COMPUTER SCIENCE

NUMBER SYSTEM

- Humans count numbers using Denary System
- Machines (computers) work on Binary number System
- To make Binary easier to read for Humans, we use Hexadecimal (Hex)
- Octets are also used to represent binary, but in 8 bits form
- Examples of each type:
  - ↳ Denary → 35, 96, 1080, 78964 etc
  - ↳ Binary → 0100111110, 1011010101, 00001010, etc
  - ↳ Hex → 3A, 9C, AF, BC, FB0, etc
  - ↳ Octet/byte → 10011001, 00010101, 11111111, etc
- Denary is the system we use everyday with base 10 (0-9, ...)
- Binary is the system with base 2 (0s and 1s)
- Hex is the system with base 16 (0-9 and A-F)

- DENARY TO BINARY
  - ↳ 35
  - ① Place at correct orders

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

  - ② Divide by 2 and read remainder from bottom to top (Modulos)

1	35
1	17
0	8
0	4
0	2

Now, it becomes,
0100011
Adding one more zero at right to make byte.

0	2
1	1
0	0

00100011

- BINARY TO DENARY
  ↳ $10010101_{(2)}$
  Place bits at their orders and add the placeholder values of the bits

1	0	0	1	0	1	0	1 $_{(2)}$
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
→ 128	64	32	16	8	4	2	1

  ↳ $128 + 16 + 4 + 1 = 149_{(10)}$

- Hexadecimal TO BINARY
  ↳ $4A_{(16)}$
  Separate both and use 4 bits to represent each and then combine the bits in their order

4				A				(A-F = 10-15)
2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	
8	4	2	1	8	4	2	1	
0	1	0	0	1	0	1	0	

  → $01001010_{(2)}$

- BINARY TO HEXADECIMAL
  ↳ 1101011011
  Separate both in 4 bytes chunks (if some bits are missing, just add 0s at left) and write the equivalent of that binary and Then combine the equivalent in their order

0011	0101	1011
$2^3 2^2 2^1 2^0$	$2^3 2^2 2^1 2^0$	$2^3 2^2 2^1 2^0$
2+1	4+1	8+2+1
3	5	B (11 = B)

  ↳ 35B

- Hexadecimal to Denary
  - ↳ $1A9B_{(16)}$

Multiply and add the equivalent multiplied by the base ~~area~~ with their placeholder to obtain denary

1	A	9	B
16^3	16^2	16^1	16^0
4096	256	16	1

Now,

$(1 \times 4096) + (10 \times 256) + (9 \times 16) + (11 \times 1)$

↳ $6811_{(10)}$

- ~~Hex~~ Denary to Hexadecimal
  - ↳ $2432_{(10)}$

Modulos the number by Hex base and read the remainder from bottom to top

0	$2432 \div 16$
8	152 //
9	9 //
	0

→ $980_{(16)}$

- SIGNED NUMBERS are integer values that can be represented in the form of positive and negative values due to the extreme left bit identifying the sign. One's Complement and Two's Complement is also used for signed integers with Two's complement being more common for this purpose.

- One's Complement
  ↳ Inverts every binary bit to obtain one's complement-

  10011010 becomes
  01 100101 in One's Complement

- Two's Complement
  ↳ It's the addition of '1' to the One's Complement

  100 11 010 becomes
  011 00101
  + 1
  011 00110 in two's complement

- Sign and magnitude representation (using the extreme left bit has differences compared to Two's Complement:
  ↳ Sign and magnitude represents negative 0 too that may cause comparison problems $(10000000)_{(2)}$ whereas Two's complement has no negative 0.
  ↳ An extra negative value can be represented in Two's complement whereas can't be represented in Sign and Magnitude (-128 in a two's complement in a byte, for example, $10000000_{(2)}$)
  ↳ In two's complement, ~~the~~ starting from the lowest value (-ve values), addition of 1 in it causes to increase the value towards higher level (+ve values) whereas there is no such phenomenon in sign and magnitude since it has a seperate bit to represent sign.

- Negative Denary to Binary (Signed)

↳ $-76_{(10)}$

Using Two's complement, we first ignore the sign, convert Denary to it's corrosponding binary, and then take Two's Complement.

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

Now,

Take Two's complement

$$\begin{array}{r} 1\,0\,1\,1\,0\,0\,1\,1 \\ + \qquad\qquad\qquad 1 \\ \hline 1\,0\,1\,1\,0\,1\,0\,0_{(2)} \end{array}$$

- Signed Binary to Negative Denary

↳ $11001010_{(2)}$ (Signed)

↳ To convert a signed binary to denary, first reverse the two's complement and then convert binary to Denary, and then add sign (-)

$$\begin{array}{r} 1\,1\,0\,0\,1\,0\,1\,0 \\ - \qquad\qquad 1 \\ \hline 1\,1\,0\,0\,1\,0\,0\,1 \end{array}$$

Now,

invert the bits to obtain one's complement

$$0\,0\,1\,1\,0\,1\,1\,0$$

Now,

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
0	0	1	1	0	1	1	0

→ $-(2+4+16+32)$

→ $-54_{(10)}$

- Nibble is a group of 4 bits (similar to byte which is a group of 8 bits)
- BINARY CODED DECIMAL (BCD) is an efficient way to represent Denary numbers. It uses 8 bits, a byte, to represent single digit in "unpacked" BCD, whereas a nibble is used to represent a single digit in "packed" BCD (2 nibbles = 1 Byte)
- BCD Binary to Denary (Packed)
  → 10010000 1001 0011 (BCD)

  In packed BCD, split the binary into nibbles, write corresponding Denary, and JOIN them.

  1001 0000 1001 0011
  $2^3\ 2^2\ 2^1\ 2^0$ $2^3\ 2^2\ 2^1\ 2^0$ $2^3\ 2^2\ 2^1\ 2^0$ $2^3\ 2^2\ 2^1\ 2^0$
  9 0 9 3
  → $9093_{(10)}$
- BCD Binary to Denary (Unpacked)
  → 0000 0011 0000 1001 (BCD)

  In unpacked BCD, split the binary into bytes and write corresponding Denary, and join them. The left nibble of unpacked BCD byte must be 0000 and has no significance.

  0000 0011 00001001
  $2^3\ 2^2\ 2^1\ 2^0$ $2^3\ 2^2\ 2^1\ 2^0$
  3 9
  → $39_{(10)}$
- Vice Versa applies the same principle but in reverse (Denary to Unpacked BCD binary, etc)

- The values 0000 1010 — 0000 1111 in UNPACKED BCD and 1010 - 1111 in PACKED BCD is not possible since BCD cannot represent two digits and only represents a single digit (0-9). Due to this, the remaining bits are simply wasted and are of no use, which is how it differs from Hexadecimal
- BCD can be used to display digits on the screen, in BIOS remembering Date and Time or can be used in currency values, real numbers or floating points
- ADDITION of BCD can cause erronos addition (values greater than 9). To conter this, we add '6' or '0110' to the least significant nibble, and then add this to the next significant nibble with carry (if the next nibble too becomes greater than 9), to get correct BCD value:

For example:

"Packed BCD"

+	0.94 →	0000 0000	1000 0100
	0.48	0000 0000	0100 1000
		0000 0000	1101 1100

Since values are greater than 9, in both, add 0110

1101 + 0111 = (1)0100 — carry it to the next nibble

1100 + 0110 = (1)0010 — carry add with 0110 = 0111

Becomes:

0000 0001 0100 0010

→ 1 . 4 2

→ 1.42 → Corect Answer

- Same applies for unpacked BCD except for neglect the 0000 nibble and carry or correct the amount to the next significant byte's nibble.

