

Unit: 1

Computer System

Computer

A computer is an electronic device designed to accept input, process it, and generate a result (output) is called computer.

1.1 Computer System

A computer along with hardware and software is called a computer system.

Computer systems come in various forms and sizes.

A computer system primarily comprises a **Central Processing Unit (CPU)**, **memory**, **input/output devices**, and **storage devices**.

Block Diagram of Computer System (5M)

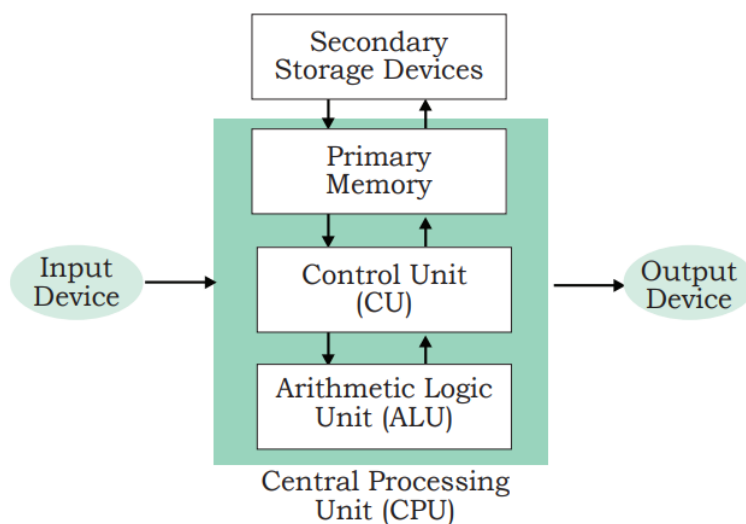


Figure 1.1: Components of a computer system

1.1.1 CPU

It is referred to as the **brain of the computer** and is commonly called the **processor**. It takes instructions and data through programs, performs arithmetic and logical operations, and stores the results back into memory. While processing, the CPU stores data and instructions in local memory called **registers**, which are high-speed temporary storage areas for holding data and intermediate results. The CPU also consists of an **Arithmetic Logic Unit (ALU)** to perform arithmetical and logical operations.

1.1.2 Control Unit

The **Control Unit (CU)** controls the sequential execution of instructions.

1.1.3 Input Devices

These devices are used to send control signals and data to the computer. They convert input data into digital form.

Examples: Keyboard, Scanner, Mouse, Microphone.

Data entered through these devices is stored temporarily in the main memory (**RAM**).

1.1.4 Output Devices

These devices are used to receive data and instructions from a computer system for display or physical production. They convert digital information into human-understandable form.

Examples: Speaker, Monitor, Printer etc.

A printer is used to produce output in physical hardcopy form.

1.2 Evolution of Computers

1) 500 BC – Abacus

- Mechanical device used for simple arithmetic calculations.
- Considered the earliest computing tool.

2) 1642 – Pascaline

- Invented by **Blaise Pascal**.
- Known as the *adding machine*.
- Could perform addition and subtraction; later multiplication and division by repeated operations.

3) 1834 – Analytic Engine

- Invented by **Charles Babbage**.
- Mechanical computing device capable of input, storage, processing, and output.

- Regarded as the first design of a general-purpose computer.

4) 1890 – Tabulating Machine

- Invented by **Herman Hollerith**.
- Used for data processing and tabulation, especially in census work.
- The data stored on punched card.
- Marked the beginning of automated data handling.

5) 1937 – Turing Machine

- Conceptualized by **Alan Turing**.
- This is general purpose programmable machine was capable of solving any problem by executing the program started on punched card.

6) 1945 – EDVAC / ENIAC

- Introduced by **John Von Neumann**.
- Brought in the **stored program concept**, which allowed both data and programs to be stored in memory.
- EDVAC and ENIAC were based on this concept.

7) 1947 – Transistor

- Developed at **Bell Labs** using semiconductor materials.
- Replaced vacuum tubes, making computers smaller, faster, and more reliable.

8) 1970 – Integrated Circuit (IC)

- A silicon chip containing an entire electronic circuit in a very small area.
- Greatly reduced the size of computers.
- Marked the beginning of microprocessor-based systems.

