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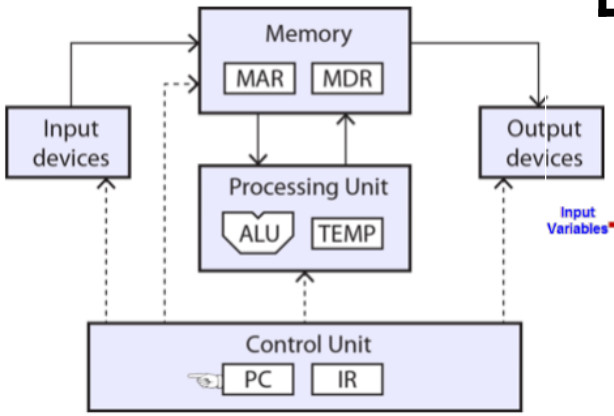
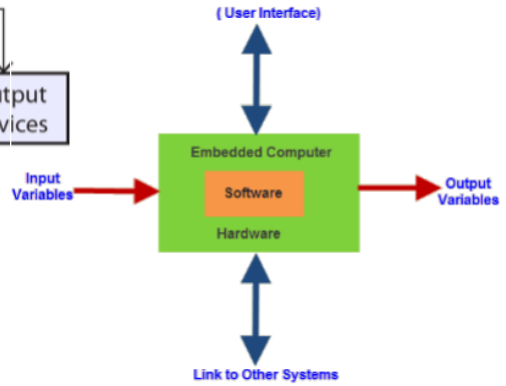
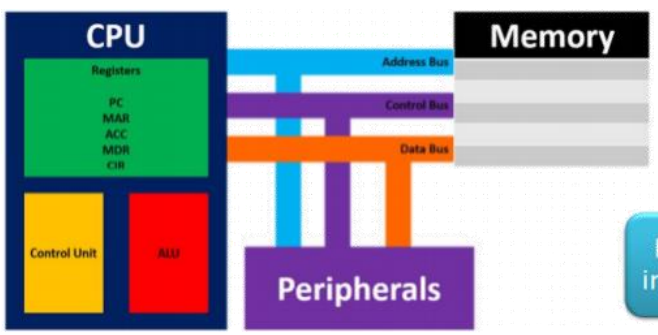
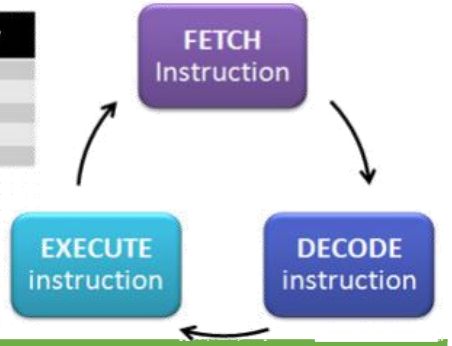
Architecture of the CPU









Special purpose registers	
Memory Address Register (MAR)	Holds the address of the instruction or data to be fetched or stored.
Memory Data Register (MDR)	Holds actual data or an instruction that is fetched from or waiting to be written to memory.
Accumulator	Special purpose fast access memory location within the CPU where the ALU stores results.
Program Counter (PC)	Holds the memory address of the next instruction to be processed.
Current Instruction Register(CIR)	Holds the current instruction to be executed which has been fetched from memory and is temporarily held in the MDR before being copied to the CIR.

Key vocabulary	
CPU	The central processing unit is computer hardware. It executes programs and manages all other hardware in the computer system.
Clock Speed	The number of instructions a processor can carry out each second
Cores	A processing unit found inside the CPU. Multiple programs can work in parallel to each other.
Cache	Quick access memory inside the CPU. Generally comes in small quantities, as it is expensive to produce. Comes in levels, as the level becomes higher, access speed slows down.
Bus	Internal connection within the CPU used to transport specific types of data. The three types of bus used include address, data and control.
Control Unit (CU)	The control unit coordinates the activities taking place in the CPU. It may be used to execute instructions, decode instructions and controls the clock speed of the processor.
Arithmetic Logic Unit (ALU)	Does all of the calculations (addition, subtraction, comparison of numbers, etc.) and logic operations (AND, OR, NOT, etc)
Registers	Temporarily holds tiny bits of data needed by the CPU, and are much faster than any other form of memory. Registers are referred to by an address number.
Von Neumann Architecture	In the 1940s John Von Neumann developed the concept of storing a program which can be run on a computer. This architecture is still used when designing and creating computers today.
Fetch - Decode - Execute Cycle	The cycle used to fetch instructions from main memory, load relevant data, decode the instruction and fully execute the instruction repeats to complete a program.
Embedded System	A device, which does not need an operating system and performs a specific task. Such as a dishwasher interface.

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Architecture of the CPU

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1. The purpose of the CPU

The purpose of the CPU	To manage basic operations of the computer. To be the 'brains' of the computer
The main components of the CPU	Control Unit. Arithmetic Logic Unit. Registers. Cache
Von Neumann Architecture	The architecture that allows for the storage of instructions and data in the same location
The FDE Cycle	The cycle the CPU continuously carries out to process instructions
Binary	The number system used to store instructions and data in the computer
The role of a register in the CPU	It is a place to temporarily hold data and instructions as they are being processed by the CPU.
The PC	The Program Counter keeps the address of the next instruction to be processed
The MAR	The Memory Address Register is used to tell the CPU where to locate data in Main Memory
The MDR	The Memory Data Register is used to store data that is fetched from Main Memory
The ACC	The Accumulator stores results of logic operations and calculations used during processing

4. CPU Performance

Clock speed	How fast a processor processes instructions. Normally measured in Megahertz or Gigahertz.
Cache Size	The "size" of the cache is the amount of main memory data it can hold.
Number of cores	Determines how many tasks can be completed at the same time.

5. Embedded Systems

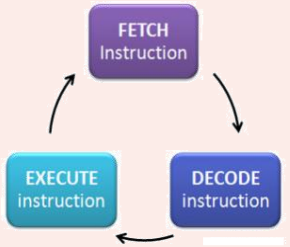
The purpose and characteristics of embedded systems.	A small computer that forms part of a larger system, device or machine. Its purpose is to control the device and allow a user to interact with it. They tend to have one, or a limited number of tasks that they can perform.
Examples of embedded systems	Central heating systems, engine management systems in vehicles, domestic appliances, such as dishwashers, TVs and digital phones etc.

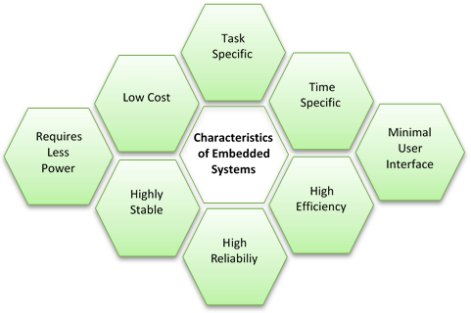
2. Common CPU Components and their Function

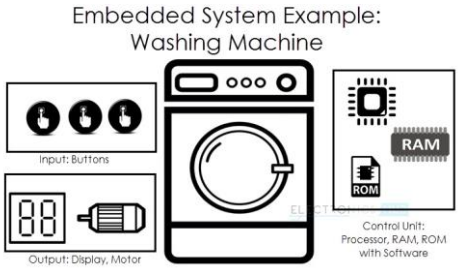
The Control Unit has two functions	(1) Sending signals to control the flow of data and instructions, and (2) decoding instructions
Cache memory	A small section of extremely fast memory used to store commonly used instructions and data. It is useful as the CPU can access the (fast) cache directly. L1 cache is closest to the CPU, L3 cache furthest
The ALU has the following functions	It carries out mathematical operations / logical operations / shifting operations on data; for example multiplication, division, logical comparisons
An Address	This is a location in he Main Memory (RAM) that stores data or instructions
Buses	Transfer information between the CPU and Main Memory (and other places).