- TEXT REPRESENTATION
  → ASCII is an internationally-agreed standard to represent text. There are some variations but 7-bit code is the common one. It assigns individual binary code to every text item defining it as the "character code". Using 7-bit ASCII code, the extreme left bit is always 0. The 7-bit code enables to use as many as 128 different character items. Conversion from Uppercase letters to lowercase letter is fairly easy as it only differs from the 6th bit from right. First few characters are non-printable and are only control characters. The codes for letters and numbers are in sequence so it's easy to remember.
  → Unicode is newer and better than ASCII since there are many scripts and languages added to the, what Unicode refers to as 'code-point'. The aim of Unicode is to be able to represent any possible text in code form. It also takes advantage of two-bytes, whilst the first byte using the ASCII ways of doing while the second adds more text to the Unicode. The second byte adds 1 at the extreme left bit so the Unicode and ASCII can be seperated from each other and aren't misinterpreted. Unicode also introduces texts like Emojis in addition to what ASCII offers. The most common of Unicode is UTF-8.

- UTF-8 can provide upto 21 bits for our data, meaning 2097151 different values which are quite larger than the ASCII's. There are currently 128,000 codepoints, or a bit greater, so it ensures any encoding for future code-points.

- IMAGES
  ↳ Is used to display graphics either on screen or paper or so and so.
  ↳ Can be drawn by appropriate drawing package or by scanning a document or with Camera photography.
  ↳ Two main types of Images: Vectors and Bitmaps.

→ Vector Graphics
  ↳ It is graphic consisting of components defined by geometrical algorithms and properties such as color, associated with it.
  ↳ Developed by a drawing package or Computer Aided design package.
  ↳ A vector graphic file contains drawing list, attributes associated to those specific, such as radius of a circle, colors and else properties.
  ↳ The image stored is relative to an imaginary drawing canvas and hence the image is scable due to the use of mathematical algorithms instead of pixels (like that in Bitmap). Due to this, zooming in the picture doesn't cause distortion.
  ↳ Most common format in vector is Scalable Vector Graphics (SVG).

→ Bitmap Graphics

↳ Pixels are fundamental ~~pieces~~ pieces which collectively make a bitmap image. Graphics on the screen is also displayed using these tiny boxes, pixels (Picture Element). Pixel has a very simple construct, it has a position and just a color. The higher the pixels, the better the quality of the picture but at the price of consumption of more space.

↳ Bitmaps contain a 2-dimensional matrix of pixels mapped with definition of color of each pixel, collectively that make bitmap image. It is general purpose approach to use bitmap to store the image.

↳ It is unlike to Vector which use geometrical pattern to display image.

↳ Bits per Pixel is known as Color depth and is used to define coloring of a pixel, 1 bit is used for black and white, about 4 are used for grayscaling and at least 8 bits are required to produce a colored image, per pixel. The bits nowadays go upto 24-bits in modern computers.

↳ The resolution of an image is the product of number of x-axis pixels with the number of y-axis pixels. Most common resolution nowadays is, FullHD, 1920x1080

vertical x horizontal pixels.

↳ Bitmap image doesn't define the size of pixels. or the physical attributes, but just the amount of pixels in the image and the color of each.

↳ Since there is fixed amount of pixels in the bitmap image, scaling the image large causes pixelation, distortion in the image as each pixel began to be visible and some ugly boxes are just seen.

↳ BMP format is usually used for raw images, whereas PNG and JPEG are common for compressed images.

↳ The bitmap file also has a header that defines resolution and color scheme.

↳ CALCULATION OF BITMAP FILE SIZE

FILE size in BITS = resolution x color depth

For example,

Size of a bitmap image with resolution 1920x1080 and color depth as 24-bits:

Size in bits = 1920 x1080 x24
= 49766400 bits

Size in bytes = $\frac{49766400}{8}$
= 6220800 Bytes

Size in multiple type of bytes = 6220800 ÷ 1024
= 6075 KiB ÷ 1024
= 5.93 MiB

KiB = 1024 Bytes
MiB = 1024 x 1024 Bytes
GiB = 1024 x 1024 x1024 Bytes and so on.

KiB vs KB

1024 Bytes 1000 Bytes

MiB vs MB
1024x1024 1000x1000 Bytes
and so on...

In general, Computer terminology, we mean KiB by saying KiB or so and so.

SOUND

↳ Sound travells to human ear in the form of waves and pressure variance but in order to store or transmit sound electronically, it needs to be converted into binary form.

↳ Sound encoder is used for this purpose

↳ In order to eliminate any high-frequency components, band-limiting filter is used in encoder, because human ear can't hear these and instead will just cause coding problems.

↳ Second component in the encoder is the Analogue-to digital converter. The sound amplitude is sampled at regular intervals, the amplitude, however isn't exact but instead is an approximate of the actual amplitude because the amplitude might not be at exact amplitude sample point.

↳ The number of bits used to store amplitude data is known as sampling resolution. If 3 bits are used, then 8 levels can be defined. 16 bits will provide reasonable accuracy for sound.

↳ The rate or interval at which every sample is taken should also be taken is consideration. The greater the sampling rate and sampling resolution, the better the quality of the sound.

↳ The sampling rate must be in accordance with the Nyquist's theorem, which states that the sampling rate must be double the highest frequency.

↳ The file size increases with greater sampling rate and resolution.

↳ Once sound is stored in digital forms, it can then be used to output sound or can be edited and added effects using sound-editing softwares.

- BIT RATE → Number of bits required to store 1 second of sound

Bit Rate = Sampling Resolution (bit depth) × Sampling Rate

File Size (in bits) = Bit rate × Sound Duration (in seconds)

OR

Bit Rate = Sampling Resolution (bit depth) × Sampling rate × channels

↓ if channels are present

- VIDEOS
  - ↳ Frame are the pictures that are displayed in a video in series.
  - ↳ Frames Per Second (FPS) are the number of pictures displayed per second.
  - ↳ 25 FPS provide reasonable frames to the eye so the brain is spooked to see a motion.
  - ↳ Interlaced encoding uses two frames to be displayed at once by using an alternating system of one frame at odd lines and other at even making our brain believe that the video is at higher refresh rates and lowers the bandwith requirements because of alternating phenomenon (Halves). Originally used in TV broadcasting.
  - ↳ Progressive encoding of video displays entire frame at the same time, rate of picture display is the same as frame rate and requires high bandwith. Used in Computer displays, traditional films etc.

- COMPRESSION: LOSSLESS vs LOSSY
  → Lossy compression reduces file size by removing some not important content, such as that in JPEG files where some quality of picture is reduced to lower file size.
  → If file is text, it would be sensible to lossless compress it as any loss of information can be disastrous.
  → The compressed lossless file need to be converted back to original form to be usable.
  → Spatial Redundancy is used to compress video via similarity in a structure, such as pixels in a still image and duplicated bit patterns etc. This method however is unlikely to be efficient because frames are always very similar in a video to the other one.
  → Temporal Redundancy is used to remove frames that have pixels with same location and values with their adjacent counterparts.
  → Multimedia Container formats are used to ensure synchronisation between images and sound - It can also contain different types of data such as subtitles of a movie - Some examples of these formats include AVI, MPEG-4, MOV etc.

