BCA SEMESTER 1 - COMPUTER FUNDAMENTALS

Complete Study Material (Topic-Wise)

TABLE OF CONTENTS

UNIT 1: INTRODUCTION TO COMPUTERS

Chapter 1: Introduction & History of Computers

1.1 What is a Computer?

A **computer** is an electronic device that accepts **input** (data), **processes** it according to a set of instructions (program), and produces **output** (information).

Full Form (Informal):

C - Commonly
O - Operated
M - Machine
P - Particularly
U - Used for
T - Technology
E - Education and
R - Research

1.2 Characteristics of Computer

Characteristic	Description
Speed	Performs millions/billions of calculations per second (measured in MIPS, GHz)
Accuracy	Produces error-free results (errors occur due to wrong input - GIGO principle)
Storage	Can store enormous amounts of data (GB, TB, PB)
Diligence	Never gets tired, can work for hours without errors
Versatility	Can perform different types of tasks
Automation	Once programmed, works automatically without human intervention
Reliability	Produces consistent results
No Intelligence	Cannot think on its own; follows instructions
No Feelings	Has no emotions, judgment, or learning ability (without AI)

1.3 GIGO Principle

GIGO = Garbage In, Garbage Out

If incorrect data is given as input, the output will also be incorrect. The computer processes whatever data is given to it — it cannot judge whether the input is correct or wrong.

1.4 Applications of Computer

Applications of Computer
- Education (E-learning, Smart Classrooms)
- Business (Accounting, Inventory, E-commerce)
- Medicine (MRI, CT Scan, Telemedicine)
- Banking (ATM, Online Banking, NEFT)
- Entertainment (Games, Movies, Music)
- Communication (Email, Video Conferencing)
- Science & Research (Simulations, Data Analysis)
- Government (E-governance, Digital India)
- Defense (Missile Systems, Radar)
- Transportation (GPS, Traffic Control)

Weather Forecasting
Publishing & Media (DTP, Digital Media)

1.5 History of Computers

Early Calculating Devices:

Device	Inventor	Year	Description
Abacus	Chinese	~3000 BC	First known calculating device, uses beads on rods
Napier's Bones	John Napier	1617	Multiplication tool using numbered rods
Slide Rule	William Oughtred	1622	Analog calculator for multiplication/division
Pascaline	Blaise Pascal	1642	First mechanical calculator (addition & subtraction)
Stepped Reckoner	Leibniz	1673	Could add, subtract, multiply, divide
Jacquard Loom	Joseph Jacquard	1801	Used punched cards to control weaving patterns
Difference Engine	Charles Babbage	1822	Mechanical calculator for polynomial functions
Analytical Engine	Charles Babbage	1837	First general-purpose computing concept
Tabulating Machine	Herman Hollerith	1890	Used punched cards for US Census

1.6 Father of Computer

Charles Babbage is known as the **"Father of Computer"** because he designed the **Analytical Engine** (1837), which had all the basic components of a modern computer:

- **Mill** (Processing Unit = CPU)
- **Store** (Memory)
- **Input** (Punched Cards)
- **Output** (Printer)

1.7 First Programmer

Augusta Ada Lovelace (Ada Lovelace) is considered the **"First Computer Programmer"** for writing programs for Babbage's Analytical Engine.

1.8 Important Milestones

Year	Event
1937	**ABC (Atanasoff-Berry Computer)** - First electronic digital computer
1943	**Colossus** - Used for code-breaking in WWII
1944	**Mark I (Harvard)** - Electromechanical computer by Howard Aiken
1946	**ENIAC** - First general-purpose electronic computer
1947	Transistor invented at Bell Labs
1949	**EDSAC** - First stored-program computer
1951	**UNIVAC I** - First commercial computer
1958	Integrated Circuit (IC) invented
1971	First microprocessor (Intel 4004)
1975	First personal computer (Altair 8800)
1976	Apple I by Steve Jobs & Steve Wozniak
1981	IBM PC launched
1983	Internet (TCP/IP) established
1991	World Wide Web by Tim Berners-Lee

Chapter 2: Generations of Computers

2.1 Overview

Generation	Period	Technology	Speed	Language	Example
First	1946-1959	Vacuum Tubes	Milliseconds	Machine Language	ENIAC, UNIVAC
Second	1959-1965	Transistors	Microseconds	Assembly Language	IBM 1401, IBM 7094
Third	1965-1971	Integrated Circuits (IC)	Nanoseconds	High-Level Languages	IBM 360, PDP-8
Fourth	1971-1989	Microprocessor (VLSI)	Picoseconds	4GL, GUI	IBM PC, Apple

Fifth	1989-Present	AI, ULSI, Parallel Processing	Femtoseconds	Natural Language	Robotics, AI Systems

2.2 First Generation (1946-1959) - Vacuum Tubes

FIRST GENERATION COMPUTERS

Technology : Vacuum Tubes (Thermionic Valves)
Memory : Magnetic Drums
Input : Punched Cards, Paper Tape
Output : Printouts
Language : Machine Language (0s and 1s)
Size : Very Large (Room-sized)
Heat : Generated enormous heat
Cost : Very Expensive
Reliability : Low (frequent breakdowns)
Speed : Milliseconds (10^{-3} sec)
Examples : ENIAC, UNIVAC, EDVAC, EDSAC Mark I

Key Facts about ENIAC:

- Electronic Numerical Integrator and Computer
- Built by J. Presper Eckert and John Mauchly (1946)
- Weight: 30 tons
- Occupied: 1800 square feet
- Used: 18,000 vacuum tubes
- Power consumption: 150 kilowatts
- Speed: 5,000 additions per second

Advantages:

- First electronic computers
- Used for scientific calculations

Disadvantages:

- Very large size
- Generated too much heat
- Unreliable (vacuum tubes burned out frequently)
- Very expensive
- Consumed huge electricity
- Required air conditioning
- Programming was very difficult (machine language only)
- Limited storage capacity

2.3 Second Generation (1959-1965) - Transistors

SECOND GENERATION COMPUTERS

Technology : Transistors
Memory : Magnetic Core Memory
Input : Punched Cards
Output : Printouts
Language : Assembly Language, FORTRAN, COBOL
Size : Smaller (Cabinet-sized)
Heat : Less than 1st Gen
Cost : Still expensive
Reliability : Better than 1st Gen
Speed : Microseconds (10^{-6} sec)
Examples : IBM 1401, IBM 7094, UNIVAC 1108, CDC 1604, Honeywell 400

Transistor: Invented in 1947 by **William Shockley, John Bardeen, and Walter Brattain** at Bell Labs.

Advantages over 1st Gen:

- Smaller size
- More reliable
- Faster processing
- Less heat generation
- Less power consumption
- Assembly language made programming easier
- Portable (compared to 1st gen)
- Commercial use began

Disadvantages:

- Still generated considerable heat
- Still required air conditioning
- Frequent maintenance needed
- Manufacturing was complex
- Still expensive

2.4 Third Generation (1965-1971) - Integrated Circuits

THIRD GENERATION COMPUTERS

Technology : Integrated Circuits (IC)
SSI & MSI
Memory : Semiconductor Memory
Input : Keyboard, Monitor
Output : Monitor, Printer
Language : High-Level Languages
(BASIC, PASCAL, C)
OS : Time-sharing, Multiprogramming
Size : Mini Computers
Speed : Nanoseconds (10^{9} sec)
Examples : IBM 360, IBM 370, PDP-8,
PDP-11, UNIVAC 1108

Integrated Circuit (IC): Invented by **Jack Kilby** (Texas Instruments) and **Robert Noyce** (Fairchild) in 1958.

An IC is a small chip containing multiple transistors, resistors, and capacitors on a single silicon wafer.

Types of IC:

Type	Full Form	Transistors
SSI	Small Scale Integration	1-100
MSI	Medium Scale Integration	100-1,000
LSI	Large Scale Integration	1,000-10,000
VLSI	Very Large Scale Integration	10,000-1,000,000
ULSI	Ultra Large Scale Integration	>1,000,000

Advantages:

- Much smaller size
- More reliable
- Even faster
- Less power consumption
- Less heat generated
- High-level programming languages
- Better I/O devices (keyboard, monitor)
- Operating systems introduced
- Time-sharing and multiprogramming

Disadvantages:

- IC manufacturing required advanced technology
- Air conditioning still required
- Still somewhat costly

2.5 Fourth Generation (1971-1989) - Microprocessors

FOURTH GENERATION COMPUTERS

```
Technology    : VLSI Microprocessors
Memory        : Semiconductor (RAM, ROM)
Storage       : Hard Disks, Floppy Disks
Input         : Keyboard, Mouse
Output        : Monitor, Printer
Language      : 4GL, C, C++, GUI-based
OS            : MS-DOS, Windows, UNIX
Size          : Desktop, Laptop
Speed         : Picoseconds (10^12 sec)
Network       : LAN, WAN, Internet
Examples      : IBM PC, Apple Macintosh,
                Intel 4004, 8085, 8086
```

Microprocessor: Entire CPU on a single chip.