Stored Program Concept (Diagram)

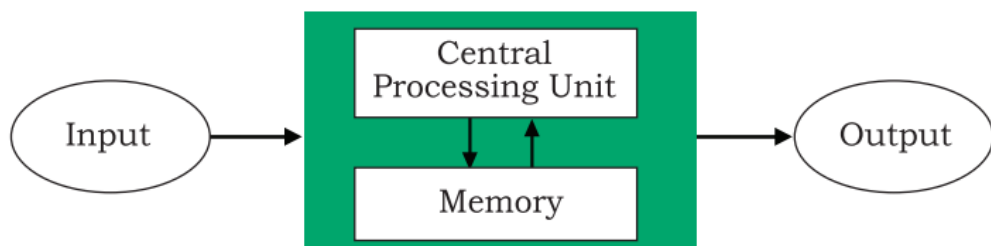


Figure 1.2: Von Neumann Architecture for the Computer

Von Neumann Architecture & Developments

- **John von Neumann** introduced the **stored program concept**, also called **Von Neumann Architecture** or **Princeton Architecture**.

- **ENIAC** was the first binary programmable computer based on this concept.

Advancements in Integrated Circuits

- After the 1970s, ICs were developed into:
 - **LSI** – Large Scale Integrated Circuit
 - **VLSI** – Very Large Scale Integrated Circuit
 - **SLSI** – Super Large Scale Integrated Circuit

Moore's Law (1965)

- Predicted that the **number of transistors on a chip would double every 2 years**.
- The **cost would be halved** over the same period.

Personal Computers

- **IBM** introduced the first personal computer in **1981**.
- **Apple Macintosh** was introduced in **1986**.

Next Wave of Computing

- Wearable gadgets: **earphones, smart watches, smart lenses**.
- Smartphones and appliances are becoming part of the **Internet of Things (IoT)** using the power of **Artificial Intelligence (AI)**.

1.3) Computer Memory

It is an Electronic storage place for data and instructions.

Classified into two types:

1. **Primary Memory**
2. **Secondary Memory**

1. Primary Memory

- It is a Main memory into which programs and data are loaded before processing.
- The CPU directly interacts with primary memory to perform read and write operations.

Two types:

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

Difference between RAM and ROM (2 Marks)

RAM	ROM
Volatile memory – stores data only while power is supplied.	Non-volatile memory – retains data even when power is off.
Used to temporarily store data currently being processed by the CPU.	Stores instructions required during computer bootstrap/start-up.
High-speed memory.	Much slower than RAM.
Large in size with high capacity.	Small in size with low capacity.
Costlier.	Cheaper than RAM.

2) Secondary Memory

- Also called **Auxiliary Memory**.
- Non-volatile in nature.
- Large storage capacity but slower than main memory.
- Used to store data and instructions for future use.
- **Examples:** HDD (Hard Disk Drive), Pen Drive, CD (Compact Disk), DVD.
- Memory cards with **SSD (Solid State Drive)** are ~100 times faster than HDD.

Cache Memory

- It is an Intermediate high-speed memory placed between CPU and RAM.
- Stores frequently accessed copies of data and instructions to speed up processing.

1.3.1 Unit of Memory

- The basic unit of memory is the **bit** (binary digit: 0 or 1).
- Bits are grouped together to form **words**.

Units of Measurement

- 4 bits → **1 Nibble**
- 8 bits → **1 Byte**
- 1024 Bytes → **1 Kilobyte (KB)**
- 1024 KB → **1 Megabyte (MB)**
- 1024 MB → **1 Gigabyte (GB)**
- 1024 GB → **1 Terabyte (TB)**
- 1024 TB → **1 Exabyte (EB)**

- 1024 EB → **1 Zettabyte (ZB)**
- 1024 ZB → **1 Yottabyte (YB)**
- 1024 PB → **1 Petabyte (PB)**

Difference between Primary Memory and Secondary Memory

Primary Memory	Secondary Memory
Stores data temporarily as long as power supply is on (e.g., RAM).	Stores data permanently (e.g., Hard Disk, CD, DVD, Pen Drive, Memory Card).
Faster than secondary memory.	Slower compared to primary memory.
Limited storage capacity.	Larger storage capacity.
Expensive.	Cheaper.

1.4 Data Transfer between CPU and Memory

Data is transferred between different components of the computer using a set of physical wires called a **bus**.

