# How does a computer work?

A computer system can be considered of as a configuration of hardware and software, functioning together, processing data, to achieve a purpose.

A computer system contains many physical components which are called **hardware**, instructions which are called **software**, and the people who operate and control them.

## Computer Systems

Computer Systems can be viewed as a set of five sub-systems.

- **Input** takes data from the environment and represents it in a form suitable for processing.
- **Output** takes processed data and presents it in a form which can be used outside the system.
- **Process** manipulates, combines and separates data.
- **Storage** retains data for later output or processing by the system.
- **Control** co-ordinates the operations of the input, processing, output, and storage sub-systems.

(Syllabus p14)
Hardware

The hardware of a computer system consists of a particular set of physical units or devices associated with the various functions of computer sub-systems.

There are many configurations of computers, ranging from devices controlled by microprocessors like calculators and microwave ovens, through microcomputers like those found in the classroom, to large computers used in industry (mainframes).

Peripheral devices are associated with input, output and secondary storage. The Central Processing Unit, or CPU, is associated with processing, control or primary storage.

Fig 3. Typical Hardware Components.
(Daly 1990, 3)
Peripheral Devices

The input and output devices act as interfaces between a system and its environment. The task of input devices is to convert data into a form that can be processed by the various sub-systems of a computer system. Output devices take the processed data and convert into a form that can be used outside the system.
**Input Devices**

Input devices include such things as keyboard, mouse, joystick, barcode reader, graphics tablet, various sensors which can detect things like temperature and light, and disk drives.

![Computer components: Monitor, CPU, Keyboard, Mouse]

Fig 5. Macintosh computer showing keyboard, monitor, and mouse.
(Macintosh miscellany, Art bits, Hypercard stacks. Apple Computer, 1991)

**Keyboard**

A computer keyboard is much like a typewriter keyboard, with mostly the same keys in just the same places. As mathematical software became available there developed a need to enhance the standard typewriter keyboard with a numeric keypad, just like a calculator. Keys to control curser movement have been added as well, although manufacturers still do not agree to a common standard. A defacto standard exists among IBM PC’s and compatible’s, where the curser keys are placed in an upside down T between the standard keys and the numeric keypad. Extra keys to control the computer operation have also been added. These are given various names like control, escape, option, command, alt (alternate?). Their position on the keyboard is not standard except that the “alt” (IBM) and “command” or 🍈 (Apple) keys seem to have found their way to the left of the space bar. The carriage return key is sometimes referred to as the “Return” key, and sometimes as the “enter” key, depending on the brand. Function keys have been added in a row above the numeric keys.
Mouse

Most computers these days come with a mouse as an input device. Beneath the mouse is a ball. As the mouse is moved the ball turns some small wheels which then generate small currents in coils which are then transmitted to the system software. In other words, a mouse will not work unless the software is installed. Some computers like Apple 2e’s even need a special card to operate a mouse. These days most DOS machines, especially those set up with Microsoft “Windows” have a mouse installed. If you need to install a mouse on a DOS machine you not only need to connect the cable, you also need to install a mouse “driver”, the actual software which recognises the mouse input, into the system software.

A mouse is essential to be able to run software which relies on the graphical user interface (GUI) like the Macintosh and “Windows”. However a mouse is a difficult tool to use for graphics applications. It is rather like writing on a whiteboard with a pen attached to a long piece of coathanger wire.

Graphics Tablet

A graphics tablet is a device which makes use of a pen which is “written” onto a special tablet. They offer the extra control for drawing, which a mouse lacks.

Modem

A Modem (short for Modulate - Demodulate) is a device which allows computers to communicate in binary signals over telephone wires (or cables). A modem is used as an input device when it receives data from a distant computer, which sends out the data via a modem. Modems can be used to link many computers to a central one, thus making a network (usually over great distances as opposed to a Local Area Network, or LAN, which is usually on a single site.) Modems are also used to access “Bulletin Boards” where one computer is set up with the sole purpose of being an electronic mail exchange. Most computer User Groups possess such Bulletin Boards by which means members type simple messages on a sort of “electronic blackboard”. Commercial applications include “Compuserve” which enables users to access huge amounts of data in databases in Australia or overseas.