COMMUNICATION AND INTERNET TECHNOLOGIES

CABLES (Transmission)

→ 3 common types available: Twisted Pair, Coaxial and Fibre Optics. Twisted pair and Coaxial use Copper.

	Twisted Pair	Coaxial	Fibre-Optics
Cost?	Low	High	Highest
Data Rate	Low	High	Highest
Attenuation (at high frequency)	High	Highest	Low
Interference	Highest	High	Low
Need for repeaters	High	High	Low

→ Twisted Pair is still in use to connect telephone handsets with telephone lines, One cable has four twisted pairs inside to reduce interference. It is also used in Ethernet Cables with RJ-45 Jacks. Two main types:

↳ Unshielded Twisted pair is made by twisting wires against each other to reduce degeneration and interference.

↳ Shielded Twisted pair uses copper shielding around twisted wires to lowers interference.

→ Coaxial Cable is generally used by television companies for television signals, which's history stretches back to 1880's. It has main copper wire at centre, a dielectric isolation surrounding the copper wire, a foil sheild around insulation, above of which is a braided shield (copper mesh) followed a PVC insulation wrap.

→ Fiber optics is made up of a glass which becomes very flexible when made thin - Light is passed in the fibre optics at an angle greater than critical angle of the glass to cause total internal reflection and allows to recieve ~~dat~~ signals at the receiving end. The signals travel at the speed of light. The signals (pulses) represent binary code. Since the cable is quite thin, the cables can be bundled in one cable, making bandwith high. The fibres are bundled inside the cable, with filling compound, around which is loose tube, around which again is filling compound and several these loose cables are bundled inside one cable, at centre of which is FRP. All of this bundle is surrounded by water blocking tape as well as a PE Jacket on top of all. Most commonly used all around the world for network connections, such as internet

WIRELESS SIGNALS

→ Electromagnetic waves are used for Transmission. Three main types: Radio, Microwave, and infrared.

	3KHz-3GHz	3-300 GHz	300GHz-400THz
	Radio	Microwave	Infrared
Bandwith	Low	High	Highest
Attenuation	Low	High	Highest
Need for repealers	Low	High	Highest
Directional focusing	Low	High	Highest
Penetration	Highest	High	Low
Interference	—	—	—

→ Infrared waves are used inside the home due to the high interference and Low penetration from the walls.

→ Microwaves cannot pass through hills or mountains, due to this, they are used at short ranges, and the receiver when pointing at the transmitter, has bandwith 30 times more than the radio spectrum, and has less attenuation than Twisted Pair and Coaxial Cables. This is the reason why microwaves are suitable for most general-purpose applications.

→ Radio waves, due to highly penetrable, and having less interference are used in long distance transmissions with less bandwith, and are often used to link buildings on a college campuses, etc. And also in sattellites.

Cable vs Wireless

→ Wireless transmission frequencies are regulated by the government and government permission is required for transmission whereas land owner's permission is required for cable.

→ More interference in Wireless than wired connections, though repeaters are less often required for wireless transmission

→ Cell phones use wireless systems because wired is not possible.

→ Lack of cable costs favors wireless transmission at small scale

INTERNET SYSTEMS

THE INTERNET

→ Created by ARPANET in US.
→ WAN was first referred in 1970s
→ With the arrival of PC, internet became more popular in 1990s, with the addition of another type of network, LANs (Local Area Network)
→ Internet is not WAN, but is the biggest internetwork in existence.
→ ISPs provide access to internet.
→ 3 Levels of ISPs,
  ↳ Tier 3 connect to consumer and allows to connect to the regional ISP, the tier 2.
  ↳ Tier 2 is a mid tier that connects Tier 1 with Tier 3.
  ↳ Tier 1 is the backbone of ISPs, by which Internet Exchange points are used to eventally make data transfer possible.
→ Dialup systems at first were used via telephone lines which converted analogue to digital signals, which was a requirement, and vice versa, protocols which include PSTN (public switched telephone network).
→ Some organisation may pay to get a leased line service with a guranteed transmission speed, mainly to establish WANs and MANs (Wide Area network and Metropolitan Networks).
→ PSTN system have altered ways of communication to fibre-optics, allowing them to make leased line services and their own ISP services, which they provide either via Broadband systems or WiFi Hotspot technologies.
→ Any Public or private access point has a wired connection with internet. In mobile phones cellular network acts as an ISP and any cell phone

with appropriate software can access internet wirelessly.

→ The technologies in Mobile communications have changed dramatically with following generations:

1G – designed for voice communication (Analogue)
2G – went digital
3G – introduced multimedia and internet capability
4G – introduced high-bandwith connectivity
5G – offers extremely high bandwith.

→ Satellites are also main component of modern communication system - Three types of satellites exists according to their orbit altitude: GEO, MEO, LEO.

↳ GEO are the highest altitude satellites (geo - Stationary Earth Orbit) with about 35786 Km altitude and used to provide long distance telephone and network communication - Only 3 are needed for full coverage of Earth.

↳ MEO (Medium - Earth orbit) satellites have an altitude of about 15000 Km which are used for Global Positioning Systems (GPS) - Ten MEO satellites are required for global coverage.

↳ LEO (Low - Earth orbit) satellites have an altitude of about 5000 Km - They are used to supplement mobile networks. Only 50 are needed for Global coverage though there are several hundreds of them currently.

WORLD WIDE WEB (WWW)

→ Application distributed on the internet which is an internetwork.

→ WWW is not same as internet

→ Web consists of collection of different, but enormous collection of websites, consisting of different web pages interconnected with each other.

Internet Supporting Hardware

→ Router acts as a node in the mesh structure, which internet is at it's heart. Backbone Fabric of Internet Networks.

→ Gateway connects different networks which use different technologies/protocols and the functionality provided by gateway could be same as router's.

→ A server is a device that provides services on a network. Server may act like:
  ↳ Application server
  ↳ Web Server → Provides web applications
  ↳ Domain Name Server
  ↳ File Server
  ↳ Proxy Server

→ In a file server, a 'server farm' is used to provide file access, commonly, where several servers are clustered to form single serving component, and can also take part as a cloud storage.

→ Proxy server acts as a buffer between LAN and WAN, can be used to cache web pages, and can provide fast access to web pages through cache instead of accessing files. The proxy can also act as a firewall.

CLIENT - SERVER ARCHITECTURE / MODEL

→ The arrival of PC made people realise that computer alone won't be viable in a large organization without being connected to a network.

→ Initially servers were made to share basic PC services (filestore, printing etc) but later a client-server model was introduced.

→ The main things to be noted are the sharing of workloads between server and client, but a middleware needs to be present for cooperation of server and client.

→ Now, server is a web server that could be installed on any computer virtually as well as the middleware is the software that supports the transmission of data.

→ E-commerce is an example of client-server model, where user interacts with the application.

Bit Stream

→ It is the travelling of bits from one computer to another via streaming media (such as music or videos etc).

→ The user streams the multimedia from the computer which already had the media stored, in one category, and the data is continuously received on the media player's buffer, which the player takes the data from and plays.

→ In live stream, the data captured is directly transferred to the users, with the same phenomenon as before.