Types of Bus:

- 1) **Data Bus:** Transfers actual data between different components. It is **bidirectional**.
- 2) **Address Bus:** Transfers addresses between CPU and main memory. It is **unidirectional**.
- 3) **Control Bus:** Communicates control signals between different components of a computer. It is **unidirectional**.

System Bus

- The **System Bus** is the combination of **Data Bus, Address Bus, and Control Bus**.
- It enables communication between different components of the computer.

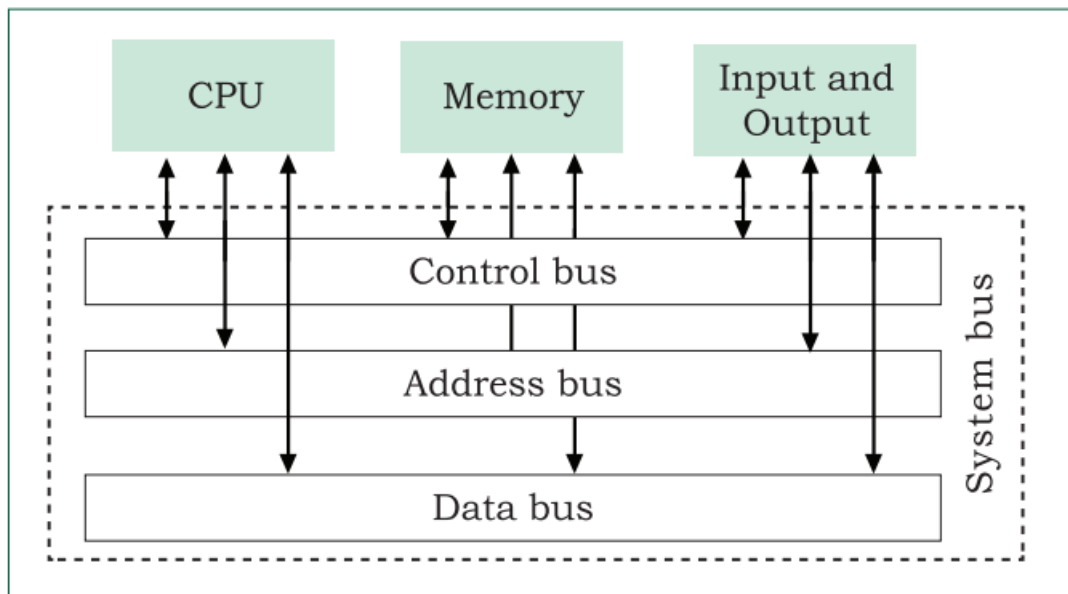


Figure 1.3: Data transfer between components through system bus

Memory Controller

- The **Memory Controller** manages the flow of data into and out of the computer's main memory.

1.5 Microprocessor

- A **Microprocessor** is a CPU implemented on a single microchip.
- Modern microprocessors are built using **Integrated Circuits (ICs)**. Which consists of **Transistors, registers and diode**.

Generations of Microprocessors

Generation	Era	Chip type	Word size	Maximum memory size	Clock speed	Cores	Example*
First	1971-73	LSI	4 / 8 bit	1 KB	108 KHz-200 KHz	Single	Intel 8080
Second	1974-78	LSI	8 bit	1 MB	Upto 2 MHz	Single	Motorola 6800 Intel 8085
Third	1979-80	VLSI	16 bit	16 MB	4 MHz - 6 MHz	Single	Intel 8086
Fourth	1981-95	VLSI	32 bit	4 GB	Upto 133 MHz	Single	Intel 80386 Motorola 68030
Fifth	1995 till date	SLSI	64 bit	64 GB	533 MHz - 34 GHz	Multicore	Pentium, Celeron, Xeon

1.5.1 Microprocessor Specification

Microprocessors are classified on the basis of different features which include chip type, word size, memory size, clock speed, etc. These features are briefly explained below:

1) Word Size

- It is the number of bits that microprocessor can process at a time.
- Minimum word size: **16 bits**
- Maximum word size: **64 bits**

2) Memory Size

- Depending on the word size, the size of RAM also varies. Initially it was 4Mb because of 4 or 8 bit word size.
- It has become feasible for a RAM to use up to 16 GB.