I discovered an area called MAUG (in Compuserve) that seemed to be the hub of the whole Macintosh universe. (Williams, Australian Macworld, 1991, 35)

Barcode Reader

Barcode readers are familiar to everyone at supermarket checkouts and libraries which not only decodes the price of the item for the point of sale checkout, but also its stock code and supplier for the warehouse.

Scanner

![Scanner](image)

Fig 6. Scanner.
(Macintosh Miscellany, Art Bits, Hypercard Stacks. Apple Computer, 1991)

A scanner is a device which is a sort of photocopier which inputs they image as binary data straight into the computer. Scanners require software to work. This falls into two groups.

Some software scans the image and records it as a bit image, where each part of the image is registered as bit of data. A basic scanner may only produce resolution of an image as good as that of a computer monitor, about 150 dots per inch. Better hardware and software can scan at much higher resolution, sometimes greater than not only the monitor, but also the printer. (over 300 dpi). The image is stored as a graphics file.
The second type of software is that which can scan text and convert it into text for a word processor, known as Optical Character Recognition (OCR) software. This software produces varying degrees of success depending on the quality of the original text. OCR is necessary in order to manipulate text in a word processor. A bit image of text can not be rewritten or edited. With OCR each character is represented as a graphic element. The OCR software then compares this with the ASCII codes until it gets a match. (Jones 1991, 40)

The Output Devices.

Output devices are those to which data from the CPU is directed. These include the monitor, printer, plotter, and modem.

![Monitor or Video Display Unit (VDU)](Macintosh Miscellany, Art Bits, Hypercard Stacks. Apple Computer, 1991)

The most obvious output device, even to the computer illiterate, is the TV type of thing which sits on top of the main case. This, like a television set, consists of a cathode ray tube (CRT) and other hardware which responds to the digital output from the CPU to create an image and is also known as the Visual Display Unit (VDU). Most computers use a separate unit as the VDU, but the compact Macintosh has a built-in 9-inch VDU.

![The "compact" Macintosh SE.](Macintosh Miscellany, Art Bits, Hypercard Stacks. Apple Computer, 1991)

Other computers can have monochrome (Black and white, Amber, or grey-scale) VDU’s and others have colour. The CPU must be capable of creating a colour image before a colour VDU can be used. The ability of the monitor to create an image is referred to by its resolution and is related to the number of dots or pixels on the screen. For text, low resolution screens contain approximately 400 x 200 pixels while for the higher resolution screen used for graphics, it is possible to purchase screens with a resolution of 1280 x 1024 .(Australian Macworld Product Guide, 1990-91, 28).
Larger screens offer greater accuracy for page layout applications, but are more expensive to purchase, and require more powerful processors with greater memory availability.

Output from computers can be either character based or graphics based. In the former, the screen is divided into a grid of, say, 25 rows and 80 columns (Chivers. 1991, 5). Each character is formed by a pattern of pixels and only 80 characters can be displayed across the screen. With graphics based output, the output is displayed as a picture of pixels and is referred to as Bit-mapped. Bit-mapped displays require more powerful processors than character mapped displays.

**Printer**

The printer is the principal device used to produce output. (Chivers, 1991,7) Because the output can actually be touched, it is referred to as hard copy as opposed to soft copy which is displayed on the monitor.