→ It is crucial for media to be received to user, and played in the same time as recorded (no delays or so). For this, bit rate must match, or be greater than the media's required bit rate (to prevent unexpected delays).

→ For buffers to work effectively, the buffer has a high-water mark, which ensures enough data is in buffer when this mark is reached by data, and has a low-water mark, which asks for data again to be received as the data in buffer is not enough.
→ Buffers should be large enough to store data.

AUXILARIES SERVICES / HARDWARE

- A Hub is a device that connects a number of computers to make a LAN, and if a message is recieved, sends to every connected computer.
- Switch is same as hub except for it forwards the message only to the computer the message is addressed to.
- Bridge links two different parts of a LAN.
- Firewall protects your LAN from any unauthorized connections from WAN (could even be from LAN)

→ A router may feature some, or all of these features, and can also act as a proxy server.

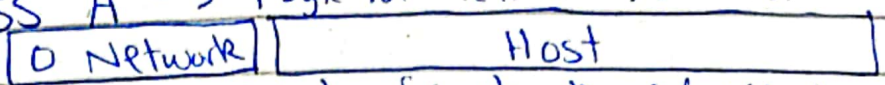
INTERNET PROTOCOL ADDRESSES (IP) on internet

→ Every computer gets assigned a unique address. Two Types: IPv4 and IPv6 addresses.
→ IPv4
↳ 32-bit address scheme. Allows 2^{32} addresses
↳ Used when transferring data to identify the origin and the destination.
↳ Five classes were made in this scheme which were identified by the leading bits, which identify the netID (one of the two parts in IP address)
↳ NetID is used to identify network with which a host is attached, whereas a hostID identifies a host on the specific network
↳ Increasing NETID shrinks host ID.

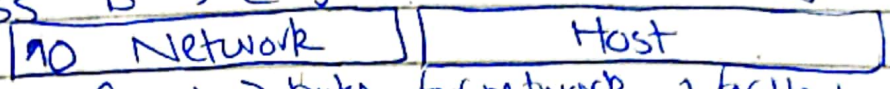
↳ All IP address bit cannot be all zeros or all ones.

↳

Class A → 1 byte for network, 3 for Host

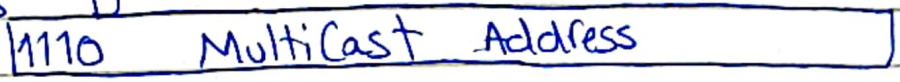


Class B → 2 bytes for network, 2 for Host

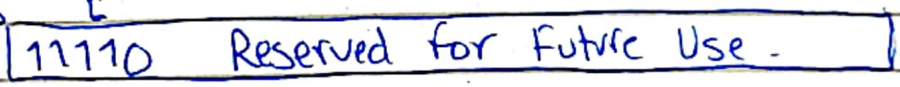


Class C → 3 bytes for network, 1 for Host

Class D



Class E



↳ Class A is assigned to large organizations.

↳ Scheme became a problem when LAN powered PCs became common since if the organizations were assigned Class C, There would be only 256 available hosts. Some modifications were made to address these.

↳ These are written in dotted decimal notation:
IP address in Binary: 10000000 00001100 00000010 00011110
Becomes in dotted decimal notation: 128.12.2.30

- CLASSLESS INTER-DOMAIN ROUTING (CIDR) OR SUPERNETTING
  → Way of allowing more flexible allocation of IP addresses than the parent system.
  → A 8-bit suffix is added to the address which defines number of bits available for NetID:
  11000011000011000000001100000111 0 /00010101
  suffix

  195.12.6.14/21 → since the suffix allocates 21 bits for netID, 11 bits would be used for HostID.

- SUB-NETTING
  → Different approach for further structuring in the address system.
  → Subnetting uses an approach that creates an internal ~~network to use local IP inside the subnet, and~~ partitioning between the HostID to use some of the HostID bits to assign to individual LANs and some of the HostID bits to assign to different computers.
  → This way, instead of using different IP addresses, and wasting many IP addresses because only some are required amongst every LAN, the IP addresses can be saved and only some proportion of addresses are wasted. For example: If Class C is used, then HostID could be effectively used by splitting bits among the Host ID. We take example of this by using 3 significant bits as LAN identifier and 5 least significant bits for the individual computer:
  → HostID with 11110101 would be the address of Computer no. 23(10101) at LAN 7(111).
  → Subnet Mask is used for routing traffic within a subnet once Internet packets reach the gateway with the network's NetworkID.

- NETWORK ADDRESS TRANSLATION (NAT)
  → Makes use of a private network that has it's own IP addresses.
  → To prevent mixing up of internal and external IP addresses, NAT scheme uses a public IP, that is used to communicate over internet and a private IP scheme that is used internally amongst the local network, and only 3 IP

addresses ranges are used and are reserved for this purpose to prevent mixing of internal and external IPs:

10.00.0	to	10.255.255.255
172.16.0.0	to	172.31.255.255
192.168.0.0	to	192.168.255.255

→ Each address (private) can be used by any different number of private network with no knowledge of this use on the internet.

IP address version 6 (IPv6)

→ Since the IPv4 were being consumed rapidly, a new IP addresses series was important to be introduced.

→ IPv6 uses 128-bits instead of 32-bits in IPv4, which gives 2^{128} addresses for IPv6, enough addresses for the coming future. ~~These~~

→ These are written in colon hexadecimal notation, in contrast to dotted decimal notation in IPv4.

→ Written as 16 bit (4 hexadecimal) each splitted with colon. Leading zeros can be omitted in each colon 16-bit, :0000: ~~0000~~ or any more number of zeros can be replaced by ::

IPv6 address	Comment
68E6:7C48:FFFE:FFFF:3D20:1180:695A:FF01	→ Full Address
72E6::CFFE:3D20:1180:245A:FF01	:0000:0000: replaced by ::
6C48:23:FFFE:FFFF:3D20:1180:95A:FF01	Leading zeros omitted
::192.31.20.46	IPv4 address used in IPv6

DOMAIN NAMES

→ System used to map a public names of domains on IP addresses

→ It is used to make domain names remember with public names rather than remembering IP addresses.

→ Domain Name System (DNS) is a distributed database on Domain name servers (installed) that maps a domain name to an IP address.

→ DNS root servers stand a hierarchial top of the DNS supporting whole internet. Domain name space is divided into non overlapping zones, with each having a primary, and and a secondary zone server (which takes data from primary).

→ There are more than 250 top-level domains, with some being generic while other representing countries, which are also included Universal Resource Allocator, which identifies a web page or email address.

→ Name resolution is the looking up of IP address associated with a domain name, which, in return, via querying the DNS, sends the IP address to the querier.

PROCESS WHEN USER ENTERS URL FOR A CLIENT-SERVER APPLICATION.

→ It is possible to develop Server-Client application by installing appropriate software on the computer, developing the code, get a domain from a web hosting server, upload the code to the server to deploy the application.

1. User enters the URL
2. Browser looks for the IP address with that specific domain
3. IP address is returned
4. The code from IP address is retrieved and Client-server application is rendered.

HTML

→ Most commonly used to develop web pages.
→ Is a scripting language and consists of tags <h1> Hi! </h1>, <marquee> Hello! </marquee> etc.
→ Can be used to display text or graphical media
→ Can be supplemented by inclusion of JavaScript or PHP.
→ Extension is .html for files.