- **First Microprocessor:** Intel 4004 (1971) by Ted Hoff

Important Microprocessors:

Processor	Year	Bits
Intel 4004	1971	4-bit
Intel 8008	1972	8-bit
Intel 8080	1974	8-bit
Intel 8085	1976	8-bit
Intel 8086	1978	16-bit
Intel 80286	1982	16-bit
Intel 80386	1985	32-bit
Intel 80486	1989	32-bit
Pentium	1993	64-bit

Advantages:

- Very small size (Personal Computers)
- Very reliable
- Affordable for individuals
- No air conditioning needed

- GUI-based (user-friendly)
- Networking capabilities
- Internet and email
- Portable (laptops introduced)
- Mass production possible

2.6 Fifth Generation (1989-Present) - AI & ULSI

```
        FIFTH GENERATION COMPUTERS

Technology    : ULSI, Bio-chips,
                Nanotechnology
Focus         : Artificial Intelligence
Features      : Natural Language Processing,
                Voice Recognition,
                Parallel Processing,
                Machine Learning
Size          : Palmtop, Wearable, Embedded
Speed         : Femtoseconds & beyond
Examples      : Smartphones, Robots,
                AI Systems (Alexa, Siri),
                Quantum Computers,
                Supercomputers
```

Key Features:

- Artificial Intelligence
- Natural Language Processing (NLP)
- Voice Recognition
- Parallel Processing
- Expert Systems
- Robotics
- Machine Learning & Deep Learning

- Quantum Computing (emerging)
- IoT (Internet of Things)

Chapter 3: Classification of Computers

3.1 Based on Size and Processing Power

Classification of Computers (By Size)
- Supercomputers
  - Fastest, largest, most expensive
- Mainframe Computers
  - Large, powerful, multiuser
- Minicomputers (Mid-range)
  - Medium-sized, departmental use
- Microcomputers (Personal Computers)
  - Desktop
  - Laptop / Notebook
  - Tablet
  - Palmtop / PDA
  - Smartphone
- Workstations
  - High-performance PCs for specialized tasks

(A) Supercomputers

Feature	Description
Speed	Fastest computers (Petaflops - 10^{15} FLOPS)
Size	Very large, room-sized
Cost	Most expensive (millions of dollars)
Use	Weather forecasting, nuclear research, space exploration, molecular modeling
Processing	Parallel processing with thousands of processors

Examples of Supercomputers:

Name	Country	Year

PARAM	India	1991
PARAM Siddhi AI	India	2020
Fugaku	Japan	2020
Summit	USA	2018
Tianhe-2	China	2013
Frontier	USA	2022

India's Supercomputer Journey:

- **PARAM 8000** (1991) - First Indian supercomputer by C-DAC
- **PARAM Siddhi AI** - Ranked in Top 500 globally (2020)

(B) Mainframe Computers

Feature	Description
Size	Large (room or cabinet-sized)
Users	Supports hundreds/thousands of users simultaneously
Speed	Very high processing speed
Storage	Massive storage capacity
Cost	Very expensive
Use	Banking, insurance, government, airlines

Examples: IBM zSeries, IBM S/390, System z

(C) Minicomputers (Mid-range Computers)

Feature	Description
Size	Smaller than mainframe, larger than micro
Users	Supports 10-100 users
Cost	Moderate
Use	Small businesses, departments

Examples: PDP-11, VAX, IBM AS/400

(D) Microcomputers (Personal Computers)

Feature	Description

Size	Desktop to pocket-sized
Users	Single user (typically)
Cost	Affordable
Use	Personal, education, office

Types of Microcomputers:

Type	Description
Desktop	Fixed setup on desk; monitor, keyboard, CPU separate
Laptop/Notebook	Portable, battery-powered, integrated screen & keyboard
Tablet	Touch screen, no physical keyboard
Palmtop/PDA	Handheld, pocket-sized
Smartphone	Phone with computing capabilities

(E) Workstations

Feature	Description
Performance	Higher than PC, lower than minicomputer
Use	CAD/CAM, Animation, Scientific computing, Video editing
Examples	Sun SPARC, HP Workstations

3.2 Based on Purpose

Type	Description	Examples
General Purpose	Designed for variety of tasks	PCs, Laptops
Special Purpose	Designed for specific tasks	ATM, Traffic Control, Weather Computer

3.3 Based on Data Handling

Type	Input	Processing	Examples
Analog	Continuous data (voltage, temperature)	Measures physical quantities	Speedometer, Thermometer
Digital	Discrete data (0s and 1s)	Counts and processes digits	PCs, Laptops, Calculators

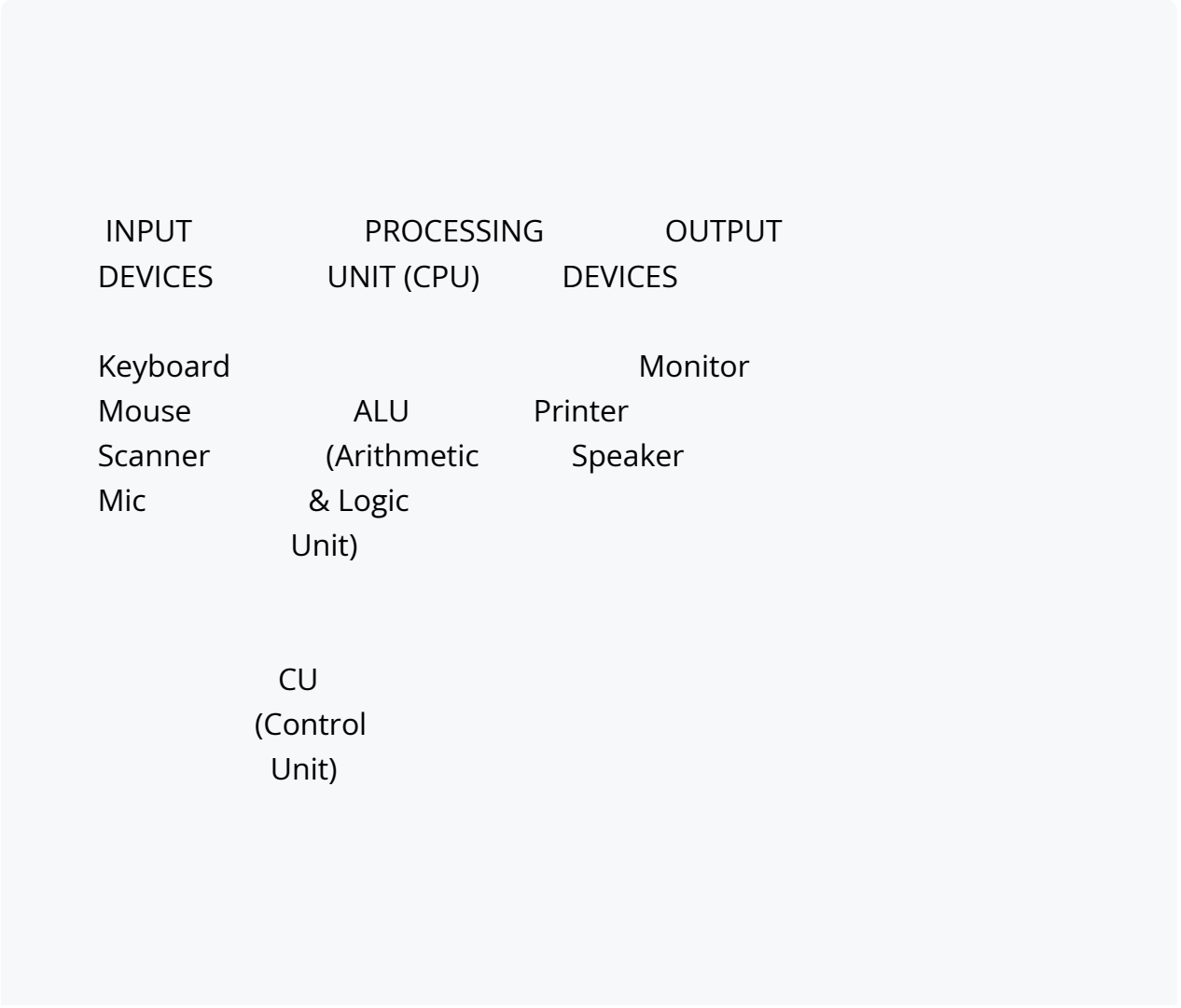
Hybrid	Both continuous and discrete	Combines analog and digital	Hospital ICU monitors, Petrol pump

Comparison:

Feature	Analog	Digital	Hybrid
Data Type	Continuous	Discrete	Both
Accuracy	Low	High	High
Speed	Very Fast	Fast	Fast
Memory	No storage	Has storage	Has storage
Examples	Thermometer	Computer	ECG Monitor

Chapter 4: Basic Computer Organization

4.1 Block Diagram of Computer



MEMORY

Primary
(RAM, ROM)