Some printers, like typewriters, create a character by a key hitting the paper through an inked ribbon. These sorts of printers are referred to as impact printers. Most have a printer head which passes back and forth in front of the paper and the character is spelled out by a set of pins in the print head creating a matrix of dots on the paper. Thus they are called Dot-matrix printers. Our Apple 2e’s are connected to this sort of printer. Some printers have 9 pins in the print-head. Others have 24 pins. The better resolution is obtained with 24 pins of course. The resolution of 9-pin printers is about 144 dots per inch (dpi). 24-pin printers can obtain resolutions of better than 300 dpi.
Other printers rely on the transmission of ink from the print head (Seiter 1990.40). These are referred to as **Ink Jet** or **Bubble Jet** depending on the method used to inject the ink. However, they depend on precision bit-maps of the characters to be printed and so cannot be used by non-graphics-based applications.

The most technically advanced printers are the Laser Printers.

![Laser Printer](image)

The name laser printer derives from the use of lasers in the print engine to expose images on photosensitive drums or belts, which then attract fine plastic toner powder and apply it to the paper. (Several so-called laser printers actually use light sources other than lasers. Technically the correct term for all these beasts is page printer.) As the paper leaves the printer, a pair of heated rollers melts the powder into place, much as in a photocopier. (Heid 1991, 144)

Laser printers have their own microprocessor, usually a Motorola 68000 or 68020 to process the data sent from the computer. They can store fonts in their own memory bank or download them from the host computer. They have a resolution of from 300 dpi to 600 dpi (IBM LaserPrinter 4029A Series).

**Plotter**

A plotter is a device rather like an extra wide dot-matrix printer which has a set of pens which can be fitted to the print head. Their primary use is in the production of plans and maps as used in the architectural business.

**Modem**

A modem can be used to send output from a computer to distant computers through the telephone lines. Some modems can now send Facsimile transmission (Fax). Another modem at the receiving computer decodes the signal so that it can be processed by the receiving computer. A modem requires communication software to link the two computers.
The Secondary Storage devices.

![Diagram of Storage Sub-System]

Although some data is stored in RAM, as soon as the power is turned off it is lost. Computers therefore need devices to store data more permanently. In the past magnetic tape was used in microcomputers, but this method of storage is slow to access since the read/write heads need to traverse the tape from start to finish to find a file on the tape. Tape drives are used these days as backup devices where they only serve to store data as a precaution against corruption of the data stored on disk systems.

Disk Drives store information on magnetised coated disks called platters. Each side of each platter is called a cylinder, and each cylinder is divided into concentric rings called tracks. Tracks are further divided into pie-shaped slices called sectors. Each sector on a disk holds 512 bytes of actual data and 12 bytes of directory. (Danuloff, Craig & McClelland 1990. 583)

A list of the sectors to which a file has been written is written in a special entry on the disk called the directory, rather like the index to an encyclopedia.

Floppy Disk Drive Systems.

![Image of Floppy Disk]

A floppy disk consists of a flexible plastic disk which has a coating of magnetised material similar to that applied to audio tape, and housed inside a rectangular drive sleeve. Earlier disk drive systems used a 51/4 inch diameter disk housed in a flexible sleeve. Later a 31/2 inch disk which is mounted in a rigid plastic case was developed.

In order for the computer to be able to write information to the disk it is necessary to have a disk drive mechanism installed, and the software to operate the drive. Microsoft Corporation developed a system for the PC which it called MS-DOS, Microsoft Disk Operating System. Apple released a version for the Apple II called Pro-DOS, Professional Disk Operating System. All systems achieve virtually the same thing. Unfortunately, each of the various systems was designed to write the data to the disks in different ways, some writing only to one side of the disk in the early days. Drives these days write to both sides of the disk. Disks also differ in the amount of magnetic material applied to the disk. This is referred to as the density. These days there are two densities, Double Density (DD) and High Density (HD).

When a new disk is inserted into the drive mechanism, the drive software has to organise the magnetic surface into “tracks and sectors”. This process is referred to as formatting. The computer can not write data to the disk until it is formatted.
Double Density 51/4 inch disks can be formatted to hold about 360 kBytes of data, and High Density 51/4 inch disks can be formatted to hold about 1.2 MBytes of data. Double Density 31/2 inch disks can be formatted to hold about 800 kBytes of data, and High Density 31/2 inch disks can be formatted to hold about 1.44 MBytes of data.

