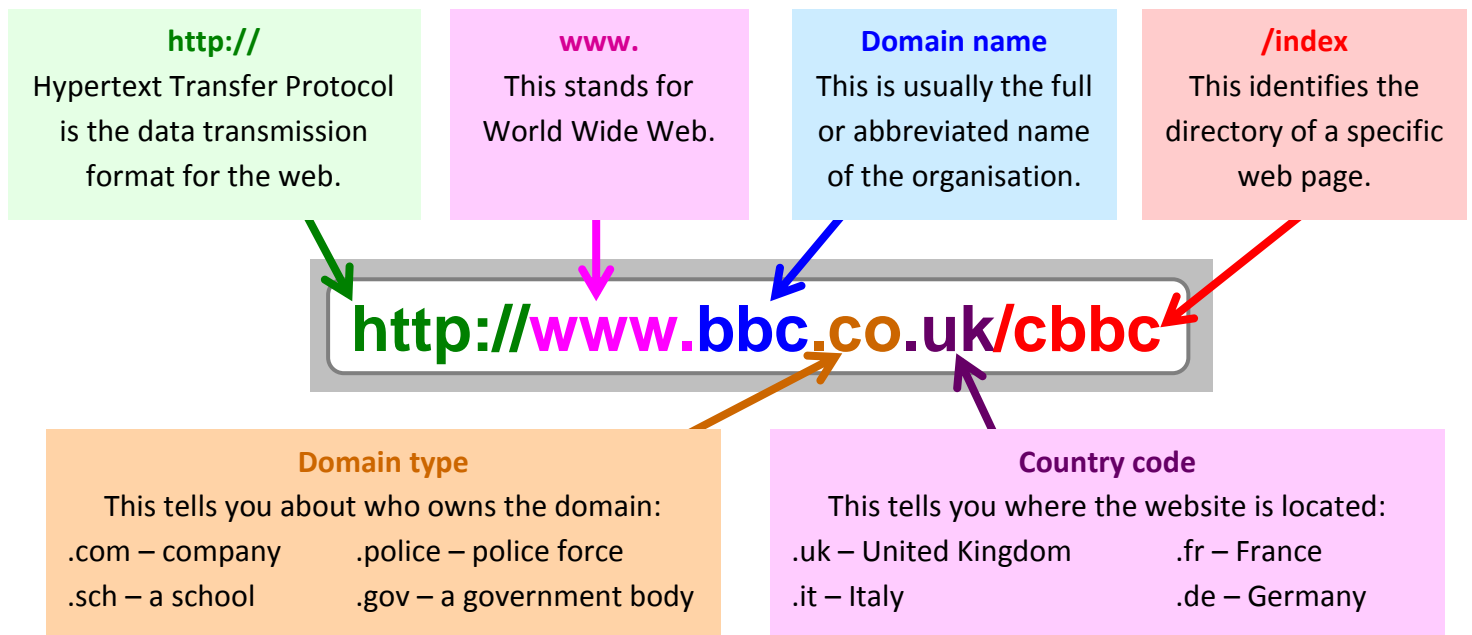
Every computer on the Internet uses a unique set of numbers called an IP (Internet Protocol) address to identify it. Also, the computers all use a common language called TCP/IP to communicate with each other and understand the data being sent (TCP stands for Transmission Control Protocol).

Packets of data will sometimes be given a set time to live (TTL). This means that the number of routers they can hop over is limited before they are then destroyed. The Internet does this so that data which can't reach its destination doesn't clog up the network.

10. What is the World Wide Web?

The World Wide Web is the collection of websites available on the Internet. It is popular for: researching, advertising, shopping and playing games on.





Each website has a unique web address (URL) to identify it. You can get some useful information about a website by looking at its URL:



Organisations have been set up for people to register domain names with that they want to use. People cannot use a domain name that has already been registered as belonging to somebody else.

Each website is made up of many different web pages. A hyperlink is some text or an image that when clicked on takes you to the page that it is joined to. Looking at web pages by clicking on links to move from one page to another is known as surfing. A hyperlink to a page that no longer exists is called a broken link.

You use a web browser to view websites on the World Wide Web and they also let you:

	save bookmarks of your favourite websites;
	navigate backwards or forwards between pages as you surf;
	open up different pages at the same time in different tabs;
	keep a list of recently visited websites (your history).

A computer language called HTML is used to set the layout of web pages. Web designers upload their web pages and files to a server and they then travel over the Internet for people to download when they want to.



11. How can you use search technologies effectively?

Search engines let you find websites on the World Wide Web. They include: *Google*, *Ask* and *Bing*.