Secondary
(HDD, SSD)

4.2 Functional Units of Computer

A computer system has **5 basic functional units:**

1. Input Unit

- Accepts data and instructions from the user
- Converts human-readable data into machine-readable form
- Examples: Keyboard, Mouse, Scanner, Microphone

2. Central Processing Unit (CPU)

Also called the **"Brain of Computer"**

It has three sub-units:

(a) Arithmetic Logic Unit (ALU):

- Performs arithmetic operations (+, -, ×, ÷)
- Performs logical operations (AND, OR, NOT, comparisons)
- Contains **Accumulator** for temporary storage of results

(b) Control Unit (CU):

- Controls and coordinates all computer operations
- Directs flow of data between CPU, memory, and I/O devices
- Fetches instructions from memory

- Decodes and executes instructions
- Does NOT process data itself

(c) Registers:

- Small, high-speed storage locations within CPU
- Hold data, instructions, and addresses temporarily
- Types: Accumulator, Program Counter, Instruction Register, Memory Address Register

3. Memory Unit

- Stores data, instructions, and results
- **Primary Memory:** RAM, ROM (fast, limited)
- **Secondary Memory:** Hard Disk, SSD, CD, DVD (large, permanent)

4. Output Unit

- Presents processed data (information) to the user
- Converts machine-readable data to human-readable form
- Examples: Monitor, Printer, Speaker, Projector

5. Storage Unit

- Stores data permanently for future use
- Hard Disk, SSD, USB Drive, CD/DVD

4.3 IPO Cycle (Input-Process-Output)

```
INPUT              PROCESS              OUTPUT
(Data)      (CPU)       (Information)

Example:
2 + 3              Addition             5
(Input)     (Process)    (Output)
```

4.4 Data vs Information

Data	Information
Raw facts and figures	Processed, organized data
Unorganized	Organized and meaningful
Input to computer	Output of computer
Example: 75, 80, 90	Example: Average marks = 81.67

UNIT 2: NUMBER SYSTEMS & BOOLEAN ALGEBRA

Chapter 5: Number Systems

5.1 Introduction

A **number system** is a system of writing numbers using a set of symbols (digits) with specific rules.

5.2 Types of Number Systems

Number System	Base/Radix	Digits Used	Example
Binary	2	0, 1	1010_2
Octal	8	0, 1, 2, 3, 4, 5, 6, 7	57_8
Decimal	10	0, 1, 2, 3, 4, 5, 6, 7, 8, 9	255_{10}
Hexadecimal	16	0-9, A(10), B(11), C(12), D(13), E(14), F(15)	$1A3_{16}$

5.3 Why Binary System in Computers?

Computers use the **binary system** because:

1. Electronic circuits have two states: **ON (1)** and **OFF (0)**
2. Easy to implement using electronic switches
3. Simple arithmetic operations
4. Reliable (only two states reduce errors)

5.4 Important Terms

Term	Definition
Bit	Binary Digit (0 or 1) — smallest unit of data
Nibble	4 bits
Byte	8 bits
Word	Fixed number of bits processed at once (16, 32, or 64 bits)
MSB	Most Significant Bit (leftmost bit)
LSB	Least Significant Bit (rightmost bit)

5.5 Data Storage Units

Unit	Equivalent
1 Bit	0 or 1
1 Nibble	4 Bits
1 Byte	8 Bits
1 KB (Kilobyte)	1024 Bytes
1 MB (Megabyte)	1024 KB
1 GB (Gigabyte)	1024 MB
1 TB (Terabyte)	1024 GB
1 PB (Petabyte)	1024 TB
1 EB (Exabyte)	1024 PB
1 ZB (Zettabyte)	1024 EB
1 YB (Yottabyte)	1024 ZB

5.6 Place Value in Number Systems

Decimal (Base 10): $$5274_{10} = 5 \times 10^3 + 2 \times 10^2 + 7 \times 10^1 + 4 \times 10^0$$ $$= 5000 + 200 + 70 + 4 = 5274$$

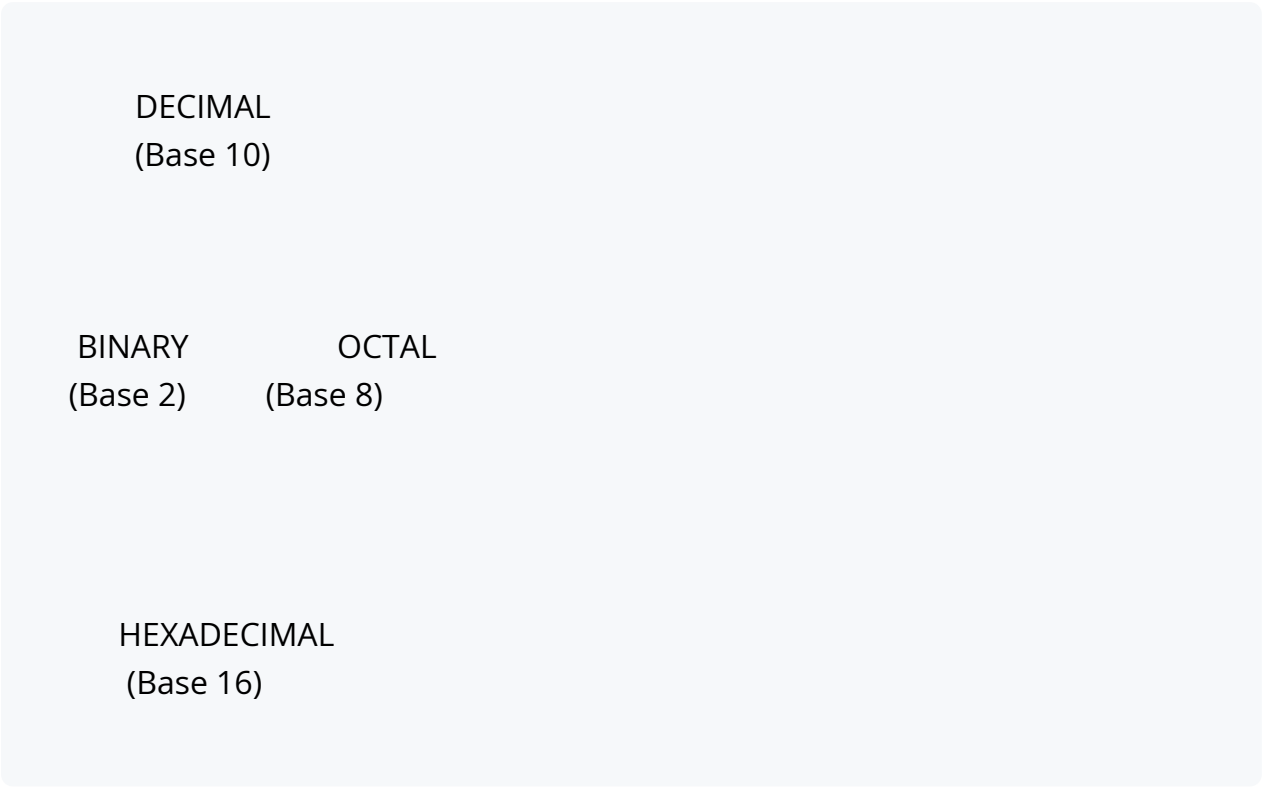
Binary (Base 2): $$1101_2 = 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$ $$= 8 + 4 + 0 + 1 = 13_{10}$$

Octal (Base 8): $$57_8 = 5 \times 8^1 + 7 \times 8^0$$ $$= 40 + 7 = 47_{10}$$

Hexadecimal (Base 16): $$2AF_{16} = 2 \times 16^2 + 10 \times 16^1 + 15 \times 16^0$$ $$= 512 + 160 + 15 = 687_{10}$$

Chapter 6: Number System Conversions

6.1 Conversion Chart



6.2 Decimal to Binary Conversion

Method: Repeated Division by 2

Example: Convert 25_{10} to Binary

```
25 ÷ 2 = 12  remainder 1
12 ÷ 2 = 6   remainder 0
6  ÷ 2 = 3   remainder 0      Read
3  ÷ 2 = 1   remainder 1      Upward
1  ÷ 2 = 0   remainder 1
```

Answer: $25_{10} = 11001_2$

Verification: $1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 16 + 8 + 0 + 0 + 1 = 25$

6.3 Decimal to Octal Conversion

Method: Repeated Division by 8

Example: Convert 156_{10} to Octal

```
156 ÷ 8 = 19  remainder 4
19  ÷ 8 = 2   remainder 3      Read
2   ÷ 8 = 0   remainder 2      Upward
```

Answer: $156_{10} = 234_{8}$

Verification: $2 \times 64 + 3 \times 8 + 4 \times 1 = 128 + 24 + 4 = 156$

6.4 Decimal to Hexadecimal Conversion

Method: Repeated Division by 16

Example: Convert 500_{10} to Hexadecimal

```
500 ÷ 16 = 31  remainder 4
31  ÷ 16 = 1   remainder 15(F)    Read
1   ÷ 16 = 0   remainder 1        Upward
```