3) Clock Speed

- Computers have an internal clock that generates pulses at regular intervals.
- **Clock speed** = number of pulses generated per second by the internal clock.
- Measured in **Gigahertz (GHz)** today.

4) Cores

- Number of computation units in the CPU.
- **Single core** → performs one task at a time.
- **Multicore processors** → perform multiple tasks simultaneously.

Examples:

- Dual core (2 units)
- Quad core (4 units)
- Octa core (8 units)

1.5.2 Microcontrollers

It is a small computing device which has a CPU, fixed amount of RAM, ROM and other peripherals all embedded on a single chip.

Example - washing machine, digital camera, remote control, keyboard, and mouse.

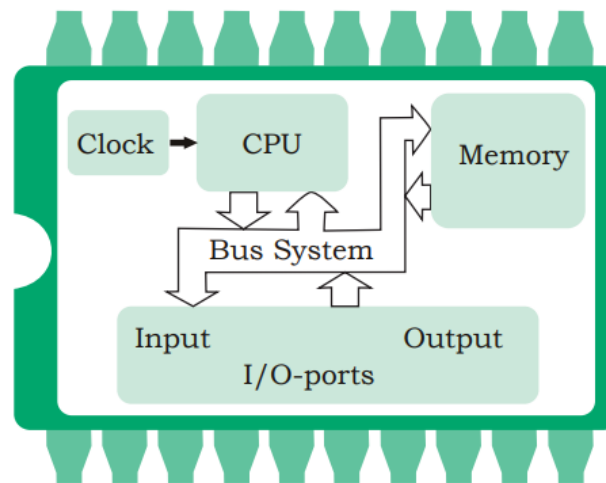


Figure 1.4: Structure of microcontroller

1.6 Data and information:

Raw facts and unorganised items are called **data**.

Data can be text, image, audio, video, document which are processed to get meaningful information.

1.6.1 Types of Data:

- 1) Structured Data
- 2) Unstructured Data
- 3) Semi structured Data

1) Structured Data:

These data follows a strict record structure and easy to comprehend.

This method is easy to understand since they are arranged in the rows and columns.

Eg. The table which shows the monthly attendance of students.

Roll No	Name	Month	Attendance (in %)
R1	Mohan	May	95
R2	Sohan	May	75
R3	Sheen	May	92
R4	Geet	May	82
R5	Anita	May	97
R1	Mohan	July	98
R2	Sohan	July	65
R3	Sheen	July	85
R4	Geet	July	94
R5	Anita	July	85

Table 1. Structured data: Monthly attendance records of students

2) Unstructured Data:

These data are not organised in pre-defined format is called unstructured data.

Eg. Audio and video files, graphics, text document etc..

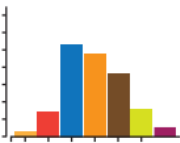


School Logo

ABC SCHOOL
Attendance record for the month of July

Name: John S.**Roll No.:** R1**Class:** XI A

Total classes held: 150**Attended:** 100**Absent:** 50

Guardian's Signature

**Principal's Signature**

Figure 1.5: Unstructured data: Monthly attendance record

3) Semi structured Data:

These data do not have well defined but maintain internal tags or markings to separate data elements.

Eg. Email document, HTML page, comma separated value (CSV) files.

Name: <i>Mohan</i>	Month: <i>July</i>	Class: <i>XI</i>	Attendance: 98
Name: <i>Sohan</i>	Month: <i>July</i>	Class: <i>XI</i>	Attendance: 65
Name: <i>Sheen</i>	Month: <i>July</i>	Class: <i>XI</i>	Attendance: 85
Name: <i>Geet</i>	Month: <i>May</i>	Class: <i>XI</i>	Attendance: 82
Name: <i>Geet</i>	Month: <i>July</i>	Class: <i>XI</i>	Attendance: 94

Figure 1.6: Semi-structured data: Month-wise total attendance record maintained by the school

1.6.2 Data Capturing, Storage and Retrieval

Data Capturing

It is the process of gathering data from different sources in digital form.

Capturing may use simple instruments like keyboard, barcode readers, and QR code scanners, comments or posts over social media, remote sensors on an earth orbiting satellite, etc.

Data Storage

It is the process of storing captured data for later process. Nowadays data is produced at a very high rate and hence data storage is becoming a challenging task in large organization.