Search engines scan websites automatically and index them on their computers. They look in their index of the web and select useful websites when you search.



To make your searches effective and to find possibly relevant websites quickly, you should:

- use just two or three key words about a topic in your search terms (e.g. Roman army soldiers);
- search for exact phrases by putting them in quotation marks (e.g. "Queen Victoria");
- don't use common words (e.g. 'the', 'a' and 'for') as they are usually ignored;
- use OR to get results containing one or more of your search terms (e.g. Henry Eighth OR VIII);
- use a wildcard (*) for any words you aren't sure of (e.g. Winston *).

Search results are ranked or ordered by:

- how relevant they are;
- how popular they are;
- which language they are written in.

You can filter search results to show certain media (e.g. images or maps) or websites from a certain time (e.g. the past week).

You can check how useful a result is by: reading its title, looking at its URL and checking who its author is.



You should also cross-reference (compare) websites to check how truthful the information on them is. Websites with similar facts are more likely to be reliable. Biased information describes only one opinion about something. Examples are companies pretending their products are better than their rivals and people describing what they personally think about something (e.g. a film review).

Plagiarism is copying other's work and pretending it's yours so you should always put information into your own words and reference the websites you've looked at.

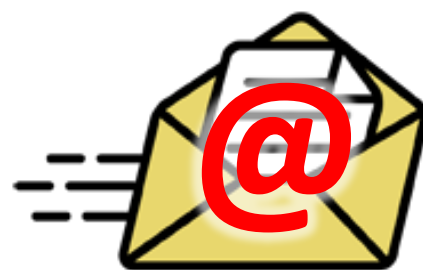
12. What is digital communication and collaboration?

Digital communication is sending messages to other people over a computer network. It allows people to share information and ideas over long distances. The best method to use will depend upon:

- the type of information being sent;
- how quickly it must arrive;
- what equipment is available.

Electronic mail (email) services let you send private messages to other people over the Internet. Each email has a subject (title) and is sent to an email address. Received emails arrive in an inbox.

Advantages	Disadvantages
Emails arrive almost instantly – unlike the postal system where a message could take days to reach its destination.	It can be difficult to check who has sent you an email if their email address is unusual.
Emails can be sent very cheaply around the world.	Parcels cannot be sent by email.
Multimedia content can be sent as email attachments.	Not everybody in the world can use or access email.



Other services for communicating online include:

- social networking websites which let you chat with your friends and followers;
- discussion forums which let you post messages for people who have similar interests to read;
- blogs which let you share your opinions on topics and let other people comment on them;
- multiplayer games which let you compete and play against other users;
- Voice over Internet Protocol (VoIP) services which let you make audio and video calls.

Online collaboration tools are web applications that allow you to work on the same document at the same time with other people. This means that you can share ideas with each other easily and create, edit and refine content as a team together.

Some computers let you wirelessly communicate with other devices, such as by:

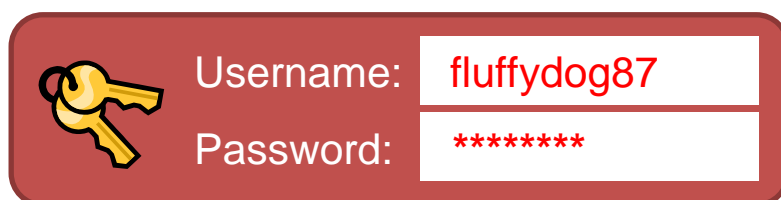
- sharing or mirroring a computer display onto a TV screen;
- interacting with a game using a remote joystick;
- controlling music which is played through speakers.



13. How can you stay safe when communicating digitally?

Some digital communication services make you login to use them. A password is a codeword that must be entered before access is allowed. They are often used with user names.

Strong passwords are at least eight characters long and include numbers and letters mixed up. You should always keep your passwords secret to stop people logging in and pretending to be you. Never share your passwords with friends or strangers and don't use the same password for different services.