Answer: $500_{10} = 1F4_{16}$

Verification: $1 \times 256 + 15 \times 16 + 4 \times 1 = 256 + 240 + 4 = 500$

6.5 Binary to Decimal Conversion

Method: Multiply each bit by its place value and add

Example: Convert 110101_{2} to Decimal

$$= 1 \times 2^5 + 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$ $$= 32 + 16 + 0 + 4 + 0 + 1$$ $$= 53_{10}$$

6.6 Binary to Octal Conversion

Method: Group binary digits in sets of 3 (from right) and convert each group

Example: Convert 110101_{2} to Octal

```
110  101

 6   5
```

Answer: $110101_2 = 65_8$

6.7 Binary to Hexadecimal Conversion

Method: Group binary digits in sets of 4 (from right) and convert each group

Example: Convert 10110101_2 to Hexadecimal

```
1011  0101

 B    5
```

Answer: $10110101_2 = B5_{16}$

6.8 Octal to Binary Conversion

Method: Convert each octal digit to 3-bit binary

Example: Convert 374_8 to Binary

```
3   7   4

011  111  100
```

Answer: $374_8 = 011111100_2 = 11111100_2$

6.9 Octal to Decimal Conversion

Example: Convert 347_8 to Decimal

$$= 3 \times 8^2 + 4 \times 8^1 + 7 \times 8^0$$ $$= 192 + 32 + 7 = 231_{10}$$

6.10 Hexadecimal to Binary Conversion

Method: Convert each hex digit to 4-bit binary

Hex	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

Example: Convert $2AF_{16}$ to Binary

```
2   A   F

0010 1010 1111
```

Answer: $2AF_{16} = 001010101111_2$

6.11 Hexadecimal to Decimal Conversion

Example: Convert $1F4_{16}$ to Decimal

$$= 1 \times 16^2 + 15 \times 16^1 + 4 \times 16^0$$ $$= 256 + 240 + 4 = 500_{10}$$

6.12 Decimal Fraction to Binary Conversion

Method: Repeated multiplication by 2

Example: Convert 0.625_{10} to Binary

```
0.625 × 2 = 1.250    1
0.250 × 2 = 0.500    0     Read
0.500 × 2 = 1.000    1     Downward
```

Answer: $0.625_{10} = 0.101_2$

Verification: $1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3} = 0.5 + 0 + 0.125 = 0.625$

6.13 Complete Conversion Example

Convert 45.6875_{10} to Binary:

Integer part (45): Divide by 2 repeatedly

```
45 ÷ 2 = 22 R 1
22 ÷ 2 = 11 R 0
11 ÷ 2 = 5  R 1
5  ÷ 2 = 2  R 1
2  ÷ 2 = 1  R 0
1  ÷ 2 = 0  R 1
```

Integer part = **101101**

Fractional part (0.6875): Multiply by 2 repeatedly

```
0.6875 × 2 = 1.375    1
0.375  × 2 = 0.75     0
0.75   × 2 = 1.5      1
0.5    × 2 = 1.0      1
```

Fractional part = **.1011**

Answer: $45.6875_{10} = 101101.1011_2$

6.14 Quick Conversion Summary Table

From	To	Method
Decimal	Binary	Divide by 2, read remainders bottom-up
Decimal	Octal	Divide by 8, read remainders bottom-up
Decimal	Hex	Divide by 16, read remainders bottom-up
Binary	Decimal	Multiply each bit by 2^n, sum up
Binary	Octal	Group 3 bits from right, convert
Binary	Hex	Group 4 bits from right, convert
Octal	Binary	Replace each digit with 3-bit binary
Octal	Decimal	Multiply each digit by 8^n, sum up
Hex	Binary	Replace each digit with 4-bit binary
Hex	Decimal	Multiply each digit by 16^n, sum up
Octal	Hex	Octal → Binary → Hex
Hex	Octal	Hex → Binary → Octal

Chapter 7: Binary Arithmetic

7.1 Binary Addition

Rules:

```
0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 10 (0, carry 1)
1 + 1 + 1 = 11 (1, carry 1)
```

Example: Add $1011_2 + 1101_2$

```
 Carry:  1 1 1
          1 0 1 1
        + 1 1 0 1

        1 1 0 0 0
```

Answer: $1011_2 + 1101_2 = 11000_2$

Verification: 11 + 13 = 24 $11000_2 = 24_{10}$

7.2 Binary Subtraction

Rules:

```
0 - 0 = 0
1 - 0 = 1
1 - 1 = 0
0 - 1 = 1 (with borrow 1 from next position)
```

Example: Subtract $1101_2 - 1010_2$

```
  1 1 0 1
- 1 0 1 0

  0 0 1 1
```

Answer: $1101_2 - 1010_2 = 0011_2 = 11_2$

Verification: 13 - 10 = 3 $11_2 = 3_{10}$

7.3 Binary Multiplication

Rules:

```
0 × 0 = 0
0 × 1 = 0
1 × 0 = 0
1 × 1 = 1
```

Example: Multiply $1101_2 \times 101_2$

```
  1 1 0 1
×   1 0 1

  1 1 0 1    (1101 × 1)
0 0 0 0 0    (1101 × 0, shifted)
```

```
    1 1 0 1 0 0   (1101 × 1, shifted)

    1 0 0 0 0 0 1
```

Answer: $1101_2 \times 101_2 = 1000001_2$

Verification: $13 \times 5 = 65$ $1000001_2 = 64 + 1 = 65_{10}$

7.4 Binary Division

Example: Divide $1100_2 \div 10_2$

```
        1 1 0

  10   1 1 0 0
      1 0
      -----
       1 0
       1 0
       ---
       0 0 0
         0 0
         ---
           0
```

Answer: $1100_2 \div 10_2 = 110_2$

Verification: $12 \div 2 = 6$ $110_2 = 6_{10}$

7.5 Complements

Used for subtraction in computers.

1's Complement:

Replace every 0 with 1 and every 1 with 0.

Example:

```
Number:       1 0 1 1 0 1
1's Complement: 0 1 0 0 1 0
```

2's Complement:

2's Complement = 1's Complement + 1

Example:

```
Number:         1 0 1 1 0 1
1's Complement:  0 1 0 0 1 0
                      + 1
2's Complement:  0 1 0 0 1 1
```

7.6 Subtraction Using 2's Complement

Steps:

1. Find 2's complement of the subtrahend (number being subtracted)
2. Add it to the minuend
3. If there's a carry, discard it result is positive
4. If there's no carry take 2's complement of result result is negative

Example: 1101_2 - 1010_2 using 2's complement

```
Step 1: 2's complement of 1010
  1's complement: 0101
  2's complement: 0101 + 1 = 0110

Step 2: Add to 1101
    1 1 0 1
  + 0 1 1 0

  1 0 0 1 1

  Carry (discard)
```

Result = $0011_2 = 3_{10}$

Verification: 13 - 10 = 3

7.7 Representation of Negative Numbers

Sign-Magnitude:

- MSB = 0 Positive
- MSB = 1 Negative
- Example: +5 = 0101, -5 = 1101

1's Complement:

- Positive: Same as sign-magnitude
- Negative: Invert all bits
- Example: +5 = 0101, -5 = 1010

2's Complement (Most commonly used):

- Positive: Same as binary
- Negative: Take 2's complement
- Example: +5 = 0101, -5 = 1011

Chapter 8: Boolean Algebra & Logic Gates

8.1 Boolean Algebra

George Boole (1815-1864) developed Boolean Algebra. It deals with **binary variables** (TRUE/FALSE or 1/0) and **logical operations**.

8.2 Boolean Operations

Operation	Symbol	Notation
AND	· (dot)	A · B or AB
OR	+ (plus)	A + B
NOT	¯ (bar) or '	Ā or A'

8.3 Truth Tables for Basic Operations

AND Operation (A · B):

A	B	A · B
0	0	0
0	1	0
1	0	0
1	1	1

"Output is 1 only when ALL inputs are 1"

OR Operation (A + B):

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

"Output is 1 when ANY input is 1"

NOT Operation (Ā):

A	Ā
0	1
1	0

"Output is opposite of input"

8.4 Laws of Boolean Algebra

Law	AND Form	OR Form
Identity	A · 1 = A	A + 0 = A
Null/Domination	A · 0 = 0	A + 1 = 1
Idempotent	A · A = A	A + A = A
Complement	A · Ā = 0	A + Ā = 1
Involution	(Ā)' = A	(Ā)' = A
Commutative	A · B = B · A	A + B = B + A

Associative	(A·B)·C = A·(B·C)	(A+B)+C = A+(B+C)
Distributive	A·(B+C) = AB+AC	A+(B·C) = (A+B)·(A+C)
Absorption	A·(A+B) = A	A+(A·B) = A

8.5 De Morgan's Theorems

Theorem 1: $$\overline{A \cdot B} = \bar{A} + \bar{B}$$ *"NOT of AND = OR of NOTs"*

Verification (Truth Table):

A	B	A·B	$\overline{A·B}$	Ā	B̄	Ā+B̄
0	0	0	**1**	1	1	**1**
0	1	0	**1**	1	0	**1**
1	0	0	**1**	0	1	**1**
1	1	1	**0**	0	0	**0**

Both columns are identical

Theorem 2: $$\overline{A + B} = \bar{A} \cdot \bar{B}$$ *"NOT of OR = AND of NOTs"*

8.6 Logic Gates

Logic Gates are electronic circuits that perform Boolean operations.