The plethora of different disk drive specifications is arguably the greatest impediment to the transfer of data files across various operating systems today. To some extent this has been addressed by Apple standardising its drives to a standard SuperDrive across the range of its computers since 1989 (Australian Macworld, June 1992. 50). The SuperDrive not only reads all Macintosh and Apple II 31/2 inch disks formats, it can also read and write in MS-DOS formats (720k and 1.44 Mb) as well.

Since floppy disks are flexible it is necessary to protect the disks from damage. It is important not to contaminate the disk surface with the fingers, or dust, water and other material and preferably stored in plastic storage boxes.. Since the material is stored in a magnetic medium, the disk should be kept away from magnetic fields.

**Hard Disk Drive Systems.**

![Hard disk platter](image)

Fig.14. Hard disk platter. (Claris Impact Library)

Hard disk drives differ from floppy disk drives in that they use an aluminium or glass platter instead of the a flexible plastic one. This facilitates greater accuracy to be achieved in the positioning of the read/write heads over the platter, and the stacking of several platters together to achieve greater storage capacity. As well as this the platters are kept spinning at a constant rate, unlike a floppy drive in which the speed of the mechanism varies. To protect the platters from the entry of dust they are sealed in airtight containers. This results in a very reliable and fast storage medium.

Hard Disk capacities range from 20 megabytes upwards. It is common for a domestic application to have a 40 or 80 megabyte hard disk. If the user is interested in applications which require large storage space, like desktop publishing, graphic illustration, multimedia applications then larger capacity drive as large as 500 megabytes (1/2 gigabyte) are not uncommon. (Danuloff, Craig & McClelland. 1990. 591)

**CD-Rom Player**

![Compact disk](image)

Fig.15. Compact disk. (Hypercard Stacks.Macintosh Miscellany, Art bits. Apple Computer 1991.)

A CD-Rom (Compact Disk - Read Only Memory) Player is a device just like a normal audio CD player except that they output signal is binary instead of converted to analogue for feeding into an audio amplifier. The CD used is similar to an audio CD.
Data is written to the disk in the manufacturing stage as a series of pits in the disk surface. As the disk rotates in the player, a laser reads the pits and turns them into signals. A CD-ROM can only be recorded to once. However, each CD-ROM can store vast amounts of information, in the order of several gigabytes at this stage of their development. (Day 1990, 42) Thus it is possible to get the whole of the 1991 New Grolier Encyclopaedia on a disk. (Clyde 1992, 69)

Each storage device has its advantages and disadvantages. Floppy disks are cheap and convenient to carry around, but are easily damaged and store only limited amounts of data. Hard disks are expensive, but very much faster in operation than floppy disks. However, with so much data stored on a hard disk, if something goes wrong, you had better have copies of the data somewhere else! Hard disks can be backed up by using floppy disks, or by using tape drives. Tapes have the advantage that the tape itself can be store in a separate location, thus increasing security. They are also quite fast at retrieving and storing information, and lend themselves to automatic backup procedures. However, because the read/write heads have to traverse the tape to find information, they are slow at retrieval of data.

![Fig 16. Tape Backup Unit.](Claris Impact Library. Claris 1994)

**Processing Devices**

### The Central Processing Unit.

The CPU is the heart of the computer. It is required to process data and execute program instructions, and store small amounts of data and instructions. It is at the CPU that the interface between hardware and software takes place.

- The CPU carries out the following tasks.
- Fetches instructions from memory.
- Translates and executes instructions.
- Fetches, processes and stores data.
- Synchronises processes in the computer by using the inbuilt clock and by issuing control signals.