JavaScript

→ Language used for supplementing HTML via Processing in such a way that processing is done on the client end.
→ Can be used for different calculations, to define the behaviour of web pages when a specific feature is applied or even after HTML.
→ It is a full-blown computer programming language
→ Can be used inside HTML file, otherwise seperate file has extension .js.

PHP

→ Language used for supplementing HTML via processing in such a way that processing is done on the server.
→ Same functions as JavaScript
→ Also a full-blow Computer programming language.
→ Can be used to communicate with different database systems such as MySQL.
→ The HTML, if used with PHP, must have a file extension of .php.

HARDWARE

THE MEMORY

→ Used to store data and files

→ This component could be split into two categories:

- Primary storage
  - Cache
  - main memory
- Secondary Storage
  - Hard Disk
  - Auxilaries

→ Primary Storage is the storge that holds data in memory (such as RAM and ROM) and in other in-built devices such as Processor's Cache (L1, L2, L3 etc). Cache is the high speed portion and used commonly for data that is repeatedly accessed.

→ Secondary Storage holds data on Hard Drives, SSDs, USB drives, Optical Disks and SD Cards etc. These devices are much slower in comparison to primary storage

→ Table shows trend:

Cost ↑ Capacity ↓ Size ↓ Access Time ↓

Component	Category
Register	Processor Comp.
Cache	Primary Storage
Main Memory	
Hard Drive	Secondary Storage
Auxilaries	

- RAM: is a volatile memory that can be read or written any time at any point with no fixed read or write limit. RAM is RANDOM ACCESS MEMORY because any RAM location can be accessed directly regardless of the previous accessed Location.

Two main types of RAM:

↳ DRAM is the most common RAM used, less expensive, due to the presence of capacitors which leak electricity, need regular recharging (every few milliseconds), has a greater access time and is less difficult to manufacture as well as less power is required for them.

↳ SRAM uses flip flops due to which they don't have to be frequently recharged, are used to make Memory Cache, which makes their access time less, and is more expensive.

↳ DRAM also have greater storage than SRAMs (Dynamic RAM and Static RAM).

- ROM is used for unchanged programs because ROM can only be read but not written to (Read Only Memory). Though it shares the same 'Random-Access' features of a RAM and is not volatile, i.e. contents are not lost on switching down the power. ROM could also be programmable, erasable or even electrically erasable and programable (PROM, EPROM and EEPROM respectively) but it doesn't affect its basic use in a system.

SECONDARY STORAGE DEVICES

→ MAGNETIC MEDIA

↳ Read-write head is used to interpret data using the basic physics laws of magnetism. The two alternative magnetic states are read as 1 or 0.

↳ In a hard drive, there are more than one platter (disk), each with it's own read-write head attached to actuator

arm which move along the surface of each disk (platter) alongside with the spinning of platters in unison themselves. The motion of each actuator head is synchronized with other actuator heads and a cusion of air is kept between head and platter so they don't touch each other. The head reads and writes the data.

↳ The logical construction instead of the physical construction discussed above uses a system that stores data in concentric tracks. Each tracks consists of sectors with each sector containing a defined number of bytes. To store a file, a sufficient number of sectors are allocated, that may or may not be adjacent to each other. Frequent manipulation of files can result in fragmentation which can be defragmented by a program designed for this purpose to reorganize the allocation of sectors to files, for the restoration of performance. The data can directly be accessed but has to be read sequentially.

Optical Media

→ Uses Optical Technology, main disks are CD, DVD and Blu-Ray all as successor to floppy disk.

→ CDs and DVDs use Red Laser Technology whereas Blu-Ray Disk uses Blue Laser Technology (which allows it to store more and more data as compared to CDs and DVDs).

→ Optical Drives make use of 'Land and Pit' (which are made by burning through laser) which "bumps and pits" are recognized as 0 and 1s.

→ The disc spins, with disc's storage dependant on the technology being used (can vary from 650 MB to 128GB). A thin layer of metal alloy or light sensitive organic dye to store data. They use spiral tracks to store data, which runs from the centre of the disk to the edge. They may be write-once, or rewritable.

→ Data is written on an optical drive, by spinning of a single track running on a spiral track (made of pits and lands to represent binary), on which a laser is shone, burning pits onto the metal making the metal change state and having a crystalline solid, or an amorphous solid after cooling the disk, making basis of 0s and 1s, and the laser beam head follows the track as disc spins allowing writing the whole binary on a spiral track

→ Reading data uses principle of reflections, a laser is shone at the surfaces, and the reflection is recorded by a photo diode sensor. The "land" area reflects light in a different way as reflected from "pits" which allows them to be read as 0s and 1s.

→ All disc technology differ from each other by the laser technology, with the laser having less wavelength being able to store more data.

Blu-Ray < DVD < CD → 780 nm

wavelength trend

405nm

SOLID - STATE MEDIA

→ It is based on a 'flash' memory which is a semi-conductor technology with no mechanical parts. It consists of series of transistor, most common technology being 'NAND' due these transistors acting like a NAND logic gate when connected in series. These memory cells, arrays of transistor, can be read as a whole block in one operation, and the data to be written in those cells require the data in the block first to be read, which the data can be erased in a single "flash".

→ Due to this, the technology can be used for Solid-State drives as a replacement to hard disk. These are mostly used in Memory cards and USB drives which uses same technology, which is USB uses a USB controller with which USB connector is attached.

→ SSDs have benefits of smaller Physical size, Low power usage, and High performance.

→ SSDs cons include high prices of SSDs, as well as finite number of reads and writes after which SSD starts to malfunction.

Computer Mouse

→ With the introduction of Graphical User Interface in 1980s, a pointing device was required to use GUI effectively, which could be used as an input through screen.

→ Buttons are used for click purposes while different technologies were introduced to give the pointer a relative movement.

↳ First initial technology used a rubber ball in contact with two perpendicular rollers. The movement of mouse cause one or both rollers to roll, and the spindle attached with rollers use that rotation along with light beam and detector so appropriate movement data is recorded and sent back to computer.

↳ Optical mouses were introduced as a replacement which uses shining of light beam from an LED to the surface on which mouse is lying. The reflected light is recorded and a camera inside takes successive images of surface which image processing software analyses and sends appropriate data to computer back.

SCREEN DISPLAY

→ Screens consists of pixels, which further have sub-pixels, blue, red, and green. Varying the amount of light from each sub-pixel allows a range of color to be displayed.

→ In original CRTs, Phosphor was used to emit light which is a material which emits light when irradiated. An electron beam was used to serve the purpose which movement was controlled to create individual pixels. For colored CRTs, red blue and green phosphor were used with same phenomenon.

→ In plasma screens, plasma is given a charge which in return irradiates the The phosphor emitting light.

→ In LCDs, LEDs back-lit the liquid crystal cells sandwitched between polarizers, and when voltage are applied to individual pixel cell, they change their alignments to display.

→ OLEDs and rest same principal apart from the fact that in OLEDs, light itself is produced by screen.

TOUCH SCREEN

→ In Resistive touch screen, two layers are separated by empty space and when that unrigid layer is touched, it touches the other layer causing a completion of circuit and the coordinates of that point is recognized by micro-processor, causing a touch affect.

→ In capacitive, when screen is touched, the layer beneath the screen undergoes a change in electrical capacitance causing a touch affect which is identified by a microprocessor. Due to these array of capacitors, multi touching is also recognized.