(A) Basic Gates

AND Gate:

```
A
    AND      Y = A · B
B
```

A	B	Y = A·B
0	0	0
0	1	0
1	0	0
1	1	1

OR Gate:

```
A
    OR      Y = A + B
B
```

A B Y = A+B

0 0 0

0 1 1

1 0 1

1 1 1

NOT Gate (Inverter):

```
A       o       Y = Ā
```

A Y = Ā

0 1

1 0

(B) Universal Gates

NAND Gate (NOT + AND):

```
A
    AND  o    Y = (A·B)' = Ā + B̄
B
```

A B Y = (A·B)'

0 0 1

0 1 1

1 0 1

1 1 0

NOR Gate (NOT + OR):

```
A
    OR   o     Y = (A+B)' = Ā · B̄
B
```

A B Y = (A+B)'

0 0 1

0 1 0

1 0 0

1 1 0

Why "Universal"? NAND and NOR gates are called universal because ANY logic circuit can be built using only NAND gates or only NOR gates.

(C) Special Gates

XOR Gate (Exclusive OR):

```
A
    XOR       Y = A  B = ĀB + AB̄
B
```

A B Y = A B

0 0 0

0 1 1

1 0 1

1 1 0

"Output is 1 when inputs are DIFFERENT"

XNOR Gate (Exclusive NOR):

```
A
    XNOR      Y = (A  B)' = AB + ĀB̄
B
```

A B Y = (A B)'

0 0 1

0 1 0

1 0 0

1 1 1

"Output is 1 when inputs are SAME"

8.7 Summary of All Gates

Gate	Expression	Output 1 when...
AND	A · B	Both inputs are 1
OR	A + B	Any input is 1
NOT	Ā	Input is 0
NAND	(A·B)'	NOT all inputs are 1
NOR	(A+B)'	All inputs are 0
XOR	A B	Inputs are different
XNOR	(A B)'	Inputs are same

8.8 Half Adder and Full Adder

Half Adder: Adds two single bits

A	B	Sum (S)	Carry (C)
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

$$S = A \oplus B$$ $$C = A \cdot B$$

Full Adder: Adds three bits (A, B, and Carry-in)

A	B	C_{in}	Sum	C_{out}
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0

1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

$$S = A \oplus B \oplus C_{in}$$ $$C_{out} = AB + BC_{in} + AC_{in}$$

UNIT 3: COMPUTER HARDWARE

Chapter 9: Input Devices

9.1 Definition

Input devices are hardware components that allow users to enter data and instructions into the computer.

9.2 Classification of Input Devices

- Input Devices
  - Keyboard
  - Pointing Devices
    - Mouse
    - Trackball
    - Joystick
    - Light Pen
    - Touch Screen
  - Scanning Devices
    - Scanner
    - OMR (Optical Mark Reader)
    - OCR (Optical Character Reader)
    - BCR (Bar Code Reader)
    - MICR (Magnetic Ink Character Recognition)
    - QR Code Reader
  - Audio Input
    - Microphone
  - Visual Input
    - Digital Camera

```
    Webcam
  Other
    Biometric Devices (Fingerprint, Retina Scanner)
    Digitizer / Graphics Tablet
```

9.3 Detailed Description of Input Devices

(A) Keyboard

Most commonly used input device

Types of Keys:

Key Type	Examples	Count
Alphanumeric	A-Z, 0-9, symbols	~48
Function Keys	F1-F12	12
Navigation Keys	Arrow keys, Home, End, PgUp, PgDn	~6
Modifier Keys	Shift, Ctrl, Alt	6
Numeric Keypad	0-9, +, -, *, /	17
Special Keys	Enter, Space, Tab, Backspace, Delete, Esc	~6
Total		**~104 keys**

Types of Keyboards:

- QWERTY (Standard)
- DVORAK
- Ergonomic
- Wireless
- Virtual/On-screen

(B) Mouse

Pointing device that controls cursor movement on screen.

Parts: Left button, Right button, Scroll wheel

Operations:

Action	Description
Click	Press and release left button once
Double-click	Press left button twice quickly
Right-click	Press right button (context menu)
Drag	Press and hold left button while moving
Scroll	Rotate scroll wheel

Types:

- Mechanical Mouse (ball-based)
- Optical Mouse (LED/laser-based)
- Wireless Mouse
- Trackpad (on laptops)

(C) Scanner

Converts **physical documents/images** into digital format.

Types:

Type	Description
Flatbed Scanner	Document placed on glass plate
Handheld Scanner	Moved over document manually
Sheet-fed Scanner	Document fed through scanner
Drum Scanner	High-quality, used in publishing

(D) OMR (Optical Mark Reader/Recognition)

- Detects **pencil/pen marks** on paper
- Used in: **MCQ answer sheets, surveys, elections**
- Reads marks based on light reflection

(E) OCR (Optical Character Recognition)

- Reads **printed or handwritten text** from paper
- Converts to **machine-readable** text
- Used in: Digitizing books, reading addresses on mail

(F) BCR (Bar Code Reader)

- Reads **bar codes** (series of parallel lines)
- Used in: **Supermarkets, libraries, inventory management**
- Uses laser beam to read

(G) MICR (Magnetic Ink Character Recognition)

- Reads characters printed with **magnetic ink**
- Used in: **Banks for processing cheques**
- Reads cheque number, bank code, account number
- Highly accurate and fast

(H) Light Pen

- Pen-shaped device that detects light from screen
- Used for **drawing and selection** on screen
- Works with CRT monitors

(I) Joystick

- Stick-based pointing device
- Used mainly for **games and simulators**
- Can move in all directions

(J) Touch Screen

- Screen that detects **finger touch** or stylus
- Used in: ATMs, smartphones, tablets, kiosks
- Technologies: Resistive, Capacitive, Infrared

(K) Microphone

- Converts **sound** into electrical signals
- Used for: Voice recording, voice commands, VoIP

(L) Webcam

- Captures **video** input
- Used for: Video conferencing, surveillance, streaming

(M) Biometric Devices

- **Fingerprint Scanner:** Reads fingerprint patterns
- **Retina/Iris Scanner:** Scans eye patterns
- **Face Recognition:** Identifies faces
- Used for: Security, attendance systems, phone unlock

Chapter 10: Output Devices

10.1 Definition

Output devices present processed data (information) to the user in human-readable form.

10.2 Classification

```
Output Devices
    Soft Copy (Temporary, non-physical)
        Monitor / Display
        Speakers / Headphones
        Projector
    Hard Copy (Permanent, physical)
       Printer
           Impact Printers
               Dot Matrix Printer
               Daisy Wheel Printer
               Line Printer
           Non-Impact Printers
              Inkjet Printer
              Laser Printer
              Thermal Printer
              3D Printer
       Plotter
```

10.3 Monitor / Display

Most common output device.

Types of Monitors:

Type	Full Form	Description
CRT	Cathode Ray Tube	Old, bulky monitors using electron beam
LCD	Liquid Crystal Display	Thin, flat panel using liquid crystals
LED	Light Emitting Diode	LCD backlit by LEDs (energy efficient)
OLED	Organic LED	Each pixel produces own light, best contrast
Plasma	Plasma Display Panel	Uses ionized gas, good for large screens
TFT	Thin Film Transistor	Active matrix LCD, better quality

Important Monitor Terms:

Term	Description
Resolution	Number of pixels (e.g., 1920 × 1080 = Full HD)
Pixel	Smallest unit of display (Picture Element)
Dot Pitch	Distance between two pixels (smaller = sharper)
Refresh Rate	How many times screen redraws per second (Hz)
Aspect Ratio	Width:Height ratio (e.g., 16:9, 4:3)
Contrast Ratio	Ratio of brightest white to darkest black

Common Resolutions:

Name	Resolution
HD	1280 × 720
Full HD (FHD)	1920 × 1080
2K / QHD	2560 × 1440
4K / UHD	3840 × 2160
8K	7680 × 4320

10.4 Printers

(A) Impact Printers

Use **physical contact** with paper (like typewriter).

Dot Matrix Printer:

- Uses print head with pins (9 or 24 pins)
- Strikes ribbon to form dots on paper
- Can print on multi-part forms (carbon copies)
- Noisy operation
- Low quality but inexpensive
- Speed: 200-600 characters per second

Daisy Wheel Printer:

- Uses wheel with characters on petals
- Produces letter-quality output
- Cannot print graphics
- Very slow, noisy

Line Printer:

- Prints one entire line at a time
- Very fast (300-3000 lines per minute)
- Used in mainframe/minicomputer environments
- Types: Drum Printer, Chain Printer, Band Printer

(B) Non-Impact Printers

Use **chemical, thermal, or laser** technology (no physical contact).