During processing, a computer stores data temporarily and acts on it. The component that is responsible for this is the central processing unit. (CPU). The CPU is a complex collection of electronic circuitry that directs electronic signals to all parts of the computer system. It contains the instruction set — the design of electronic circuitry that determines what a computer can do. A programmer manipulates this relatively small set of instructions in order to harness the power of the computer. The CPU decides what to do with the instructions that the programmer gives the computer and insures that assigned tasks are carried out properly. It consists of three parts that function together as a unit in processing a program.

The CPU contains two main elements: the control unit and the Arithmetic Logic Unit (ALU). (Day 1990, 28)

The control unit maintains order and controls the activity that occurs in the CPU. It does not process or store data but directs the sequence of commands that constitutes a program through the computer.

The arithmetic/logic unit (ALU) does not hold data but performs arithmetic computations and logical operations on the data. The ALU can often be supplemented with another custom designed chip referred to as a maths co-processor.

The control unit directs and coordinates the entire computer system by firstly fetching the next program instruction from the main memory, then decoding it, then executing the command and finally storing the result in memory. The Arithmetic Logic Unit performs any necessary arithmetic or logical operations on the data. Arithmetic operations include addition, subtraction, multiplication, and division and logic operations include comparisons between two items like greater than, less than, or equal to. (Chivers 1991, 35-6)
Fig 17. Arithmetic/Logic Unit. (Syllabus p19)
The data and instruction are held in the address and instruction registers until the ALU performs an operation. After the ALU acts on the data, the result may be sent to the accumulator register. The control unit also directs the primary storage unit to release the results to an output device such as the monitor. All the individual steps are synchronised by a clock in the CPU so execution takes place quickly and orderly.

Fig 18. Simplified view of the operation of the CPU. (Syllabus p21)
Other control devices are used to control signals to the disk drive, monitor, and printer.

The computer uses chips for the processor and for memory.

The silicon chip was invented in the 1960’s when scientists developed a method for building circuits incorporating many transistors by etching pieces of silicon with chemicals. (Newhouse 1985, 17). The silicon chip has facilitated miniaturisation on a scale not seen before. Whole sets of instructions can be placed on one chip. These chips became known as microprocessors and can now be found in all sorts of devices from microwave ovens to Space Shuttles.
Fig 19. Microprocessor “chip”. (Novy Systems 1992)

Other chips may be used for video display and other input-output devices.

In a microcomputer these chips can be placed on a board referred to as the logic board or motherboard, or they can be inserted as plug-in cards into slots which are wired to the CPU. These chips communicate with the CPU via a “bus”, which is a set of wires or conducting strips joining the computer chips. The bus enables the transfer of information between the computer memory and its peripherals by holding and relaying messages between the various components of the computer hardware. (Danuluff 1990, 573). Some manufacturers, for example Apple, have adopted a bus design called NuBus, which can transfer data at up to 37.5 Mb per second.

The processor functions by converting the instruction from a program into a series of 1’s and 0’s called bits, which is an abbreviation of binary digits. Eight bits make up a unit called a byte.

<table>
<thead>
<tr>
<th>8 bits</th>
<th>= 1 byte</th>
</tr>
</thead>
<tbody>
<tr>
<td>1024 bytes</td>
<td>= 1 kilobyte</td>
</tr>
<tr>
<td>1024 kilobytes</td>
<td>= 1 megabyte</td>
</tr>
</tbody>
</table>

Fig 20. Bits and bytes.

Any single character typed at the keyboard can be represented by a byte. Computers use a binary number system to count.

We use our fingers and toes to count to a base of 10. In fact, the word digit represents one finger. So as we count from 1 to 9 we in fact count off our fingers. When all ten fingers are revealed we then say we have one decimal unit and represent this as 10. We have ten unique symbols to represent each counted digit from none to nine. We then cycle these symbols through to count up to one hundred where we once again move our symbols one place to the left. With the binary numbers we can only use a base of two, representing an on or off state of an electric circuit.