3. The F-D-E (Fetch Decode Execute) Cycle

The F-D-E Cycle repeatedly cycles







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Primary Storage (Memory)

The **need** and **purpose** of primary storage is to hold both data and programs that are in current use by the CPU

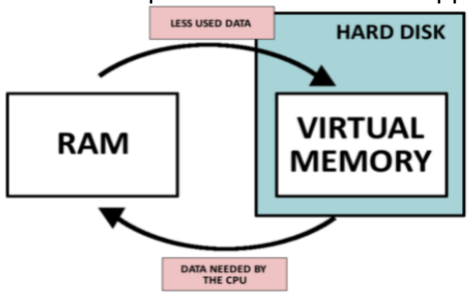
Secondary Storage → RAM → Cache Memory → CPU

The CPU will first search for data in the Cache memory and then move further away until it finds what it is looking for. The further away from the CPU, the longer data will take to transfer.

Type of Memory	What does it do?	When is it Used?
Read-only memory (ROM)	Stores permanent information like telling the computer how to start up.	When you turn a computer on or off.
Random-access memory (RAM)	Stores temporary information when you are working in a file.	When you start and use software

RAM vs. ROM	
RAM	ROM
Volatile memory	Non-volatile memory
Stores the user data / programs / part of the operating system that is currently in use.	Used to store the BIOS / bootstrap loader.
Memory can be written to or read from.	Memory can only be read from and not written to.

Virtual memory enables data that is in RAM and not currently being used to be transferred to the hard disk. This frees up room in RAM for other programs and data. When the data on the hard disk is needed again, any other unused data is transferred to the hard disk before the original data is transferred back to RAM. This process is known as swapping.



Key vocabulary	
Primary Memory	Memory used to store data and instructions that are required by the CPU.
RAM	Random Access Memory is volatile memory used to store data and instructions which are needed by the CPU. Also referred to as main memory.
Dynamic RAM	Contains 1 transistor and capacitor that hold charge briefly. This needs to be refreshed every few milliseconds.
Static RAM	Uses 5 transistors which are wired together to represent each bit. No need to be refreshed. More wiring per bit.
ROM	Read only memory. Used to store the boot sequence as this should never be changed. This memory is non- volatile.
Bootstrap loader	A small program that loads the operating system. Once the operating system is loaded it takes care of the rest.
Flash Memory	Electrons are forced into a layer between two barriers which hold the charge by using a high electric current.
Virtual Memory	When RAM is full, a section of the hard drive can be used to store programs and instructions.
Volatile Storage	which needs to have power to store data. If power is lost, data is lost.
Non - Volatile Storage	which does not lose its contents when the power is lost

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Secondary Storage

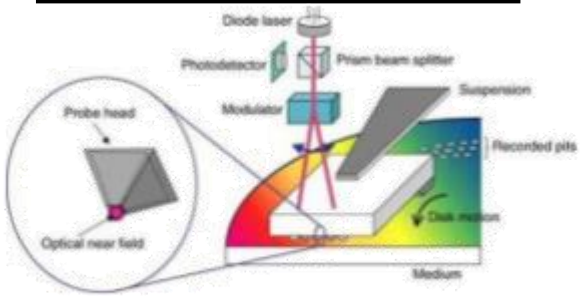

Figure 2 - Optical storage

Comparing secondary storage	
Capacity	The amount of space that is available to store files. Generally measured in GB.
Speed	How quickly a computer can read and write data from a storage device.
Portability	How easy a device is to be transported. Some devices may be permanent hardware, others may be easier to transport.
Durability	Will the device withstand a certain amount of damage without corrupting files?
Reliability	The length of time that a device is expected to last for, how long will it retain functionality?
Cost	The cost of a device is compared in terms of cost per GB

Floppy disc	1.44MB
Zip disc	750MB
CD-ROM	800MB
Jaz Drive	2GB = 2,000MB
DVD	4.7GB = 4,700MB
USB memory stick	16GB = 16,000MB
Backup tape	800GB = 800,000MB
Hard drive	1TB = 1,000,000MB

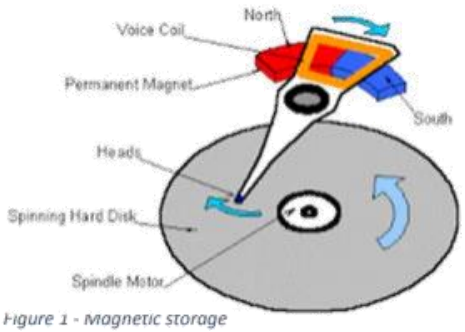

Figure 1 - Magnetic storage

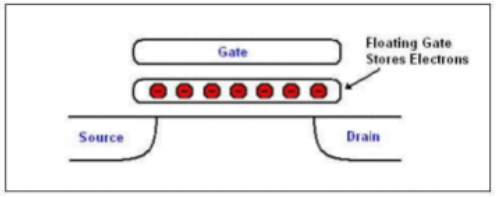

Figure 3 - Solid State storage

Key vocabulary	
Secondary Storage	A non-volatile storage medium which stores files and programs. Examples include the hard drive (HDD) and solid state drives (SSD).
Magnetic devices	Magnetic disks are read and written to with a moving head inside the disk drive. They often contain moving parts and are susceptible to damage. Magnetic devices can be either internal or portable.
Solid State devices	SSD has no moving parts. It retains an electronic charge using logic gates. Examples include SD cards and USB memory sticks. Also referred to as flash storage.
Optical devices	Optical media includes CD, DVD and Blu-Ray disks. Lasers are used to read and write data to a disk. Data is stored on tracks around the disk as a series of pits which represent binary code.
Cloud storage	Cloud storage refers to saving data in an off-site location maintained by another party. Examples include Dropbox, Google and Microsoft. This relies on having an internet connection to be able to upload and download files from a cloud server.

1 Hard-Drive

=

750,000 Floppy Discs!

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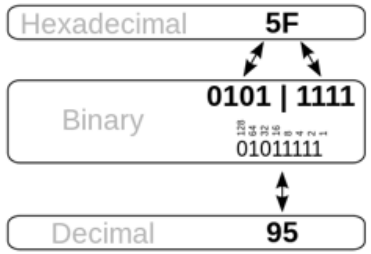
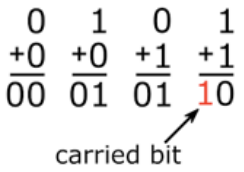
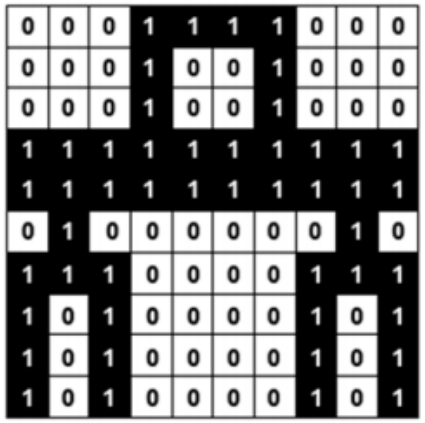
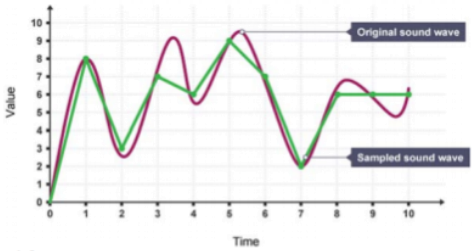
Units, Data Storage & Compression