Inkjet Printer:

- Sprays tiny droplets of ink onto paper
- Good quality color printing
- Relatively inexpensive
- Ink cartridges can be costly
- Speed: 1-20 pages per minute
- Resolution: 300-4800 DPI

Laser Printer:

- Uses laser beam to create image on drum
- Toner (powder) transferred to paper and fused by heat
- High quality, high speed
- Ideal for office/business use
- Speed: 10-200 pages per minute
- Resolution: 600-2400 DPI

Thermal Printer:

- Uses heat on special thermal paper
- Used in: ATM receipts, billing machines, fax
- Fade over time
- Low cost per print

3D Printer:

- Creates three-dimensional objects from digital models
- Uses materials like plastic, metal, resin
- Layer by layer construction
- Used in: Manufacturing, medicine, architecture

Comparison: Inkjet vs Laser

Feature	Inkjet	Laser
Technology	Ink spray	Laser + toner
Cost (Printer)	Low	High
Cost (Per page)	High	Low
Speed	Slow	Fast
Quality	Good (photos)	Excellent (text)
Color Printing	Excellent	Good
Noise	Low	Low
Best For	Home use, photos	Office, bulk printing

10.5 Plotter

- Produces **large-sized drawings** (maps, blueprints, architectural designs)

- Uses pen or inkjet technology
- Types: **Flat-bed plotter, Drum plotter**
- Used by: Engineers, architects, designers

10.6 Speaker

- Produces **audio output**
- Converts electrical signals to sound
- Types: Desktop speakers, Headphones, Earphones

10.7 Projector

- Projects computer output onto **large screen/wall**
- Used in: Presentations, classrooms, theaters
- Types: LCD, DLP, LED projectors

Chapter 11: Memory (Primary & Secondary)

11.1 What is Memory?

Memory is the component that stores data, instructions, and information in a computer.

11.2 Memory Hierarchy

```
Registers       Fastest, Smallest, Most Expensive
Cache
RAM          Primary Memory
ROM
SSD
```

HDD Secondary Memory

Optical

Mag. Tape Slowest, Largest, Least Expensive

Speed Capacity
Cost Access Time

11.3 Primary Memory (Main Memory)

Directly accessible by CPU. Temporary (volatile) or permanent (non-volatile).

(A) RAM (Random Access Memory)

Feature	Description
Full Form	Random Access Memory
Nature	**Volatile** (data lost when power is OFF)
Purpose	Stores currently running programs and data
Access	Read and Write
Speed	Fast
Also Called	Main memory, Primary memory, Working memory

Types of RAM:

Type	Full Form	Description
SRAM	Static RAM	Uses flip-flops, faster, expensive, used as Cache
DRAM	Dynamic RAM	Uses capacitors, slower, cheaper, used as main memory

SRAM vs DRAM:

Feature	SRAM	DRAM
Speed	Faster	Slower
Cost	Expensive	Cheaper
Size	Larger per bit	Smaller per bit
Refresh	Not needed	Needs periodic refresh
Power	Less	More

Use	Cache Memory	Main Memory
Capacity	Small (KB-MB)	Large (GB)

Modern RAM Types:

Type	Description
DDR	Double Data Rate
DDR2	2× speed of DDR
DDR3	2× speed of DDR2
DDR4	2× speed of DDR3
DDR5	Latest, fastest

(B) ROM (Read Only Memory)

Feature	Description
Full Form	Read Only Memory
Nature	**Non-volatile** (data retained without power)
Purpose	Stores permanent instructions (BIOS, firmware)
Access	Read only (generally)
Speed	Slower than RAM
Contains	Boot instructions, BIOS, firmware

Types of ROM:

Type	Full Form	Description
ROM	Read Only Memory	Written during manufacturing, cannot be modified
PROM	Programmable ROM	Can be programmed once by user
EPROM	Erasable PROM	Can be erased using UV light and reprogrammed
EEPROM	Electrically Erasable PROM	Can be erased electrically and reprogrammed
Flash Memory	Flash EEPROM	Modern EEPROM, used in USB drives, SSD

(C) Cache Memory

Feature	Description
Purpose	Bridge between CPU and RAM
Speed	Faster than RAM, slower than registers
Size	Very small (KB to few MB)
Type	SRAM
Location	Between CPU and Main Memory
Function	Stores frequently used data for quick access

Levels of Cache:

Level	Location	Size	Speed
L1	Inside CPU	16-128 KB	Fastest
L2	Near CPU	256 KB - 2 MB	Fast
L3	Shared among cores	4-64 MB	Moderate

RAM vs ROM Comparison

Feature	RAM	ROM
Full Form	Random Access Memory	Read Only Memory
Volatility	Volatile	Non-Volatile
Operation	Read & Write	Read Only
Speed	Faster	Slower
Cost	Expensive	Cheaper
Use	Running programs	Boot instructions, BIOS
Size	4 GB - 64 GB typical	Few MB
Data	Temporary	Permanent

11.4 Secondary Memory (Auxiliary/External Memory)

Non-volatile, large capacity, permanent storage.

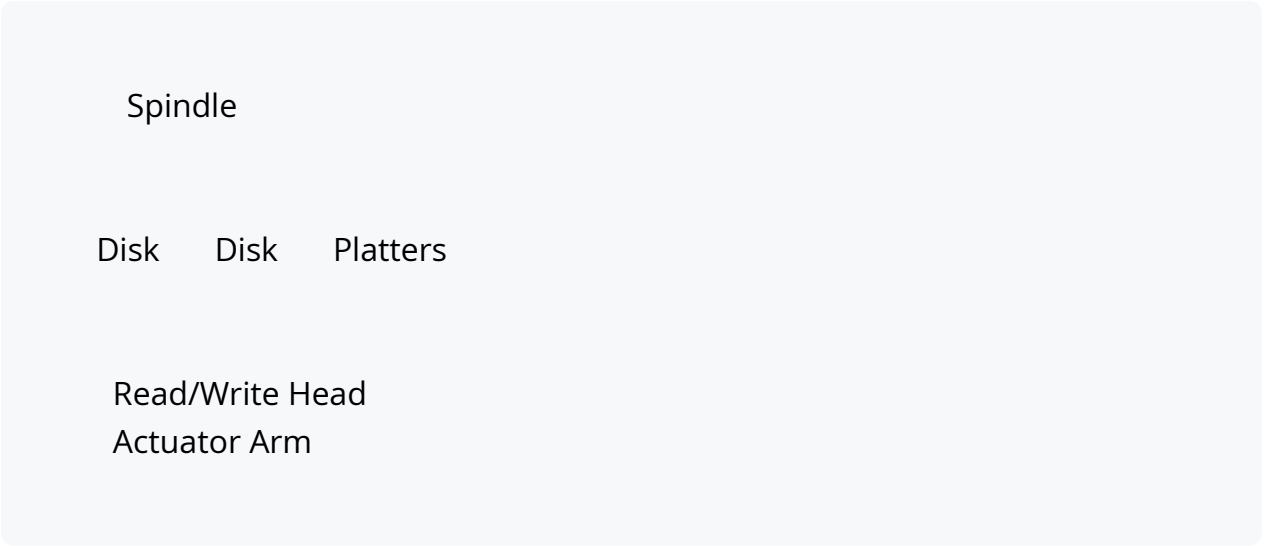
(A) Magnetic Storage

Hard Disk Drive (HDD):

Feature	Description
Technology	Magnetic platters rotating at high speed

Capacity	250 GB - 20 TB
Speed	5400-7200 RPM
Access Time	~10 ms
Volatile	No
Interface	SATA, IDE, SCSI
Use	Primary storage in computers

Components of Hard Disk:



Terms:

- **Track:** Concentric circles on disk surface
- **Sector:** Division of a track (smallest addressable unit)
- **Cylinder:** Same track on all platters
- **Cluster:** Group of sectors

Floppy Disk (Obsolete):

- 3.5-inch floppy: 1.44 MB capacity
- Magnetic storage on flexible disk
- Portable but low capacity

Magnetic Tape:

- Sequential access
- Very high capacity

- Used for backup and archival
- Slow access time

(B) Optical Storage

Device	Full Form	Capacity	Type
CD	Compact Disc	700 MB	Read (CD-ROM), Write once (CD-R), Rewritable (CD-RW)
DVD	Digital Versatile Disc	4.7-17 GB	DVD-ROM, DVD-R, DVD-RW
Blu-ray	Blu-ray Disc	25-100 GB	BD-ROM, BD-R, BD-RE

How Optical Discs Work:

- Data stored as **pits (grooves)** and **lands (flat areas)**
- **Laser beam** reads the reflections
- CD uses **infrared laser** (780 nm)
- DVD uses **red laser** (650 nm)
- Blu-ray uses **blue laser** (405 nm) more data per disc