<table>
<thead>
<tr>
<th>The Decimal System</th>
<th>The Binary System</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero 0</td>
<td>0</td>
</tr>
<tr>
<td>one 1</td>
<td>1</td>
</tr>
<tr>
<td>two 2</td>
<td>10</td>
</tr>
<tr>
<td>three 3</td>
<td>11</td>
</tr>
<tr>
<td>four 4</td>
<td>100</td>
</tr>
<tr>
<td>five 5</td>
<td>101</td>
</tr>
<tr>
<td>six 6</td>
<td>110</td>
</tr>
<tr>
<td>seven 7</td>
<td>111</td>
</tr>
<tr>
<td>eight 8</td>
<td>1000</td>
</tr>
<tr>
<td>nine 9</td>
<td>1001</td>
</tr>
<tr>
<td>ten 10</td>
<td>1010</td>
</tr>
</tbody>
</table>

Fig 21. The binary counting system.

The amount of data which can be processed by the processor at any one time is known as the word size. Some processors have an 8-bit word. Examples of computers with 8-bit processors are the Apple II series (Motorola 6502 processor) and the Microbee (Z-80 processor). The IBM PC was designed around the Intel 8088, a 16-bit processor. The familiar compact Macintoshes also have a sixteen-bit processor. The later Apple Macintoshes and IBM compatible’s fitted with either the Intel 80386 or 80486 processors have processors with a 32-bit word. Super computers like the Cray have a 64-bit word. (Day 1990, 37).
The speed at which a computer works is governed by both its word size and the speed at which its processor works, the "clock" speed. An 8-bit processor can process 8 bits at a time; a 16-bit processor can process 16 bits or 2 bytes at a time; and a 32-bit processor can process 32 bits, or 4 bytes, at a time. The word length also affects how many different instructions can be actually used in a processor's instruction set (a part of its design) and the limits to the memory it can address. The speed at which a computer works is also a function of the processor design. The processor speed is measured as Millions of Instructions Per Second or MIPS. This is often referred to as the clock speed and is rated in megahertz (MHz - millions of cycles) The early computers like the Apple II series used a clock speed of 1 MHz. The compact Macs, like the SE, used a processor rated at 8 MHz and the 8088 series of PC's had a clock speed of only 6 MHz which later grew to 8, 10 then 12 MHz in the 80286 series. Currently, 25 MHz Processors are found in most of the low end Macs and PCs, with 33 MHz, and even 66 MHz processors found in both Macintosh and PC type computers now. However, clock speed is not the sole measure of a processor's performance.

The Memory Unit.  

The main memory chips of the computer can be of two types. Read Only Memory, or ROM, consists of memory chips which are designed with a set of instructions built into them. Apple include a set of proprietary ROM into every Macintosh and fiercely guard their copyright through the legal system. They do not make these chips available to anyone and prosecute anyone trying to emulate them. The Mac ROM chips contain two parts of the operating system, one called the Toolbox, and the other the Operating System. The ROM based Operating System contains instructions which place images on the screen when the computer is first turned on and the Toolbox contains diagnostic programs which check all aspects of the overall operation of the computer and contains the instructions which operate the Mac Graphical User Interface. (Danuloff, C and McClelland, D 1990, 564). In IBM PC’s the ROM chip which controls how data is accessed from the disk drives and sent to the monitors is known as the Basic Input Output System or BIOS. (This is also copyright to IBM) Because ROM chips have their instructions written into them at the manufacturing stage they can not lose them when the computer is turned off. They are therefore said to be non-volatile.

The chip which contains the instructions currently being used by the computer is known as Random Access Memory or RAM, and is volatile in nature. If the computer loses power, then whatever is in RAM is lost. Hence the need to constantly backup volatile data on a frequent recurrent basis.