Key vocabulary	
Binary	Numbering system which uses base 2 (0s & 1s) – the only language that computers truly understand. 0 means off, 1 means on.
Denary	Numbering system which uses base 10 (0-9) – these are our normal numbers that we use every day. (Otherwise known as decimal)
Hexadecimal	Numbering system which uses base 16 (0-9 and A-F). These numbers are used to represent colours and code in assembly language, as they are easier for humans to understand than binary.
Overflow	If you cannot represent a number in the given amount of space (IE more bits are needed to represent a number), then this is an overflow error.
Binary Shift	Moving bits within a binary number in a certain direction. Any empty positions are filled with 0.
Check digit	An additional digit at the end of a string of numbers used to check for mistakes in transmission. ISBNs are formed of 12 bits for the item number, then a check digit.
Character	A single letter, number or symbol. (e.g., A, 1, !).
Character set	A set of characters used in a language, which are each represented using a unique binary number. ASCII, Extended ASCII and UBNICODE are examples of character sets.
Image	A picture that has been created or copied and stored in electronic form.
Bitmap	A map of bits, whereby the image is made of pixels.
Vector	An image represented using lines and shapes with specific properties such as line and fill colour. Data about each shape is stored in binary.
Pixels	The individual units (dots) that make up an image.
Colour depth	The number of bits, which are used to represent each pixel in an image. Increased numbers of colours means more bits are needed.
Resolution	The level of detail in an image, measured in dots per inch (dpi). If the size of an image is increased then the quality will reduce.
Metadata	Data, which is stored about a file. Examples include the type of file, date and time created, file size and geolocation.
Sampling	Method of converting an analogue sound signal into a digital file containing binary numbers.
Sample rate	The frequency at which you record the amplitude of a sound. Measured in Hertz.
Bit rate	The number of bits used to store each sample.
Compression	The re-encoding of data so that less bits are used to store it. Usually done to increase speed of transmission.
Lossy	Removes data completely to reduce the size of a file (eg. JPG).
Lossless	Organises data to reduce the size of a file without removing any information (eg. ZIP).









File types (* means lossy compression used)	
.BMP*	Image
.JPG*	
.GIF*	
.PNG	
.MP3*	Sound
.WAV*	
.WMV*	Video
.MP4*	
.MPG*	
.MOV	
.PDF	Document
.DOCX	

$$Image\ file\ size\ = (width * height * colour\ depth) / 8$$

$$Sound\ file\ size = sample\ rate * sample\ resolution * seconds$$

Units	
Bit	The smallest amount of data (stands for binary digit) (0 or 1).
Byte (B)	8 bits
Kilobyte (KB)	1024 bytes
Megabyte (MB)	1024 kilobytes
Gigabyte (GB)	1024 megabytes
Terabyte (TB)	1024 gigabytes
Petabyte (PB)	1024 terabytes

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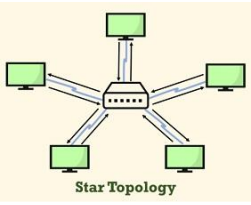
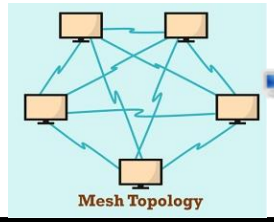
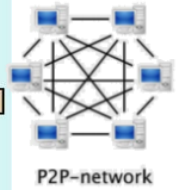
Networks & Topologies

Hardware

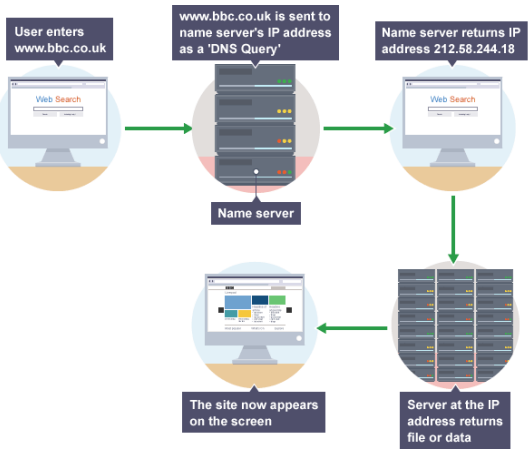
NIC (Network Interface Controller)	The component that allows a device to connect to a network, typical examples are WiFi and Ethernet..
WAP (Wireless Access Point)	The point to which a wireless- enabled device connects to a network. It normally connects to or is built into a router.
Hub	The role of a hub is to allow communication between multiple devices in a network. They are used in LAN networks. Hubs will send a copy of the packets received to all devices on a network. When the devices receive packets they will either accept or reject them, they use the destination IP address to do this.
Switch	The role of a switch is to allow communication between multiple devices in a network. They are used in LAN networks. A switch will behave like a hub when it is switched on, however it will learn which devices are connected to which ports, and then send packets directly to the correct computer, saving bandwidth.
Router	A router is designed to route packets across wide area networks such as the internet. It will pass packets between other routers until the final destination is reached. Modern routers have built in WAP and switches.
UTP (Unshielded Twisted Pair)	A cable used for providing fast data transmission and minimal interference. Relatively easy to install.
Coaxial Cable	Bulkier than UTP and less convenient to install.
Fibre Optic	A cable which transmits light at the speed of light to send binary code. Not subject to interference from neighbouring cables.
Wireless	A commonly used connection as it gives portability to devices and required minimal alteration to buildings. Easy to add new devices to the network







Domain Name Servers (DNS) are used to convert a web address into an IP address. This makes is because web addresses are easier for humans to remember compared to IP Addresses.



Factors affecting Network Performance

Bandwidth	The amount of data that can be sent from one point to another in a certain period of time.
Latency	How much time it takes for a packet of data to get from one designated point to another
Error rate	The degree of errors encountered during data transmission over a network
Transmission media	A pathway that carries the information from sender to receiver

Key vocabulary

Client	A client is a piece of computer hardware or software that accesses a service made available by a web server.
Client-Server	One or more computers are designated as servers, providing a service to clients on a network.
Hosting	A service that hosts websites for clients. Allows them to create, maintain and makes sites it accessible on the World Wide Web.
LAN (Local Area Network)	All devices are connected on one site. The network may be in a single building or campus or group of buildings in a small area. Management and maintenance is usually completed by a group of network engineers.
Network	A collection of computer systems that are linked together and can share data.
Node	A device connected to a network via a link.
Peer-to-peer	A distributed system where functionality can be divided among the nodes on the network. All computers have an equal status and may partially act as a server to other devices. Peers are both suppliers and users of network data and services.
WAN (Wide Area Network)	Typically covers a large geographical area, talking in many cities or worldwide. The connections are typically provided by a telecoms company such as BT. The largest example of a WAN is the internet. A WAN connects multiple LAN networks.
Web Server	A web server is an instance of a computer program that accepts and responds to requests made by another program, known as a client.

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Wired & Wireless Networks

Layering

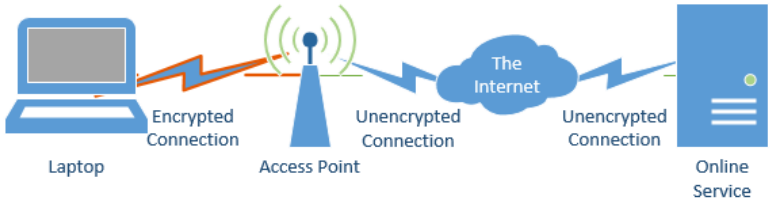
1 Application	Concerned with presenting data in an acceptable format for the user. The software generating the data needs to supply the data in a format acceptable to the software that receives it.
2 Transport	This layer forms connections across the network and agrees on the communication protocols to be used. It will then break information into packets and prepare for transmission.
3 Internet / Network	The internet layer is concerned with transmitting the data across different networks. The source and destination IP are used to establish a path across the network. EG which routers should be used and in what order.
4 Data Link / Physical	Passes the data to the local physical network. It converts data into binary electrical signals that can be understood by the network hardware.