Computers with huge and faster storage called Data servers. Data servers are deployed to store huge amount.

Data Retrieval

It involves fetching data from storage devices for its processing as per the user requirements.

1.6.3 Data Deletion and Recovery

Data Deletion

The storage devices can malfunction or crash down resulting in the deletion of data stored.

Users can accidentally erase data from storage devices, or a hacker or malware can delete the digital data intentionally.

Data Recovery

Data recovery is a process of retrieving deleted, corrupted and lost data from secondary storage devices.

There are usually two security concerns associated with data.

1) Unauthorized Deletion/Modification

- Risk: Data may be deleted or altered by unauthorized users or software.
- Prevention: Limit system access, use passwords, and encrypt files.

2) Unwanted Recovery

- Risk: Old or discarded storage devices may still contain recoverable data, threatening confidentiality.
- Prevention: Use proper tools to permanently delete or shred data before disposal.

1.7 Software

- A set of instructions referred to as **software**.
- It is a component of a computer system that **cannot be touched or viewed physically**.
- Comprises **instructions and data** to be processed using computer hardware.

1.7.1 Need of Software

The main purpose of software is to make the computer hardware useful and operational. Depending on the mode of interaction software is classified into 3 types

1. **System software**
2. **Programming tools**
3. **Application software**

1. System software

- The software that provides the basic functionality to operate a computer by interacting directly with its constituent hardware is termed as system software.
- A system software knows how to operate and use different hardware components of a computer.
Examples operating systems, system utilities, device drivers, etc.

(A) Operating System

- A **system software** that operates the computer.
- Most basic system software — without it, other software cannot work.
- Manages application programs and provides **access** and **security** to users.
- Popular examples: **Windows, Linux, Macintosh, Ubuntu, Fedora, Android, iOS.**

(B) System Utilities

- Software used for **maintenance and configuration** of the computer system.
- some utilities are **shipped with the operating system**, e.g.:
 - Disk defragmentation tool
 - Formatting utility
 - System restore utility
- some utilities are **not shipped with the OS** but improve performance, e.g.:
 - Anti-virus software
 - Disk cleaner tool
 - Disk compression software

(C) Device Drivers

It ensures the proper functioning of a particular device in the computer. It is not possible for an OS alone to operate all the existing and new devices, hence the device drivers are used which acts as an interface between the device and OS.

Soft copy: A document or image stored on the hard disk or pen drive is called softcopy.

Hard copy: Printed document or image is called a hard copy.