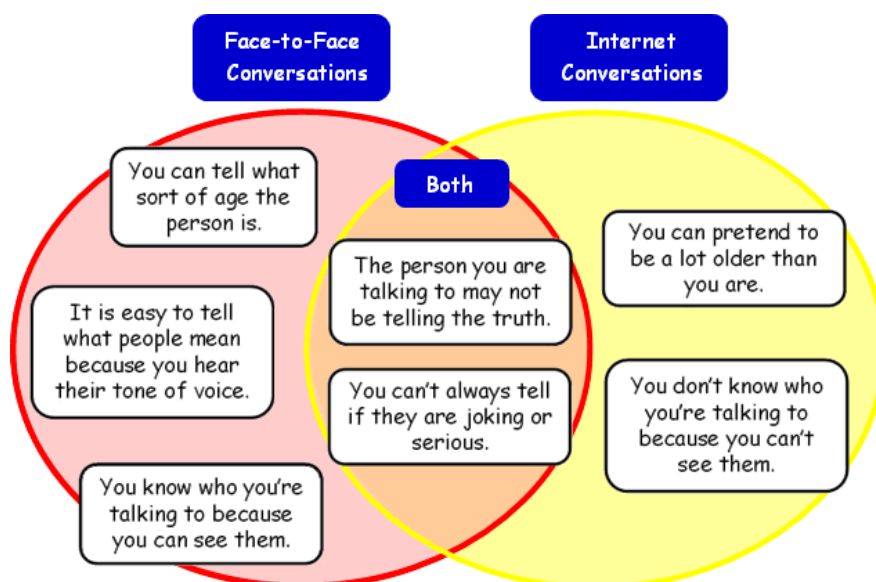


Username: fluffydog87

Password: *****

Age restrictions stop people signing up to services if they are too young. If you pretend to be older, you are lying, breaking the terms and conditions of the service and could get involved in adult discussions that are not appropriate. Child friendly services are safer because they only allow children to join them and are often moderated by an adult to keep everyone behaving nicely.

There are differences between online communications and real-life conversations when talking with somebody face-to-face:



A real-life person can be trusted more than a stranger on the Internet who could hide their true identity from you more convincingly.

Personal information is something that can identify you or where you live, such as your postcode or school name. You should always check with a responsible adult before sharing personal information online because it could be misused.

There are several hazards you could encounter when using digital communication services:



Spamming	Viruses	Cyber-bullying
A spam message is a message trying to persuade you to buy or visit somewhere.	A virus is a nasty program that can damage your computer and files on it. They are often sent as attachments to messages.	Cyber-bullying is people sending you unkind or nasty messages over the Internet.

If something worries or upsets you online, you should always report it to a responsible adult straight away. Try to keep any evidence such as screenshots of websites or copies of messages that you've been sent.



ZIP IT

Keep your personal stuff private and think about what you say and do online.



BLOCK IT

Block people who send nasty messages and don't open unknown links and attachments.



FLAG IT

Flag up with someone you trust if anything upsets you or if someone asks to meet you offline.



www.ceop.police.uk

The *Child Exploitation and Online Protection* centre provides help and advice to children about Internet safety. They also support the reporting of online abuse.

You should always show good netiquette when communicating digitally. This means that you should be polite and show respect towards others. It can also be useful to type messages in Standard English with correct spellings because it makes your work easier to read and less likely to be misinterpreted by others.

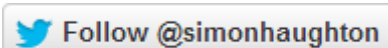
14. Who were the most significant pioneers of computer science?

Here is a list of some of the most famous people who have had a significant role in developing new technologies and computers:

- Charles Babbage was a British mathematician and mechanical engineer who first developed the idea of a programmable computer in the early Victorian period.
- Alan Turing is often called the founder of computer science because he created the concepts of 'algorithm' and 'computation' during World War II.
- Tommy Flowers was a British engineer who designed the world's first programmable electronic computer, to help solve encrypted German messages during World War II.
- Douglas Engelbart invented the computer mouse in 1968 and helped to develop the idea of networking computers.
- Tim Berners-Lee is best known as the inventor of the World Wide Web. He sent the first communication via the Internet in November 1989.
- Bill Gates was the chairman of Microsoft, the world's largest personal computer software company, which launched its first version of the *Microsoft Windows* operating system in 1985.
- Steve Jobs was the chairman of *Apple*, which pioneered the development of mobile technology.

Here is a list of some of the most famous computers from the 20th century:

- The *Turing machine* was invented in 1936 by Alan Turing to simulate the logic of a computer algorithm.
- The *Colossus* computer was the world's first electronic programmable computer, built to help solve encrypted German messages during World War II.
- The *Manchester baby* was the world's first stored-program computer, which first ran in 1948.
- The *Ferranti Mark 1* was the world's first general-purpose computer which was commercially available in 1951.
- The *BBC Micro* was built for the *BBC Computer Literacy Project* in 1981. About 80% of British schools had a *BBC Micro* because lots of educational software was created for it.
- The *ZX Spectrum* was a personal home computer with a colour display released in the UK in 1982 by Clive Sinclair. It led to a boom in the British IT industry because it was so popular.



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