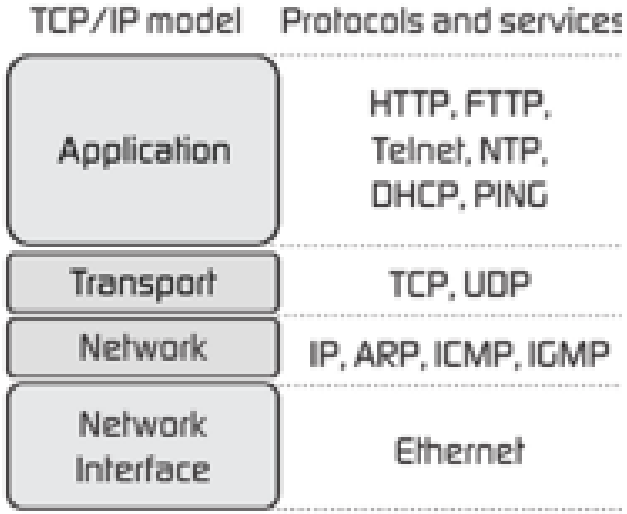
Wired networks

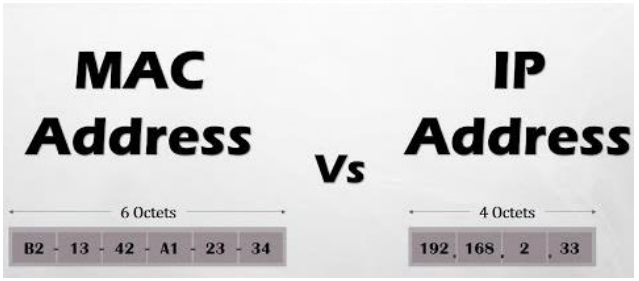
✓ Can't intercept signals down the wire; high-security
✓ Immensely high speeds (depending on cable and hardware)
✓ Incredibly long cables are still really cheap
✓ Plug and play; usually no faffing around with settings, instant-on
x Cable can be damaged

Wireless networks

✓ Convenient, allows freedom of working anywhere
✓ Less/no cables; more people connecting to one access point
x Limited signal range; speed decreases the further away you go
x Signals can be intercepted; low security
x Signals affected by other signals and radio waves
x Speed not as fast as wired networks







Bluetooth is a short-range wireless technology standard that is used for exchanging data between fixed and mobile devices over short distances using UHF radio waves

Key Protocols

Protocol	A set of rules which can be followed to complete a given task. The implementation of an algorithm which allows two or more devices to communicate data.
HTTP	HyperText Transmission Protocol. Protocol used for sending and receiving webpages between users and web servers.
HTTPS	HyperText Transmission Protocol Secure. Protocol used for sending and receiving webpages between users and web servers securely.
FTP	File Transfer Protocol Allows files to be sent and received between client and server.
DHCP	Dynamic Host Configuration Protocol DHCP allocates an IP address to a device when it connects to a network. Without an IP address a device cannot communicate.
TCP/IP	Transmission Control Protocol / Internet Protocol Protocols work together to control the break down of information into packets and adding correct addresses to ensure transmission.
POP	Post Office Protocol Used for transferring emails between the email server and the client. Deletes mail from server once downloaded. No-longer standard.
IMAP	Instant Mail Access Protocol Stores emails on a server, but allows the user to manipulate emails on the server. Allows a user to view mail on multiple devices.
SMTP	Simple Mail Transfer Protocol Transfers emails between different email servers when a new email or reply is sent.

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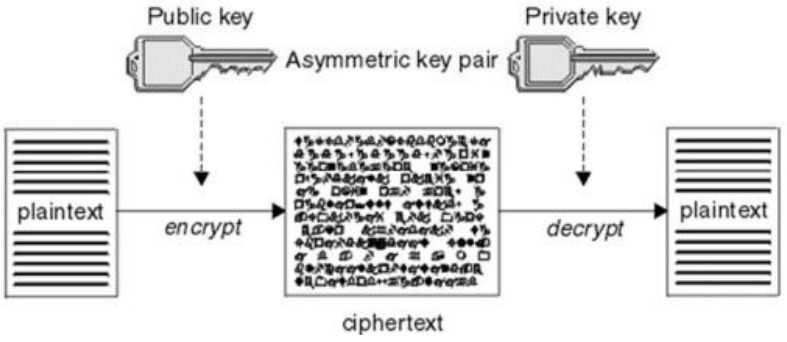
Network Security

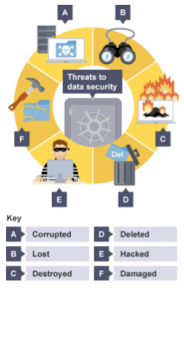
Threats Posed to Networks

Passive attack	Where someone monitors data travelling on a network and intercepts any sensitive information they find.
Active attack	When someone attacks a network, for example with malware.
Malware	Software that can harm devices, which is installed on someone's device without their knowledge or consent. May be spread by email, messaging services or downloading infected files.
Phishing	Emails designed to appear as a reputable organisation to gain trust of users and harvest personal information.
Social engineering	People are often the weakest part of security systems and criminals take advantage of human error and gullibility.
Brute force attacks	An attack that runs through a list of different passwords or letters until access to an account is gained.
Denial of service attacks	Where a hacker tries to stop users from accessing a part of a network or website, mostly by flooding the network with useless requests, making the network very slow or completely inaccessible.
Data interception and theft	Shouldering is attempting to look over someone's shoulder when using an ATM. Measures to reduce this risk include destroying paper documents when no longer needed, logging off or locking computers when not in use and locking rooms containing computers.
The concept of SQL injection	Exploiting a technique that exploits security weaknesses in websites. Achieved by inserting malicious code into a database field on a website such as a password field.
Poor network policy.	Network policies are not always designed to provide maximum security. For example, a strong policy should recommend changing passwords regularly and ensure that the passwords used are strong.

Identifying and Preventing Vulnerabilities

Penetration testing	A strategy to identify security weaknesses including: - Gathering information about the target of possible attacks - Identifying possible entry points to the network - Attempting to break in - Report findings and respond
Anti-malware software	Software designed to protect a computer in one of 3 ways: preventing installation of harmful software, preventing important files from being changed, scanning for virus activity on the system and removing as appropriate. Antimalware protects against worms, Trojan Horses, spyware, adware and key loggers.
Firewalls	Hardware or software designed to prevent unauthorised access to or from a private network or intranet. All messages entering or leaving the network will pass through the firewall to be examined.
User access levels	Part of an access control procedure for computer systems, which allows a system administrator to set up a hierarchy of users. Thus, the low-level users can access only a limited set of information.
Passwords	In a networked environment such as a school or a company, multiple users use many of the computers. Passwords should be strong (Not easy to guess, lower and uppercase letters, numbers, symbols).
Symmetric Encryption	A secret key algorithm (sometimes called a symmetric algorithm) is a cryptographic algorithm that uses the same key to encrypt and decrypt data
A-Symmetric Encryption	Asymmetric cryptography, also known as public key cryptography, uses public and private keys to encrypt and decrypt data. The keys are simply large numbers that have been paired together but are not identical (asymmetric).
Physical Security	Physical security is designed to prevent unauthorized personnel from gaining physical access to network components such as routers, cabling cupboards and so on. Controlled access, such as locks, biometric authentication and other devices, is essential in any organisation.