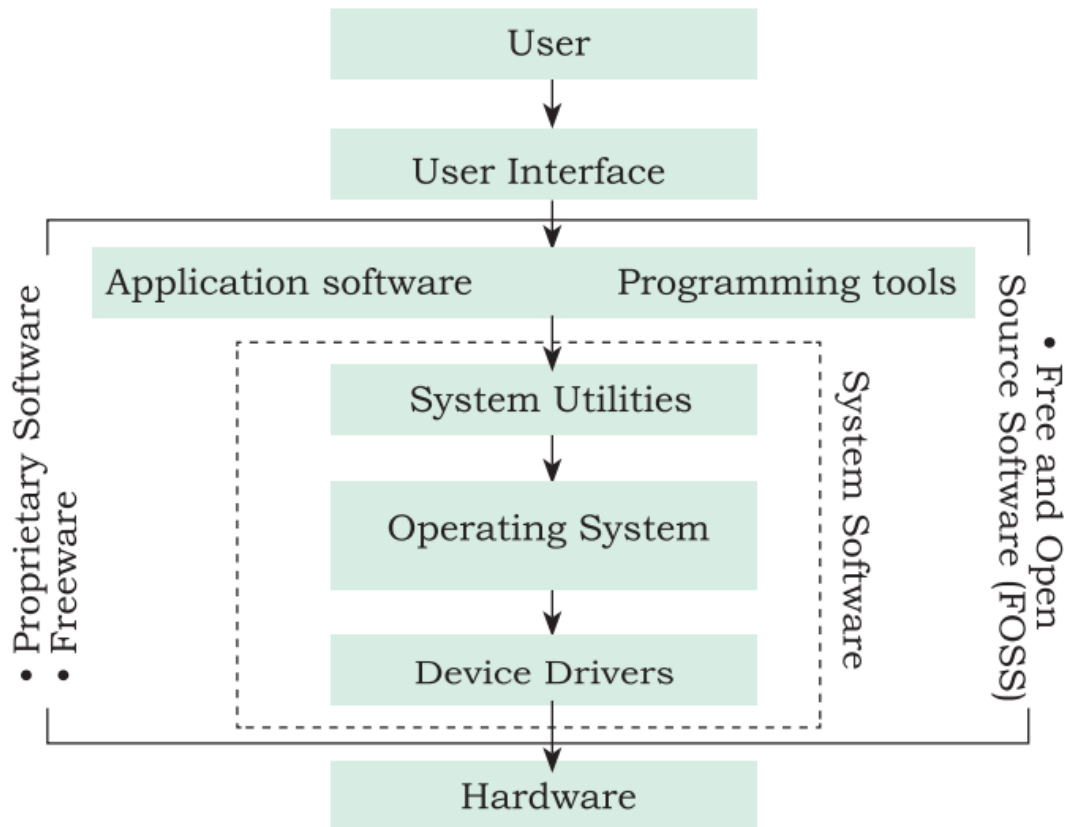


Figure 1.7: Categorisation of software

1.7.3 Programming Tools

- To get work done, we give **instructions** applied on input data to produce output.
- Computer **languages** are developed for writing these instructions.
- Humans write programs in **high-level languages**, while **computers** understand **machine language**.
- Continuous **conversion** from high-level to machine language is required → done by **translators**.
- Code **editors** (e.g., **IDLE in Python**) are used to write instructions.
- covers three aspects:
 - **Programming languages**
 - **Language translators**
 - **Program development tools**

- **Programming Languages**

- Writing instructions in **1s and 0s** (machine language) is very difficult.
- To simplify coding, different **programming languages** were developed.
- Two major categories:
 - **Low-level languages**
 - **High-level languages**

Low-Level Languages

- **Machine Language**
 - Uses 1s and 0s.
 - Directly understood and executed by the computer.
 - Difficult to write (requires remembering operation codes and addresses).
 - Error detection is hard.
- **Assembly Language**
 - Uses English-like words and symbols instead of 1s and 0s.
 - Easier than machine language.
 - Drawback: **machine dependent** (code for one CPU cannot run on another).

High-Level Languages

- **Machine independent** and simpler to write.
- Instructions resemble **English-like sentences**.
- Each language follows a set of rules (syntax).
- Not directly understood by computers → requires **translators**.
- Examples: **C++, Java, Python**.

(B) Language Translators

- Computers understand only **machine language** → need translators to convert assembly/high-level code.
- **Source code** = program written in assembly or high-level language.
- **Object (machine) code** = machine-understandable form after translation.

Types of Translators

1. **Assembler**
 - Converts **assembly language** into machine language.
 - Each assembler works for a specific microprocessor instruction set → machine code is **not portable**.

2. Compiler

- Converts **high-level language source code** into machine code.
- Executes if code follows syntactic rules.
- Once translated, compiler is **not needed again**.

3. Interpreter

- Translates **one line at a time**.
- Checks syntax, converts to executable code, then repeats for all lines.
- Interpreter is **always needed** whenever source code is executed.

Difference between compiler and interpreter

Compiler	Interpreter
It translates source code to object code	It also translates source code to object code
It reads the whole program at once and translates it	It reads the line of the program and interprets
Once compiled the program is saved permanently	The user has to save each time after interpretation
Execution is faster	Execution is slower
Example: C,C++,Java	Example: Python

(C) Program Development Tools

- To write a program, a **text editor** is needed.
- Editor allows creation of a text file where instructions are typed and stored as **source code**.
- A **translator** converts source code into **object code** for execution.
- **Integrated Development Environment (IDE):**
 - Simplifies program development.
 - Includes text editor, building tools, and debugger.
 - Programs can be typed, compiled, and debugged directly.
- Examples of IDEs: **Python IDLE, NetBeans, Eclipse, Atom, and Lazarus**.
- **Debugger:** software used to **detect and correct errors** in source code.