KEYBOARDS AND KEYPADS

→ Default method of input to computer (text)

→ Matches typewriter layout (QWERTY)

→ Keypress is converted into a key code which is controlled under processor and displays the text.

→ Keyboard has it's own ROM and microprocessor, pressing a key causes a specific wires intersection, ROM identifies the correct character code and sends it back to computer.

PRINTERS, SCANNERS AND PLOTTERS

INKJET	LASER
1- Cheap	1- Expensive
2- Smaller Size	2- Larger Size
3- Expensive Ink Replacements	3- Cheaper Ink Replacements
4- High Quality Printing	4- Good quality printing
5- Cannot be effectively used for batch printing	5- Can be used for high volume printing
6- Uses liquid ink	6- Uses dry ink
7- Uses dropping of ink on page using thousands of nozzles	7- Uses laser to draw on the page

→ Graphics plotter is used to draw high-level graphics for example for CAD programs, whereas a 3D Printer prints it. The 3D printer uses powdered plastic etc to draw the required model using x, y and z planes. The material is glued together to produce a 3D model.

SOUND

→ FOR INPUT OF sound, ~~mic~~ mic is used which has a diaphram which vibrates when receiving sound, causes change in capacitance, or a piezoelectric crystal is used as an alternative, which then is passed through ADC to get a digital form.

→ For output of sound, speakers are used, which does exactly reverse of what Mic does. The sound card of computer produces signals (digital) which are sent ~~converted~~ to speakers which causes vibration in diaphram. with the use of a permanent magnet and the direction of current causes sound to produce.

LOGIC GATES AND CIRCUITS

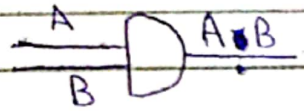
→ Logic Proposition is a logical statement that is in binary occurance, yes or no.
→ Combination of propositions is problem statement.
→ TRUE = 1 = ON = YES
→ FALSE = 0 = OFF = NO

→ ~~TAKE~~ GO_OUTSIDE = IF (COVID-19 = FALSE) AND (GOVERNMET_RESTRICTION = FALSE OR SOPs = TRUE) etc.

→ Logic Gates

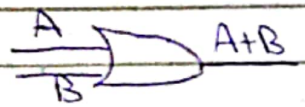
Not gate

Boolean = $\bar{A}$
Logic Notation = A NOT



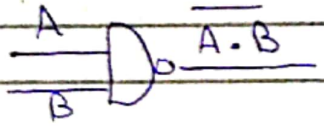
Boolean = A•B
Logic Notation = A AND B

AND GATE



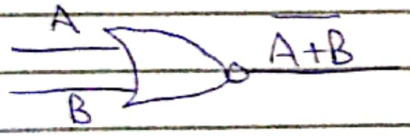
Boolean = A+B
Logic Notation = A OR B

OR GATE



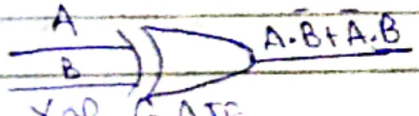
Boolean = $\overline{A \cdot B}$
Logic Notation = A NAND B

NAND GATE



Boolean = $\overline{A+B}$
Logic Notation = A NOR B

NOR GATE



Boolean = $\bar{A} \cdot B + A \cdot \bar{B}$
Logic Notation = A XOR B

XOR GATE

TRUTH TABLE

→ Technique to represent logical expressions for possible outcome to logical circuit.

TRUTH TABLES FOR LOGIC GATES:

NOT GATE

A	$\bar{A}$
0	1
1	0

AND GATE

A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

OR GATE

A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

NOR GATE

A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

NAND GATE

A	B	$\overline{A \cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

XOR GATE

A	B	$A \cdot \bar{B} + \bar{A} \cdot B$
0	0	9
0	1	0
1	0	0
1	1	1

LOGIC CIRCUITS

→ It is combination of different gates to form a logical circuit.

→ Priority ORDER = NAO (NOT, AND, OR)

SAMPLE GATE

turbine speed	S	0	<= 1000 rpm
		1	> 1000 rpm
bearing temperature	T	0	<= 80°C
		1	> 80°C
wind velocity	W	0	<= 120 Kph
		1	> 120 Kph

X, output will be one if,

→ either turbine speed <= 1000 rpm and bearing temperature > 80°C

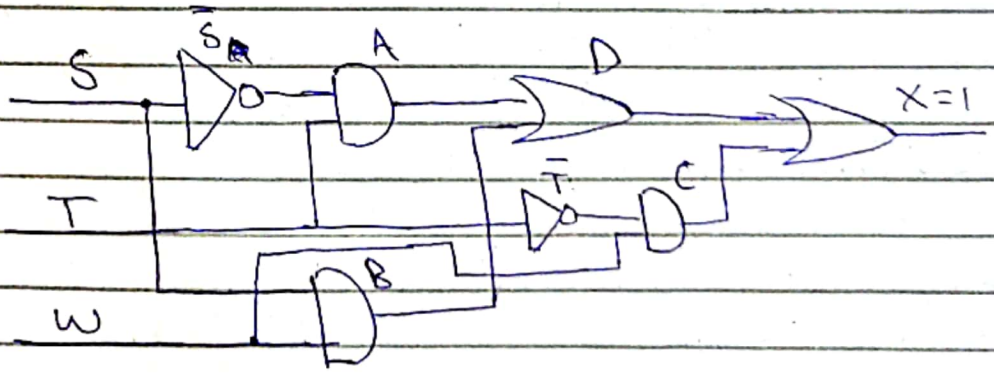
→ or turbine speed > 1000 rpm and velocity > 120 Kph

→ or bearing temperature <= 80°C and wind velocity > 120 Kph

Logical problem proposition would be,

X=1 if (S=0 AND T=1) OR (S=1 AND W=1) OR (T=0 AND W=1)

Logical Circuit would be,



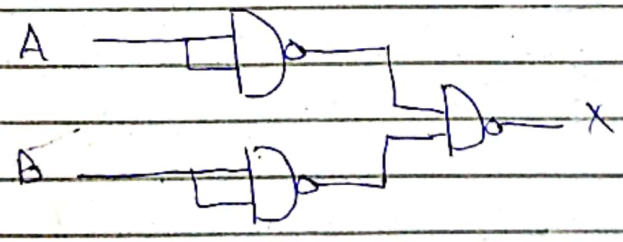
* Assign names to gate for ease in drawing truth table

The truth table would be,

S	T	W	$\bar{S}$	$\bar{T}$	A	B	C	D	X
0	0	0	1	1	0	0	0	0	0
0	0	1	1	1	0	0	1	0	1
0	1	0	1	0	1	0	0	1	1
0	1	1	1	0	1	1	0	1	1
1	0	0	0	1	0	0	0	0	0
1	0	1	0	1	0	0	1	0	1
1	1	0	0	0	0	0	0	0	0
1	1	1	0	0	0	1	0	1	1

ALTERNATIVE CIRCUITS

→ SAME logical conclusion can be reached via different logical gates, which can also considerably reduce manufacturing cost by replacing expensive gates with those which are cheaper. In this scenario, NAND gate is quite common. For example, construction of OR gate via NAND follows:



For NOT gate:

PROCESSOR FUNDAMENTALS

VON NEUMANN MODEL

→ All modern computers works on Von Neumann model principles which were introduced to solve the reprogramming, everytime, problem.