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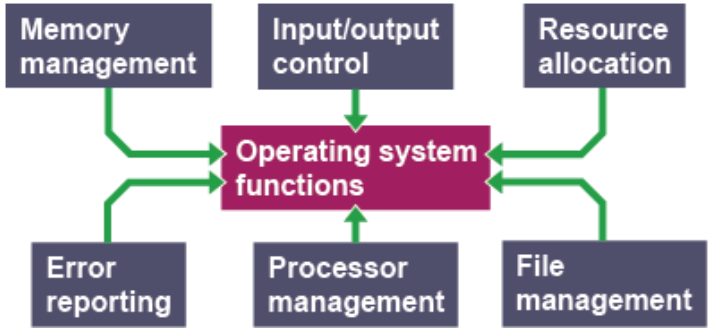
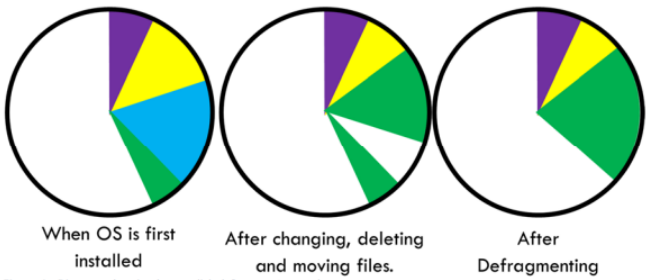
System Software

Operating Systems Vocabulary

Command line interface	Commands are given to the operating system through using text. Normally used by technicians as it can provide powerful instructions quickly.
Graphical User Interface [GUI]	The use of small icons that represent applications and actions that are performed to reduce the need to learn commands
Voice input	Mainly used on mobile devices to provide voice input to a computer system.
Memory management	Operating system ensures that all data is stored safely and efficiently in the correct location.
Multi-tasking	If a current program is loading data from a slow peripheral, rather than allow the CPU to stand idle it will turn its attention to another process. Often used to run several programs at one time.
Peripheral management	Managing the communication through signals between a device and its driver.
Drivers	A program that controls a peripheral device.
User management	A set of controls that allow the access and actions of users to be restricted





Roles of an operating system

- Managing hardware & peripherals
- Managing programs installed and being run
- Managing data transfer between memory locations, the CPU and secondary storage
- Providing the interface between the hardware and the applications
- Providing an interface between the computer and user, managing display to the screen
- Managing security and organising data so that it is not overwritten
- Providing a file system for the storage and retrieval of files

Utility Software Vocabulary

Encryption software	Encryption of data to prevent anyone from gaining unauthorised access to the system and reading the data.
Defragmentation	Reorganising files on the surface of a disk to create large areas of free space and eliminate unused fragments.
Lossy / lossless compression	Software to compress data to use less space in memory, or prepare for sending via the internet
Backup	A technique used to make copies of data in case of data loss or damage.

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Ethical, Legal, Cultural & Environmental Impact

Ethical & Cultural Vocabulary	
Driverless cars	A vehicle that is capable of sensing its environment and navigating without human input.
Manufacturing	Computer technology is used to produce items faster, more accurately and cheaper than can be done by hand.
Shopping	Online shopping has led to the closing of many high street stores. It has also helped people who find it difficult to get to a supermarket for their food shopping.
Communication	Advancements in technology now make it much easier to communicate all over the world using social media, email, texting and phone calls. Information is spreads at a much faster rate.
Employment	The advancement of computer technology has made many new jobs, but has also put many people out of work in a number of industries (for example, manufacturing). Some jobs are now automated or controlled by robots.
Developments in software	Computer software is becoming substantially more developed as time goes on – this is especially visible within the field of artificial intelligence.
Artificial Intelligence	The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.
Healthcare	Technology is used to monitor patients, administer drugs and diagnose illnesses. Health apps are used more regularly on smartphones than ever before.
Social networking	Many people of all ages use social networking sites to keep in touch with others. It is much easier to communicate in this way than it would be to send a card, for example.
Rating culture	Services use star or score-based rating systems to judge people's performance. For example, the taxi company Uber does this to assess the performance of their drivers, based on what their passengers suggest.
Privacy	According to a recent study, Google is within a few years of having sufficient information to be able to track the exact movements and intentions of every individual, via Google Earth and other software they are developing. Greater advancements in technology could further risk our privacy.
Cookies	File, often unique identifiers, that are sent by web servers to web browsers and which may then be sent back to the server each time the browser request a page from the server. Can be used to recognise computers when they revisit a website, track users navigating the site, etc.

Environmental Vocabulary	
Carbon footprint	The amount of carbon dioxide released into the atmosphere as a result of the activities of a particular individual, organization, or community.
Pollution	The presence in or introduction into the environment of a substance which has harmful or poisonous effects.
Computer - aided manufacturing	The use of software to control machine tools and related ones in the manufacturing of workpieces.
Sensors	A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena.

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Ethical, Legal, Cultural & Environmental Impact

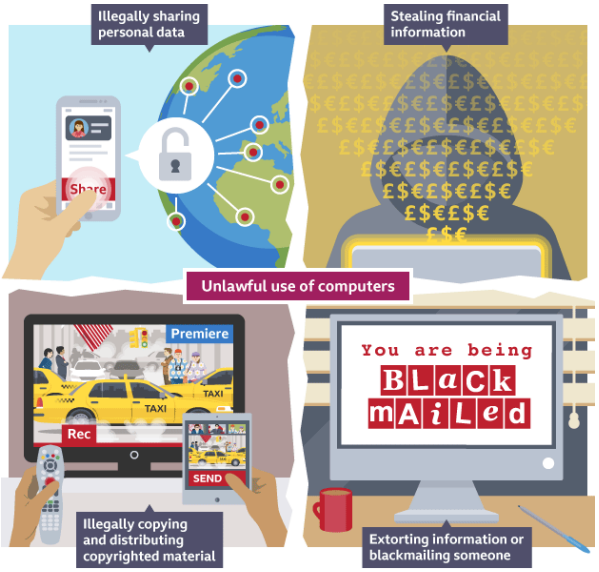
Legal Vocabulary	
Data Protection Act 2018	This Act states that anyone who stores personal details must keep them secure. Companies with computer systems that store any personal data must have processes and security mechanisms designed into the system to meet this requirement. Made up of 8 principles.
Computer Misuse Act 1990	This Act has three main principles, primarily designed to prevent unauthorised access or 'hacking' of programs or data. These are: unauthorised access to computer material; unauthorised access with intent to commit or facilitate a crime; unauthorised modification of computer material.
Copyright Designs and Patents Act 1988	This Act is designed to protect the creators of books, music, video and software from having their work illegally copied.

A picture, drawing or photograph

A video, television programme or film

Text, such as a book, article or report

A game



The Differences between Proprietary and Open Source Software

Open Software (Linux Ubuntu, OpenOffice.org Write, GIMP)	Proprietary Software (Windows Vista, Microsoft Word 2007, Adobe Photoshop CS3)
Purchased **with** its source code	Purchased **without** its source code
User can get open software for **free** of charge	User **must pay** to get the proprietary software
Users **can** modify the software	Users **cannot** modify the software
Users can install software freely into any computer	User must **have a license** from vendor before install into computer
No one is responsible to the software	Full support from vendor if anything happened to the software

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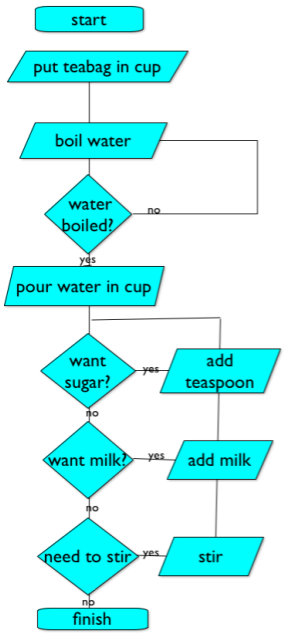
Algorithms

Flowchart



Pseudocode

```
PROGRAM make tea

put teabag in cup

WHILE (water not boiled)
    boil water
    ENDWHILE
pour water in cup

WHILE (sugar needed)
    add sugar
ENDWHILE

WHILE (milk needed)
    add milk
ENDWHILE

WHILE (need to stir)
    stir tea
ENDWHILE

Server and finish
```