1.7.4 Application Software

- It is a system software which provides the internal functionality of the computer system.
- Two broad categories:
 1. **General Purpose Software**
 2. **Customised Software**

(A) General Purpose Software

- Developed for **generic applications** to serve a wide audience.
- Ready-made software usable by end users as per needs.
- Examples:
 - **Calc (LibreOffice spreadsheet tool)** – for calculations/account sheets
 - **Adobe Photoshop, GIMP** – image editing
 - **Mozilla web browser** – browsing
 - **iTunes** – media management

(B) Customised Software

- **Tailor-made** to meet specific requirements of an organisation or individual.
- Designed for **special needs** → better suited for unique purposes.
- Examples:
 - Websites
 - School management software
 - Accounting software
- Analogy: Like buying cloth and getting a **tailor-made garment** with chosen fitting, colour, and fabric.

1.7.5 Proprietary or Free and Open Source Software

- **Free and open source software (FOSS):**

Some software provide source code as well as the software freely to public with an aim to develop and improve with each other's help. Eg. Ubuntu, Python, Mozilla Firefox

- **Freeware:**

Software freely available for use but source code may not be available. Examples:
Skype, Adobe Reader.

- **Proprietary Software:**

- must be **purchased** from vendor holding copyright.
- Source code not accessible.

Examples: **Microsoft Windows, Tally, Quick heal.**

1.8 Operating System

- Acts as a **resource manager** for all computer resources: CPU, RAM, Disk, Network, and I/O devices.
- Controls application software and device drivers.
- Manages **system security** and user access.
- Most important **system software**.

Examples: **Windows, Linux, Android, Macintosh.**

1.8.1 OS User Interface

We have different types of interfaces of operating system depending on their functionality.

1. Command-based Interface

- User enters commands to perform tasks like creating, opening, editing, deleting.
- User must remember names of all commands/programs → difficult.
- Less interactive.

Eg: MS-DOS, Unix

2. Graphical User Interface

- Users run programs or give instructions in the form of icons, menus, and other visual options.

- Mouse is used to interact with GUI.

Eg: MS Windows, Ubuntu, and Fedora

3. Touch-based Interface

The user interacts with the computer using touchscreen like in smartphones, tablets, and smart watches.

Eg: Android, Ios, Windows 8.1 and Windows 10

4. Voice-based Interface

- Here the user provides input through using his mic and other devices.
- These are useful for users who cannot use keyboard, mouse, or touchscreens.

Eg: Android (Google), iOS (Siri), Microsoft Windows 10 (Cortana)

5. Gesture-based Interface

These devices use gestures like waving, tilting, eye motion, and shaking for inputs. This is a fast-evolving technique nowadays.

Eg: Android, iOS

1.8.2 Functions of Operating System

(A) Process Management

- While a computer is operational, **multiple tasks run simultaneously**.
- A **program** carries out tasks; a task in execution is called a **process**.
- **System monitor programs** can show information about running processes (e.g., activated with **Ctrl+Alt+Delete** in some systems).
- The **operating system manages processes** to complete multiple tasks in minimum time.
- **CPU allocation** among processes is the most important OS service.
- Process management involves:
 - Managing multiple processes.
 - Allocating required resources.
 - Exchanging information among processes.

(B) Memory Management

- **Primary memory is limited** in a computer system.
- OS must **allocate (give)** and **free (take back)** memory for running processes.
- Multiple processes run simultaneously → requires **dynamic (on-the-go) allocation and freeing** of memory.
- Allocation should not affect other processes already in memory.
- Once a process finishes, OS reclaims memory space for **re-utilisation**.
- Concern of memory management:
 - Ensure **maximum utilization** of memory by many processes.
 - Keep track of **every memory location** (free or occupied).

(C) File Management

- **Data and programs** are stored as files in **secondary storage**.
- File management involves:
 - **Creation** of files
 - **Updating** of files
 - **Deletion** of files
 - **Protection** of files
- **Protection** is crucial because:
 - Multiple users can access the system.
 - Mechanism needed to prevent unauthorized access to files belonging to other users.
- **File Management System** → manages **secondary memory**.
- **Memory Management System** → manages **main memory**.

(D) Device Management

- A computer system has many **I/O devices and hardware** connected.
- OS manages these **heterogeneous, interdependent devices**.
- OS interacts with **device drivers** and related software for each device.

- Provides **configuration options** so devices can be used by end users or other devices.
- Devices, like files, also require **security measures**.
- OS restricts access to devices → only **authorized users, software, and hardware** can use them.