→ The model suggested for the basic features that:
- A processor should be in a computer as Central processing unit
- The processor has direct access to memory
- Memory contained a stored program and the data required by it.
- Stored programs consists of individual instructions
- The processor executes instruction sequentially

PROCESSOR

→ Processor played a vital part in the Von's Model. Components of a CPU are, at main, arithmetic and logic units and control unit.

→ ALU does calculations and logical processings (greater than, equal to etc.).

→ CU manages the flow of data and ensures that a program's instructions are handled correctly. Clocks are also associated with CU, internal and external clocks, which is used to synchronize processes

→ Internal clock manages the cycles of activities within a processor, while the external clock manges activities outside the CPU.

→ CPU has a defined frequency for it's clock cycle, which is known as clock speed which is the minimum period of time between successive activities. The greater the frequency, the faster the processor is

REGISTERS

→ Another important CPU component
→ Fastest access memory, due to proximity with ALU.
→ Consists of special and general purpose registers.
→ Accumulator used as general purpose register to store values before and after calculations by ALU.
→ Special purpose register are several with specific uses:
  ↳ Current Instruction Register (CIR) used to store currently being decoded/executed instruction
  ↳ Index Register used for storing value for indexed addressing
  ↳ Memory Adress Register/Buffer Register stores the address of memory location at which a value is going to be read or written, acts as a buffer
  ↳ Program Counter stores the address of next instruction in memory
  ↳ Status Register contains individual bits that are either set or clear, it is used during arithmetic and logical processing, with individual bit being set to 1 when a condition is detected, for instance flag C is used, the carry flag if there is a carry, same applies for overflow and negative flags, V and N respectively.

BUSES

→ Means of transfer of data parallely via several wires.
→ Mechanism that transfers data from one system to another.

SYSTEM BUSES

→ System bus consists of three components:
  ↳ Address Bus
  ↳ Data Bus
  ↳ Control Bus

Address Bus
→ Unidirectional
→ Carries signals relating to memory addresses between processor and memory

Data Bus
→ Bidirectional
→ Used to exchange data between processor, memory and Input/output devices

Control Bus
→ Carries signals used to coordinate the computer's activities

Bus Width
→ It is no. of wires used for data transfer as bits (one bit at each wire).
→ For address bus, especially, it is crucial for a computer to have a larger bus width, since, for example, 16 bits are only able to address 65536 addresses, and 32-bits allowing only 4GB of RAM to be addressed.
→ For data bus, the bus width is ideal to be the same as size of a "Word", which is essentially a small number of bytes considered as a "unit" by computer
→ For control bus, only signals are sent so large bus width aren't required

Universal Serial Bus
→ First plug and play for peripherals.
→ Hierarchy of connections supported with computer being top of it and able to handle 127 attached devices
→ Can be Hot-swapped, automatically configured
→ Standard evolving with speeds being increased.

PORT

→ Each I/O device is connected to port interface
→ The controller handles communication between I/O device and CPU, via port.
→ Internal Ports connect integral parts of computer while external ports connect peripheral devices.

FETCH, DECODE, EXECUTE CYCLE

1- Load address in PC to MAR
2- Load Instruction at MAR address into MDR
3- Load MDR Instruction into CIR
4- Increment PC by 1
5- Decode the instruction that is in the CIR
6- If instruction is a jump instruction:
   → Load the address of instruction to PC
   → Reset to step 1
7- Execute the instruction
8- Reset to step 1

Step 1 to 4 = Fetch.
Steps 5, 6a and 7 = Execute
Steps 6b and 8 = Reset

Register Transfer Notation

→ The representation of operation involving registers
→ Representation for fetch execute cycle:

MAR ← [PC]
PC ← [PC] + 1; MDR ← [[MAR]]
CIR ← [MDR]

two instructions in one line means simultaneous

MAR has address (content) which is data (content) is been retrieved

Store contents of MAR contents is being transferred

double brackets means it

Brackets represent moving of DATA with possible arithmetic operations

INTERRUPT HANDLING

→ Interrupts can be generated for many reason:
- Paper stuck in printer
- Printer asking for papers of data to print
- Error in a program
- Hardware faults
- I/O processing need
- Timer signals
- User interacting

etc

→ Handled at the end of fetch-execute cycle
→ Interrupts have different priorities, types etc
→ The currently being processed instructions are moved to a safe memory address and after servicing the interrupt, the contents are restored
→ To prioritize interrupts, an approach can be to use an Interrupt register with different flags and types such as SR register to service every interrupt accordingly.

ASSEMBLY LANGUAGE

MACHINE CODE

→ 0s and 1s
→ Directly understood by processor
→ Different processors have different instructions set, so different machine code
→ For each individual machine code, These are defined and vary among every processor
- Total number of bits for whole instruction
- Number of bits defining opcode
- Number of operands that are defined in the remaining bits
- Whether the opcode occupies most or least significant bits

ASSEMBLY LANGUAGE

→ Made to create ease for writing progras (use mnemonics instead of 1s and 0s)
→ Writing a 0s and 1s could be erroneous.
→ Assembly instruction comprises of,
↳ Mnemonics, for opcode
↳ Character representation for the operand
→ Needs to be converted into machine code (because it is only machine code understood by computer) by 'assembler'.
→ Features of Assembly language:
↳ comments
↳ symbolic names for constants
↳ labels for addresses
↳ macros } may be executed more than once
↳ Subroutines }
↳ directives
↳ System calls

→ Directives are instructions to the assembler about how to produce the final executable machine code.

Addressing Modes

→ Ways of ~~storing~~ identifying values in registers.

↳

Addressing Mode	Corresponding Operand
Immediate	value to be used in instruction
Direct	address holding ~~value~~ to be used
Indirect	// // address of the value to be used
Indexed	address in which value of index register is added to obtain address containing instruction's value

↳ These are addressing mode using 2 bits defining addressing mode only (4 modes).

→ '#' identifies as immediate addressing

	Instruction Opcode	Operand	Explanation
Data Movement	LDM	#n	Immediate; load n to ACC reg.
	LDR	#n	// load n to IX
	LDD	<address>	direct ; load to ACC
	LDI	//	indirect; //
	LDX	//	indexed ; //
	STO	//	store ACC contents to <address>
Arithmetic	ADD	//	add contents of the address to ACC
	INC	<register>	Add 1 to value of <register>
	DEC	//	Subtract // // //
Comparisons, Jumps; Flow of code	JMP	<address>	Jump to the <address>
	CMP	//	Compare ACC contents with <address> contents
	CMP	#n	// // // with n
	JPE	<address>	Jump to <address> if previous comparison was True
	JPN	//	// // // False
INPUT/OUTPUT and END	IN	–	Input character; store in ACC
	OUT	–	Output character stored in ACC
	END	–	Return control to OS

SYSTEM SOFTWARE

Operating System (OS): A software platform that provides facilities for programs to be run which are of benefit to a user.

↳ Software that controls and is intermediate layer to hardware.

↳ Windows, Linux, macOS, Android (based on linux), iOS etc.

→ OS Activities

↳ USER-SYSTEM INTERFACE PROVISION: CLI and GUI, for input/output.

↳ PROGRAM–HARDWARE INTERFACE: Becomes a layer between software written by programmers and hardware.