Key vocabulary

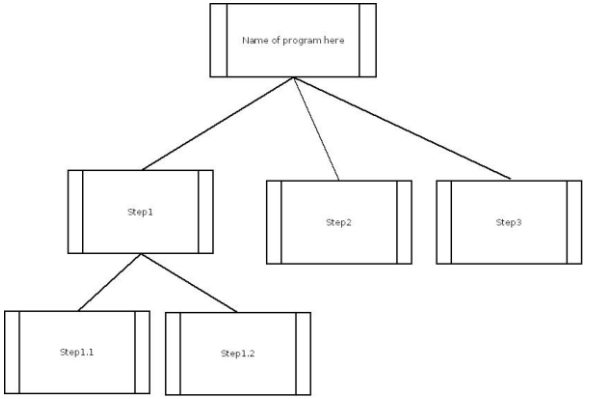
Algorithm	A set of instructions which is followed to solve a given problem. Can be represented using a flowchart or Pseudocode.
Abstraction	Removing any unnecessary detail from a problem in order to solve it. Identifies the information that can be removed from the problem without changing it.
Decomposition	Breaking a large problem down with no known solution into smaller steps and stages.
Algorithmic thinking	Algorithmic thinking is a way of getting to a solution through the clear definition of the steps needed – nothing happens by magic.
Searching algorithm	An algorithm for finding values within a set of data.
Sorting Algorithm	An algorithm used to sort a set of data into a given order. Examples include bubble sort, insertion sort and merge sort.

Flowchart Symbols

Terminator	This marks the start or end of a process
Flow line	Denotes the direction of flow
Input / Output	Represents either an input or output operation
Process	Denotes a process to be carried out
Decision	Represents a decision or branch. The result should follow one of two paths ("yes" or "no")

Abstraction = **removing unnecessary detail** from a problem

Decomposition using a structure diagram



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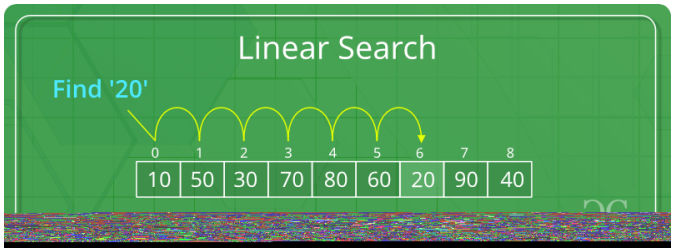
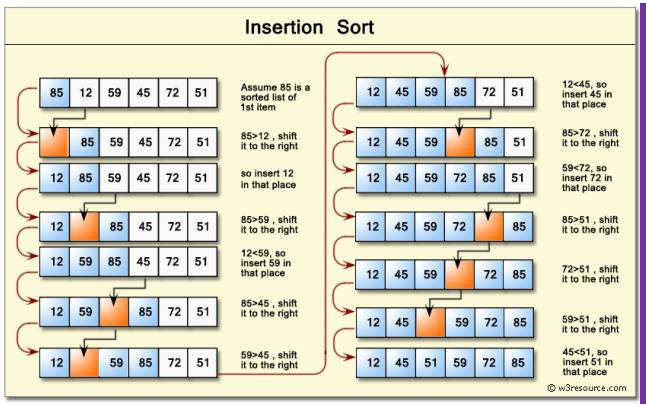
Algorithms

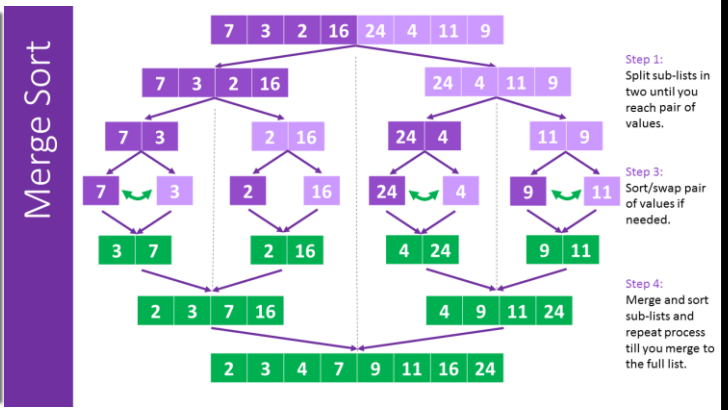
Your list doesn't have to be sorted for linear search to work.



Your list must be sorted for binary search to work.

Searching & Sorting Algorithm Examples	
Linear search	When a list is unsorted and an item needs to be found the algorithm will start at the beginning and move through until it finds the required value.
Binary search	If a list is sorted, an efficient search can be undertaken. It works by repeatedly dividing the set in half and checking where the value is in relation to the current one. It continues until the list has been fully checked or the search term found.
Bubble sort	Works by repeatedly going through the list to be sorted, comparing each pair of adjacent elements. If the elements are in the wrong order they are swapped, else they are left in position.
Insertion sort	Sorts data one element at a time. The algorithm takes one data item from the list and places it in the correct location in the list. This process is repeated until there are no more unsorted items in the list. More efficient than bubble sort.
Merge sort	This is a two-stage sort. Firstly the list is split in half into sub lists repeatedly. The algorithm stops splitting the lists when each list has only 1 element in it. The second stage involves repeatedly merging the lists in order until there is only one sub list remaining.





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Programming Fundamentals & Data Types

Arithmetic Operators			
Operation	Symbol	Example	Output
Addition	+	2 + 10	12
Subtraction	-	9 – 6	3
Multiplication	*	5 * 4	20
Division	/	5 / 2	2.5
Integer Division	//	7 // 2	3
Modulus (Remainder)	%	7 % 3	1

Data Types		
Data Type	This indicates how the data will be stored. The most common data types are integer, string, and float/real.	Casting code
String	A combination of letters, numbers or characters. (eg, Hello, WR10 1XA)	str(x)
Integer	A whole number. (eg. 1, 189)	int(x)
Float/Real	A decimal number, not a whole number. (eg. 3.14, -26.9)	float(x)
Boolean	1 of 2 values. (eg. True, False, Yes, No) bool(x) Char A single character	char(x)

```
print("hello!")
```

```
input("")
```

```
x = input("")
```

```
x = int(input(""))
```

```
answer = x + y
```

```
print(str(x))
```

```
print("Hello", "World")
```

```
age = 12
print("Age: " + str(age))
```

```
if name == "Fred":
```

```
else:
```

```
elif name == "Tim":
```

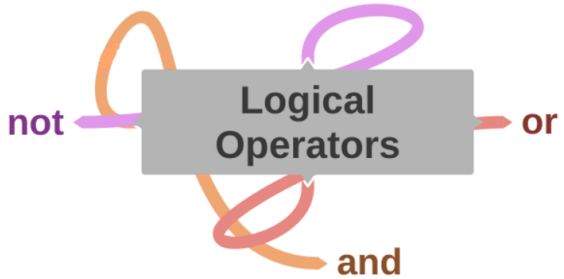
```
# COMMENT
```

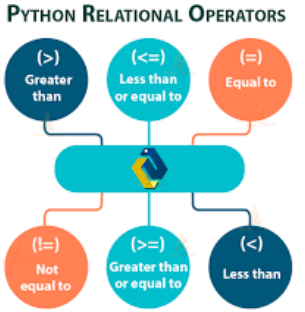
```
for i in range(0,10):
    # WRITE CODE HERE
```

```
while x < 10:
    # WRITE CODE HERE
```

```
list = ["","",""]
```

Key vocabulary	
Sequencing	Writing steps down in an order in which they must happen.
Selection	Being able to select between different options or scenarios.
Iteration	Iteration is the act of repeating a process, either to generate an unbounded sequence of outcomes, or with the aim of approaching a desired goal, target or result.
Variable	A value, which can change when a program is run. A variable is a memory location. It has a name that is associated with that location; the location stores some data.
Python	A programming language used to write programs.
Shell	The place where code is run.
Code editor	The place where code is written.
Programming	The process of writing computer programs.
Code	The instructions that a program uses.
Variable	A value that will change whilst the program is executed. (eg. temperature, speed)
Function	A collection of code that works outside the main program. These are created to speed up programming. They can be called from a single line of code at any time.
Syntax	The punctuation/way that code has to be written so that the computer can understand it. Each programming language has its own syntax.