(C) Solid State Storage

SSD (Solid State Drive):

Feature	Description
Technology	Flash memory (NAND) chips
Moving Parts	None
Speed	5-10× faster than HDD
Capacity	128 GB - 8 TB
Durability	More durable (no moving parts)
Power	Less power consumption
Noise	Silent
Cost	More expensive than HDD

HDD vs SSD:

Feature	HDD	SSD
Technology	Magnetic	Flash Memory
Moving Parts	Yes (spinning disk)	No
Speed	Slower	5-10× Faster
Durability	Less (fragile)	More (shock resistant)
Noise	Audible	Silent
Power	More	Less
Heat	More	Less
Cost/GB	Cheaper	Expensive
Lifespan	~5-10 years	~5-10 years
Capacity	Up to 20 TB	Up to 8 TB
Best For	Large storage	Speed, OS drive

USB Flash Drive (Pen Drive):

Feature	Description
Technology	Flash memory
Capacity	2 GB - 2 TB
Interface	USB
Portable	Yes, pocket-sized
Use	Data transfer, portable storage

Memory Card:

- Used in cameras, phones, tablets
- Types: SD, MicroSD, SDHC, SDXC, CF
- Capacity: 2 GB - 1 TB

Chapter 12: CPU (Central Processing Unit)

12.1 Definition

The **CPU** is the **"Brain of the Computer"** — it performs all processing, calculations, and decision-making.

12.2 Components of CPU

CPU

Control Unit (CU)
- Fetches instructions
- Decodes instructions
- Controls data flow
- Coordinates all units

Arithmetic Logic Unit (ALU)
- Arithmetic: +, -, ×, ÷
- Logical: AND, OR, NOT
- Comparison: <, >, =

Registers
- Accumulator (ACC)
- Program Counter (PC)
- Instruction Register (IR)
- Memory Address Register
- Memory Buffer Register

12.3 Functions of CPU Components

Component	Function
Control Unit (CU)	Controls and coordinates all operations; fetches, decodes, and executes instructions
ALU	Performs arithmetic calculations and logical operations
Registers	Ultra-fast temporary storage within CPU

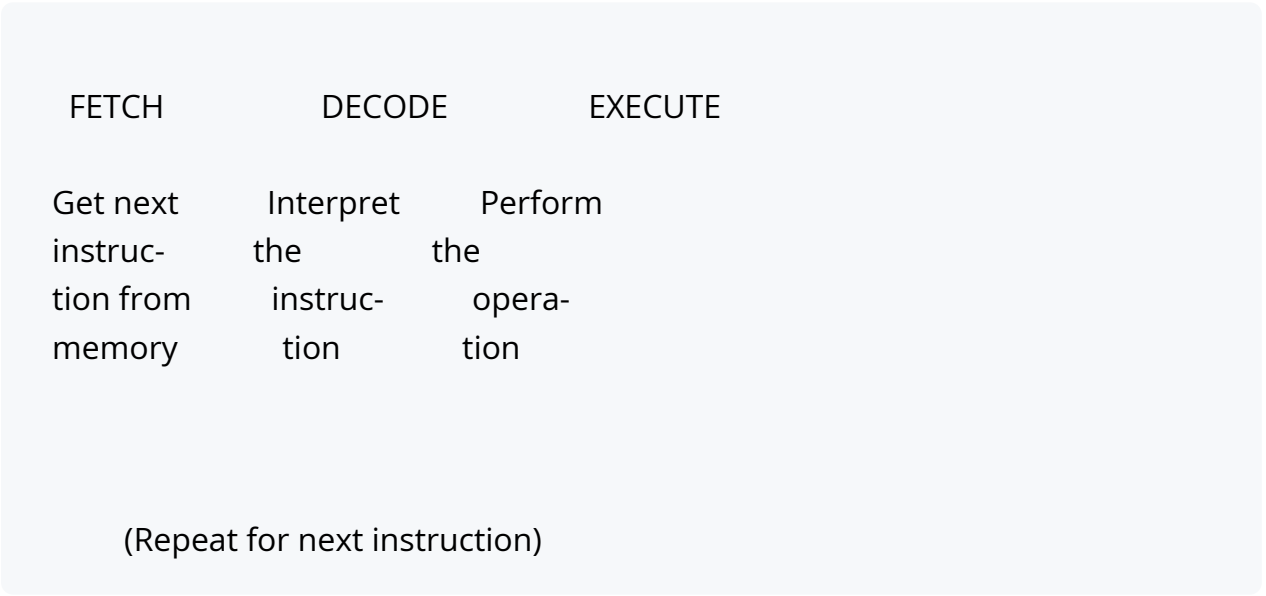
12.4 Important Registers

Register	Full Form	Function
ACC	Accumulator	Stores intermediate results of ALU operations

PC	Program Counter	Holds address of next instruction to execute
IR	Instruction Register	Holds the current instruction being executed
MAR	Memory Address Register	Holds address of memory location to be accessed
MBR/MDR	Memory Buffer/Data Register	Holds data being transferred to/from memory
SP	Stack Pointer	Points to top of stack in memory
FR/PSW	Flag Register/Program Status Word	Holds status flags (carry, zero, overflow, etc.)

12.5 Machine Cycle (Instruction Cycle)

The CPU processes each instruction through the **Fetch-Decode-Execute** cycle:



Detailed Steps:

1. **Fetch:** PC sends address to MAR Instruction fetched from memory to MBR Stored in IR PC incremented
2. **Decode:** CU decodes the instruction in IR Determines operation to perform
3. **Execute:** ALU performs the operation Result stored in ACC or memory
4. **Store:** Result written back to memory if needed

12.6 CPU Performance Measures

Measure	Description
Clock Speed	Number of cycles per second (measured in GHz)
MIPS	Millions of Instructions Per Second
FLOPS	Floating Point Operations Per Second
Word Size	Number of bits processed at once (32-bit, 64-bit)
Cache Size	Amount of cache memory
Cores	Number of processing units (dual-core, quad-core, etc.)

12.7 Types of Processors

Type	Description
Single-core	One processing unit
Dual-core	Two processing units
Quad-core	Four processing units
Octa-core	Eight processing units
Multi-core	Multiple processing units for parallel processing

Popular Processor Manufacturers:

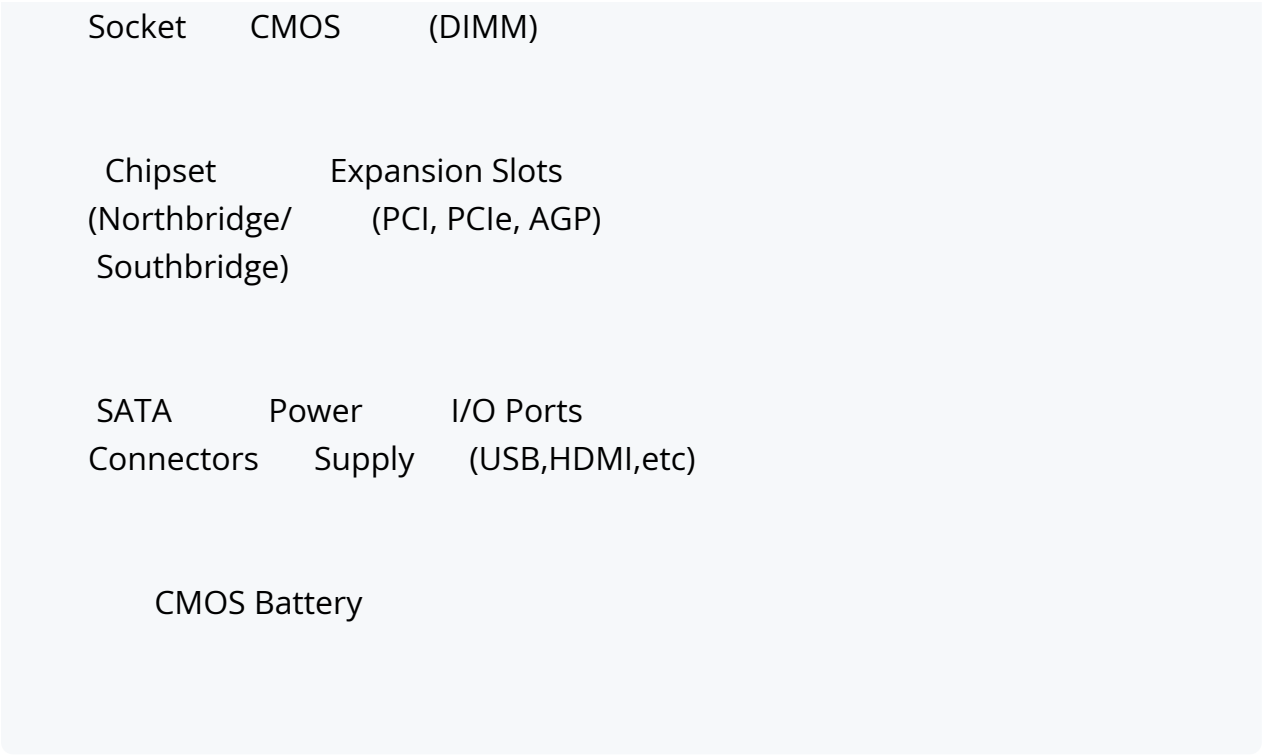
- **Intel:** Core i3, i5, i7, i9, Xeon, Celeron, Pentium
- **AMD:** Ryzen 3, 5, 7, 9, EPYC, Athlon
- **Apple:** M1, M2, M3 (ARM-based)
- **Qualcomm:** Snapdragon (mobile processors)

Chapter 13: Motherboard & Ports

13.1 Motherboard

The **motherboard** (mainboard/system board) is the main **printed circuit board (PCB)** that connects all components of a computer.