↳ RESOURCE MANAGEMENT: To manage hardware resources divided among different processes, how to divide them, scheduling of processes and resolution of conflicts if simultaneous processes demanding same resource.

- Process: A program that has began execution

↳ MEMORY MANAGEMENT: Memory protection of memory used by one program from other; providing paging, swapping as virtual memory; memory optimizations etc.

↳ DEVICE MANAGEMENT: Manages devices connected to computer, installing device drivers for example.

↳ FILE MANAGEMENT: How to store file, file namings, access control mechanisms etc.

↳ SECURITY MANAGEMENT: Data recovery if lost, protections from intruders, ensuring data privacy.

↳ Error detections and recovery to provide appropriate interrupts and diagnostics for example.

↳ Provision of Utility programs

UTILITY PROGRAMS

→ May or may not be provided by the OS.
→ Not part of OS routines, used under specific circumstances -
→ Maintenance Utilities include: Backup utilities, disk cleaner utilities, disk defragmentation, formatting etc.
→ Security Utilities: User Accounts, Encryption, anti-virus softwares, firewalls etc.

HARD DISK FORMATTER AND CHECKER

→ For formatting, disk formatter removes existing data from disk, set up new filesystem with partition table and partitioning into logical drives.
→ DISK CHECKER checks and tries to repair disk, mark bad sectors which might have developed due to the mishandling of system or abnormal power cut off for example, to boost the performance.

HARD DISK DEFRAGMENTER

→ Used to defragment hard drive which becomes fragmented due to the constant creation, deletion and editing of files -
→ Fragmentation is the development of non-sequential files storage on hard drive sectors.
→ Defragmenter reorganizes the files in a state where all files are in sequence boosting the read-write speeds of file

BACKUP SOFTWARE

↳ Backups data at predefined schedules, creates new backups only when change is made.

FILE COMPRESSION

↳ Utility that compresses file to minimise hard disk storage occupa

VIRUS CHECKER

↳ Utility used to protect system
↳ Mostly scans file when entering system
↳ Should be regularly updated.

LIBRARY PROGRAMS

→ Libraries containing subroutines or procedures/functions) are predefined which a programmer uses in his code.
→ These need to be linked with code before execution in order to work.
→ Libraries are mostly used to develop further with what already exists developed.
→ Dynamic Link Library files (DLLs)
→ More than one process can dynamically link to DLLs.

LANGUAGE TRANSLATORS

→ Assembler
↳ Converts Assembly language into Object Code linked with any kind of library files. Linker generates the executable machine code. Program is loaded by loader into memory.
↳ Assembler looks for removal or addition of extra contents before converting into object code

→ Compilers And interpreters
↳ Used to program in high level language
↳ Errors shown immediately on interpreter, so later errors may not be discovered at once, and the source code needs to be available to get executed.
↳ Executable can be generated directly in Compiler, which is faster, but less secure (because it could contain a virus) and only object code needs to be available.

Compiler	Interpreter
1. Only source code made available	Source code and data both are made available
2. Execution Begins	Execution Begins
3. First line of source code is read	First line . . . . .
4. Line Analysed	Line Analysed
5. Error found: Recorded	Error found : Program Execution Halts
6. No error: Converted into intermediate code	No Error . . . . .
7. Next line read and 4-7 steps repeated	Intermediate code used to execute required action
8. when whole source code is read : If no errors: complete intermediate code is converted into object code If errors: Errors outputted and no object code is produced	Next line is read and 4-8 steps are repeated

JAVA (LANGUAGE)

→ Computers must install Java Virtual Machine in order for that program to work.

→ Program source code converted into Java Byte Code

→ Java Byte Code is interpreted by any computer having Java Virtual Machine installed.

DATA SECURITY

PRIVACY AND INTEGRITY

Data security → Prerequisite for the other two
→ A requirement for data to be recoverable if lost or corrupted.

Data Privacy
→ Requirement for data available only to authorised users.

Data Integrity
→ Requirement for data to be accurate and up to date.

Data Protection Law
→ Laws that relate to data privacy.

Authentication
→ Verification of a users identity, either by password or biometrics

Authorisation Policies
→ Definitions of a user's access rights to system and it's components.

Validation
→ Checking whether the data is correct for the format ~~demanded of it~~ being demanded - Length, Range, type checks, for example.

Verification
→ Confirmation of data received by a system.
→ In case of data transfer, from one system to another, parity checks, checksums, echo check, for example.

ETHICS AND OWNERSHIP

COPYRIGHT: Formal recognition of ownership of a created and published work.

Shareware
↳ Software free to use for a limited time but no source code supplied.

Freeware
↳ Software free with unlimited use but no source code provided

Open Source Software
↳ Softwares free with unlimited use with source code provided.

THE ACM/IEEE SOFTWARE ENGINEERING CODE OF ETHICS
↳ 8 preamble principles, 80 clauses - Principles being:

1. PUBLIC - Soft. Engineers shall act consistently with public interest
2. CLIENT AND EMPLOYER - Shall act in a manner that is in the best interest of their clients consistent with public interest.
3. PRODUCT — Ensure their products reach at highest professional standards
4. JUDGEMENT — Maintain integrity and independence in their professional judgements.
5. MANAGEMENT - Subscribe and promote ethical approach to software development and maintenance management
6. PROFESSION - Advance integrity and profession consistent with public interest
7. COLLEAGUES - Be fair and supportive to their colleagues
8. SELF — Should participate in lifelong learning regarding practice of their profession and promote an ethical approch to the practice of profession.

DATABASES AND DATA MODELLING

DATA REDUNDANCY

→ Same data stored more than once without any need.

DATABASE

→ Storage and collection of data along with implementation to the rules of a theoretical model, which was proposed, at it's basic, by ANSI.

↳ Three-level model was proposed including:
- External level
- Conceptual Level
- Internal Level (Physical storage)

→ Database Management System is software that controls access to data in a database and only knows how to store data.

→ Database Administrator is the person who uses the DBMS to customize the database to suit user and programmer requirements.

RELATIONAL DATABASES

↳ Data stored in special type of table called relation.

↳ Attributes are assigned, as a column in the table containing data or values, on the creation of table.

↳ Table must have a primary key that should be unique → having values, so promotes entity integrity

↳ Foreign key establishes the relationship by defining an attribute in on table that refers to the primary key in other table.

ENTITY – RELATIONSHIP MODELLING

↳ Used to establish relationship between any entity type to the primary and foreign keys making them joined because of that relationship identifying.

↳ In logical entity – relationship model, M:M relationship problems are conferred by inserting a link entity in the model. Since one foreign key value cannot have or handle many references required – Two foreign keys can be used in link entity allowing the ~~table~~ relationship to be working.

NORMALIZATION

↳ PROCESS used to convert data items into corresponding tables.

STRUCTURED QUERY LANGUAGE (SQL)

→ Programming Language provided by DBMS to support all operations associated with a relational database.
→ Data Definition Language (DDL) in SQL is used to create structure or altering them (tables).
→ Data Manipulation Language (DML) is used in SQL to manipulate data inside the structure.

DBMS FEATURES

↳ Include security control, interrupted transaction handling, setting access rights for users, etc.
↳ Improving performance of Database
↳ Showing metadata of Physical level database to Database Administrator only, etc.
↳ Providing Indexing, a data ~~structure and~~ dictionary and a backup procedures.