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Additional Programming Techniques

Arrays

Used when a programmer needs to store a lot of related data. For example, a game might record the scores achieved by players.

One way to do this would be to declare a variable for each score. So for ten scores, the game program would require ten variables:
Score1
Score2
Score3
And so on, up to score10

A better method to solve the problem above is to use an array. It is a data structure that holds similar, related data. An array is like a collection of boxes, each of which is called an element. Each element has a position in the array, and can hold a value. The data in an array must all be of the same data type.

This way, all data is stored under one identifier. For example, the array called "Score" could contain the following information:

0	1	2	3	4	5	6	7	8	9
100	110	85	80	92	72	66	98	100	120

A two-dimensional array can hold more than one set of data this type of array is like a table, with data held in rows and columns.
The following array would hold ten scores for two players. The first player (0) has data stored in the first row. The second player (1) has data stored in the second row.

	0	1	2	3	4	5	6	7	8	9
0	100	110	85	80	92	72	66	98	100	120
1	90	99	102	88	78	100	67	120	88	105

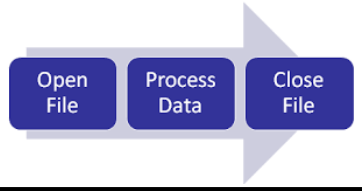
String manipulation

Length e.g. len(wordOne)	The length of a string can be determined using the len statement. This gives the length as an integer.
Character position e.g. wordOne[2]	Used to determine which character features at a position within a string.
Upper and lowercase e.g. topic.lower topic.upper	Changes al the letters within a string to either lowercase or uppercase. Very useful when checking possible inputs.
Concatenation e.g. Sentence = wordOne + " " + wordTwo	Joins multiple strings together to form another string.

File Handling Operations

Programs process and use data. When the program finishes, or is closed any data it held is lost.
To prevent loss, data can be stored in a file so that it can be accessed again at a later date.
Files have two modes of operation:

- read from – the file is opened so that data ca be read from it
- Write to – the file is opened so that data can be written to it



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Additional Programming Techniques

Databases:

A database enables the effective storage of data in a logical and structured way. A large collection of data items and links between them, structured in a way that allows it to be accessed by a number of different application programs.

Records:

A record is a data structure that we can create when we want to group related items of data together.

The name of your record

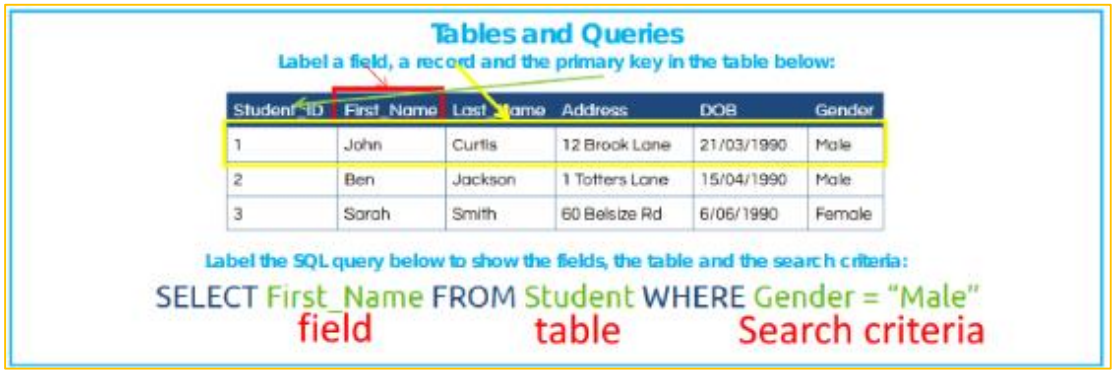
Attributes of your record will be placed inside of the brackets separated by commas.

```
TYPE RECORD Person(STRING VARCHAR=10 Name, STRING CHAR=4 PIN, FLOAT Balance)
```

'VARCHAR=10' means it can be any amount of characters up to 10 characters.

'CHAR=4' means it has to have 4 characters.

Tables Techniques	A table contains a set of records.
Query	A request for information from a database which matches a set of criteria.



Structured Query Language (SQL)	
SELECT	Used when we want to select information from a database.
FROM	This word will come before the table name that we are selecting data from.
WHERE	This is used when we want to specify a condition.
AND	Used when we want to use multiple piece of information or tables.
OR	Used when we want to use a choice of information or tables.

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Producing Robust Programs

Key vocabulary

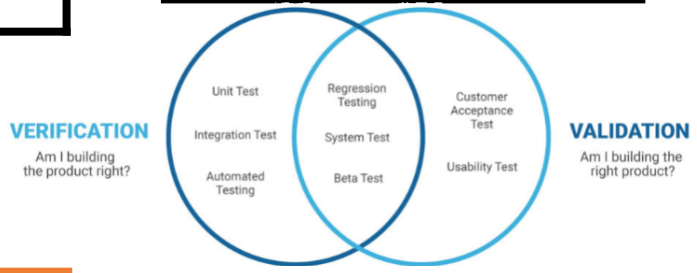
Syntax error	An IDE can often identify syntax errors before running a program. Syntax refers to the structure of the code and grammar of the language being used, if syntax is wrong, the computer will not understand what to do and will not run the program. In Python this includes closing brackets, using colons after if, and indentation. Below on line 3 a semicolon was used instead of a colon.
	`n = 1`
	`sum1toN = 0`
	`while n <= 5;`
	`    sum1toN += n`
	`    print "%3d: %5d" % (n, sum1toN)`
	`    n += 1`

Logic error	These errors may be generated by values and variables not being as expected, for example, division by zero. The computer understands how to run the code, but does not produce the correct result.
Runtime error	A runtime error is a program error that occurs while the program is running. The term is often used in contrast to other types of program errors, such as syntax errors and compile time errors.
Final/Terminal testing	Process of testing a program by real end users.
Iterative testing	Process of testing a program at every stage of the development process. It is vital that the programs are checked at a modular level during development to ensure that the components of the program function as expected.

'); DROP TABLE Users;--

Sanitise

DROPTABLEUsers



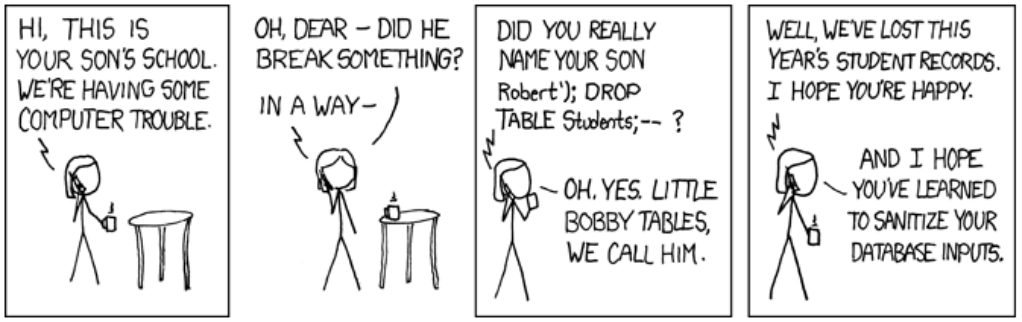
Maintainability

Code should follow agreed naming conventions (EG Lowercase for variable names, schemes to be followed).
Language code is written in.
Sub programs used to tidy up repeated code.
Comments explain the code clearly.
Correct use of indentation.
Useful identifiers (File names & Variable names)
Code should follow agreed conventions

```
def my_function(x, y):
    """This is the docstring. This
    function does blah blah blah."""
    # The code would go here...
```

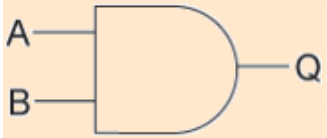
Test Data

Normal	Data a program should accept
Boundary	Data on the boundary of what a program should accept
Invalid	Data that the program should not accept.
Erroneous	Data a that the program wouldn't accept but can cope with (doesn't error because of it).