RAM chips used to be actually soldered to the motherboard, but recent advances have seen them installed in modules on cards. These are known as Single In-line Memory Modules or SIMMs, and consist of small circuit boards containing eight RAM chips. These chips can provide either 256k, 1Mb, 4 Mb or 16 Mb of memory. (Danuloff, C 1990, 549)

• Software

The software of a computer system consists of sets of instructions which control the processing and movement of data within the computer system.

Software enables computer hardware to process data.

Software is a set of instructions written in a code known as a programming language. Some popular programming languages include BASIC, LOGO, Pascal, C and HyperScript.

Software code is stored on a medium like floppy or hard disks, and, increasingly nowadays, on CD-ROM.

When a computer is turned on it goes through a routine whereby it checks its permanent memory, the ROM chips mentioned above, for instructions, which it then executes. Firmware is another name which refers to this permanent set of instructions which resides in a part of the computer's hardware. The firmware may contain the operating system for the computer, which may be needed before the computer can actually access data on a disk drive. The operating system may interact with hardware components like the clock which sets the time. The distinction between firmware and hardware is hazy as each computer manufacturer uses different strategies to store the operating system instructions. For example the Macintosh operating system and toolbox reside in the proprietary ROM chips inside every Mac. These control such functions as how to draw the rectangles which make up the windows of the graphical user interface (GUI). However, Microsoft's Windows software must get its GUI from the system software on disk since none of these instructions reside in ROM chips in machines with Intel chips.
The software which controls how the computer operates is called system software or the operating software. With a Macintosh this software is designed and developed by Apple, the current version of its operating system being 7.1. With Intel based systems, most of the world's PC's use system software developed by Microsoft Corporation known as MS-DOS (Microsoft Disk Operating System). As well as using MS-DOS (DOS for short) a great many PC's now use a graphical user interface (GUI) developed by Microsoft called Windows. There is some litigious discussion as to who actually was responsible for originally developing the GUI, Apple taking Microsoft to court over its look and feel alike similarity to the Mac OS. Actually it all started at the Xerox research laboratories at SPARC (Palo Alto Research Centre) in the late 1970's. (Davidson, 1993, 32)

System software also can be designed to update the software in the ROM chips, so that the latest developments can be always used. This is done in the boot-up process. System software must also manage and control the hardware like the disk drives (hence the DOS name), monitors (Visual display units), mouse, printers, CD-ROM players, sound input and output devices.

**Fig 22. The Extended Machine.**
(Syllabus p20)
The system software also acts as the interface between the computer hardware and the applications software. Other software, which is often incorporated into the operating system, is known as utility software. This includes software which prepares disks by formatting them, copies disks, libraries of procedures, text editors, and compiler and interpreter software which compiles common text into programs which execute a computer program in a language that the computer understands, machine language, or interprets such language.

An example of a disk utility is the popular Norton Utilities. Most computer language software includes its own compilers and interpreters, examples being Think C and Quick Basic.

**Fig 23. Translation.**
(Syllabus p21)
Once the operating system has been installed, whether it is a GUI like the Mac and Windows or whether it is a command line interface like DOS or UNIX (another operating system favoured in Universities) the computer must then load the software which actually enables the user to do something with the computer. This is known as application software.

Obviously there are literally thousands of these but some popular examples would include Microsoft Word, a word processor, and Lotus 1-2-3, a spreadsheet. Database software which is popular in industry would include DBase. Page Layout or Desktop Publishing software would include Aldus Pagemaker and a graphics programs could include MacPaint and MacDraw, for example.
Programming languages are sets of instructions which are written in a **programming language**. Examples of popular programming languages include Basic, Fortran, Logo, Pascal, and C. Lower level languages are machine specific and translate common language into the code used by that computer. These are known as machine languages or assemblers. Higher level languages translate the common language of people into code which can be read by lower level languages. Compilers translate the entire program as a unit into machine language. Interpreters translate the program line by line.