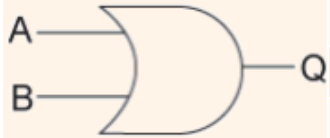
KNOWLEDGE Boolean Logic ORGANISER

Binary Logic Gate Diagrams



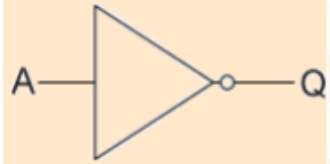
Input A	Input B	Output Q
0	0	0
0	1	0
1	0	0
1	1	1

Q = A ∧ B



Input A	Input B	Output Q
0	0	0
0	1	1
1	0	1
1	1	1

Q = A V B

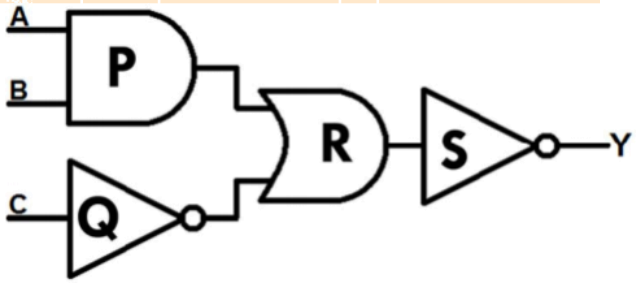


Input A	Output Q
0	1
1	0

Q = ¬A

Computing-related mathematics

+	-	/
*	DIV	MOD
Exponentiation (^)		



Key vocabulary

Logic gate	A logic gate is an building block of a digital circuit. Most logic gates have two inputs and one output. At any given moment, every terminal is in one of the two binary conditions 0 or 1.
And	A logic gate which returns a 1 when both inputs are 1's. Else a 0 is returned.
Or	A logic gate which returns 1 when either or both of the inputs are 1.
Not	A logic gate which inverts its input.
Truth table	A table which shows outputs from a logic gate or circuit given certain inputs.
Transistor	A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power.

A	B	C	P	Q	R	S/Y
0	0	0	0	1	1	0
0	0	1	0	0	0	1
0	1	0	0	1	1	0
0	1	1	0	0	0	1
1	0	0	0	1	1	0
1	0	1	0	0	0	1
1	1	0	1	1	1	0
1	1	1	1	0	1	0

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Programming languages

Key vocabulary	
Opcode	The part of an instruction that tells the CPU the operation to be executed.
Operand	The part of the instruction that tells the CPU the data on which to apply the opcode.
Translator	A program that converts source code (High level) to machine code (Low level).
High level code	Programming languages that are most like human language. They make programming easier because the programmer can concentrate on the logic of the program and not worry about the hardware.
Low level code	Binary code that a CPU can execute.
Assembly Language	A low-level symbol code made of pneumonic words converted by an assembler.
Instruction set	The complete set of instructions that a processor can handle.
Source code	A program written in a high-level language before conversion to machine code.
Object code	The machine code produced by a computer.
Compiler	Compiles work through the source code, spot certain errors and translate all code into a machine code file called object code. Object code is stored in a file to be executed.
Linker	A program used with a compiler or assembler to provide links to the libraries needed for an executable program.
Interpreter	Interpreters work through the source code and translate it one command at a time then immediately execute it. When errors are found the process of execution will stop. (Like in Python).
Execution	The process of running a program.
Editor	A software used to write source code in a simple way.
Integrated Development Environment	A software tool that provides many of the utilities required to develop a program in one place. Common features may include: editor for a particular language; debugging tools; systematic progression through a program; linker.
Run time environment	All the necessary facilities to run a program on a different platform, rather than creation of a program.

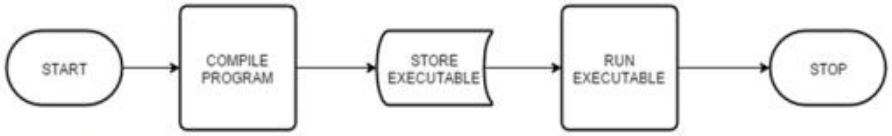


Figure 1 - How a compiler translates programs.

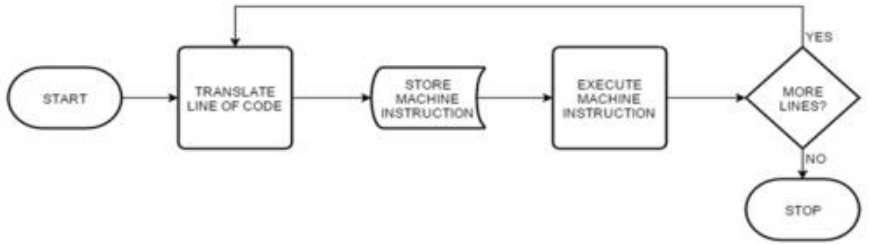
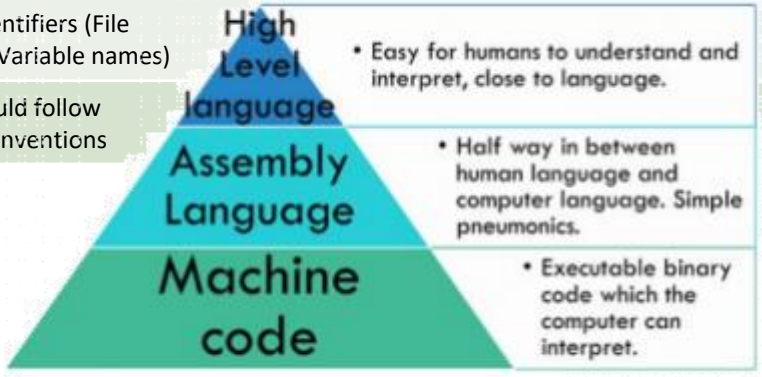


Figure 2 - How an interpreter translates programs.

Programming Standards
Code should follow agreed conventions (EG Lowercase for variable names, schemes to be followed).
Language code is written in.
Functions used to tidy up repeated code.
Comments explain the code clearly.
Correct use of indentation.
Useful identifiers (File names & Variable names)
Code should follow agreed conventions



KNOWLEDGE ORGANISER

Integrated Development Environment (IDE)

Key vocabulary	
IDE	An application used to create software. They can support different languages. They have a number of tools and functions that assist a developer in the creation of so
Code Editor	Auto Completion – designed to save time while writing code. As you start to type the first part of a function, it suggests or completes the function and any arguments or variables.
	Bracket matching – this is used for languages that uses pairs of brackets to mark out blocks of code. It allows the code to be read and understood more quickly. If you forget to close a bracket whilst writing, coloured sections may help you detect the missing bracket.
	Syntax checks - where the IDE recognises incorrect use of syntax and highlights any errors.
Translator	This compiles or interprets the code.
Libraries	These provide functions that are not included in the core part of the programming language. These functions can be imported and used at the start o the program code.
Error diagnostics	Used to detect errors. If the debugger detects errors it may suggest what type of error it is on.