13.2 Components on Motherboard



13.3 Important Components

Component	Function
CPU Socket	Where processor is placed
RAM Slots (DIMM)	Where RAM modules are inserted
Chipset	Manages data flow between CPU, memory, and peripherals
BIOS/UEFI Chip	Contains startup program (Basic Input/Output System)
CMOS Battery	Powers BIOS settings when computer is off
Expansion Slots	For adding extra cards (graphics, sound, network)
SATA Ports	Connect hard drives and optical drives
Power Connector	Receives power from PSU (Power Supply Unit)
I/O Ports	External connections (USB, HDMI, Ethernet, etc.)

13.4 BIOS (Basic Input/Output System)

Feature	Description
Location	ROM chip on motherboard
Function	First program that runs when computer starts
Tasks	POST (Power-On Self Test), hardware initialization, boot sequence
Modern Version	UEFI (Unified Extensible Firmware Interface)

13.5 Ports and Connectors

(A) Serial and Parallel Ports

Port	Data Transfer	Use
Serial Port (COM/RS-232)	One bit at a time	Mouse, modem (legacy)
Parallel Port (LPT)	Multiple bits simultaneously	Printer (legacy)
PS/2 Port	Serial	Keyboard, mouse (legacy)

(B) Modern Ports

Port	Full Form	Description
USB	Universal Serial Bus	Most common; connects keyboard, mouse, pen drive, printer
HDMI	High Definition Multimedia Interface	Audio + Video output to TV/monitor
VGA	Video Graphics Array	Analog video output (older monitors)
DVI	Digital Visual Interface	Digital video output
DisplayPort	Display Port	High-resolution video output
Ethernet (RJ-45)		Network/Internet connection
Audio Jack	3.5 mm	Headphones, speakers, microphone
Thunderbolt		High-speed data + display (Apple)
Type-C	USB Type-C	Modern universal connector

USB Versions:

Version	Speed	Name
USB 1.0	1.5 Mbps	Low Speed
USB 1.1	12 Mbps	Full Speed
USB 2.0	480 Mbps	High Speed
USB 3.0	5 Gbps	SuperSpeed
USB 3.1	10 Gbps	SuperSpeed+
USB 3.2	20 Gbps	SuperSpeed+
USB 4.0	40 Gbps	Latest

UNIT 4: COMPUTER SOFTWARE

Chapter 14: Types of Software

14.1 Definition

Software is a set of instructions (programs) that tells the computer what to do. It is the **non-physical** part of a computer system.

14.2 Hardware vs Software

Feature	Hardware	Software
Definition	Physical components	Programs and data
Tangible	Yes (can touch)	No (cannot touch)
Examples	Monitor, Keyboard, CPU	Windows, MS Word, Chrome
Wear & Tear	Yes (degrades)	No (doesn't wear out)
Transfer	Not easily	Easily copied/transferred
Virus	Not affected	Can be affected
Development	Manufactured	Programmed/coded

14.3 Classification of Software

```
Software
    System Software
        Operating System (Windows, Linux, macOS)
        Language Translators (Compiler, Interpreter, Assembler)
        Device Drivers
        Utility Software (Antivirus, Disk Cleanup)

    Application Software
       General Purpose
          Word Processor (MS Word)
          Spreadsheet (MS Excel)
          Presentation (MS PowerPoint)
          Database (MS Access)
          Web Browser (Chrome, Firefox)
```

- Media Player (VLC)
- Specific Purpose
  - Accounting (Tally)
  - Payroll Software
  - Hospital Management
  - Railway Reservation
  - Banking Software
- Customized Software
  - Built for specific organization

14.4 System Software

Definition: Software that manages computer hardware and provides a platform for application software to run.

(A) Operating System (OS)

- Most important system software
- Acts as interface between user and hardware
- Manages hardware resources
- Detailed in Chapter 15

(B) Language Translators

- Convert programming language code to machine code
- Types: Assembler, Compiler, Interpreter
- Detailed in Chapter 17

(C) Device Drivers

- Small programs that allow OS to communicate with hardware
- Each hardware device needs its own driver
- Examples: Printer driver, Graphics driver, Audio driver

(D) Utility Software

- Performs maintenance tasks

Utility	Function
Antivirus	Detects and removes viruses
Disk Cleanup	Removes unnecessary files
Disk Defragmenter	Reorganizes fragmented files
File Compression	Reduces file size (WinZip, WinRAR)
Backup Software	Creates copies of data
Firewall	Protects from unauthorized access
System Monitor	Monitors system performance
Disk Formatter	Prepares disk for use

14.5 Application Software

Definition: Software designed for users to perform specific tasks.

(A) General Purpose Application Software

Software Type	Examples	Function
Word Processor	MS Word, Google Docs, LibreOffice Writer	Create/edit documents
Spreadsheet	MS Excel, Google Sheets, Calc	Data analysis, calculations
Presentation	MS PowerPoint, Google Slides, Impress	Create slideshows
Database	MS Access, Oracle, MySQL	Manage data
Web Browser	Chrome, Firefox, Edge, Safari	Browse internet
Email Client	Outlook, Thunderbird, Gmail	Send/receive emails
Media Player	VLC, Windows Media Player	Play audio/video
Image Editor	Photoshop, GIMP, Paint	Edit images
DTP	PageMaker, InDesign	Desktop publishing

(B) Specific Purpose Application Software

Software	Use
Tally	Accounting
AutoCAD	Engineering design
Adobe Premiere	Video editing
SPSS	Statistical analysis

MATLAB	Mathematical computation
SAP	Enterprise Resource Planning

14.6 Types of Software by Distribution

Type	Description	Examples
Commercial	Paid, licensed	MS Office, Adobe
Freeware	Free, but not open source	Skype, Adobe Reader
Shareware	Free trial, then paid	WinRAR
Open Source	Free, source code available	Linux, LibreOffice, GIMP
Proprietary	Owned by company, closed source	Windows, macOS

14.7 Firmware

- Software **permanently stored** in hardware (ROM)
- Controls basic hardware functions
- Examples: BIOS, Embedded system software
- Cannot be easily modified by user

Chapter 15: Operating Systems

15.1 Definition

An **Operating System (OS)** is system software that manages computer **hardware** and **software resources** and provides services for application programs.

OS is the interface between USER and HARDWARE.

```
        USER

   Application Software

   OPERATING SYSTEM
(Resource Manager)

      HARDWARE
```

(CPU, Memory, I/O, Disk)

15.2 Functions of Operating System

Function	Description
Process Management	Creates, schedules, and terminates processes
Memory Management	Allocates and deallocates memory
File Management	Creates, deletes, organizes files and directories
Device Management	Manages I/O devices through drivers
Security	User authentication, access control
User Interface	Provides CLI or GUI for user interaction
Error Handling	Detects and handles errors
Job Scheduling	Determines order of job execution
Networking	Manages network connections
Resource Allocation	Allocates CPU, memory, devices to processes

15.3 Types of Operating Systems

Type	Description	Examples
Batch OS	Jobs collected in batches, processed without user interaction	Early mainframe OS
Time-Sharing OS	Multiple users share CPU time (round-robin)	UNIX, Multics
Multi-programming OS	Multiple programs in memory, CPU switches between them	Windows
Real-Time OS (RTOS)	Instant response required, strict time constraints	VxWorks (missile systems, medical devices)
Distributed OS	Multiple computers work together as one system	LOCUS
Network OS	Manages network resources, server-based	Windows Server, Novell NetWare
Mobile OS	Designed for mobile devices	Android, iOS
Embedded OS	Built into devices (limited resources)	Embedded Linux, RTOS
Multi-tasking OS	Runs multiple programs simultaneously	Windows, macOS, Linux

Multi-user OS	Multiple users use system simultaneously	UNIX, Linux, Windows Server
Single-user OS	One user at a time	MS-DOS, Windows (desktop)

15.4 Popular Operating Systems

(A) MS-DOS (Microsoft Disk Operating System)

- **Year:** 1981
- **Interface:** CLI (Command Line Interface)
- **Type:** Single-user, single-tasking
- **Developer:** Microsoft
- **Commands:** DIR, COPY, DEL, MD, CD, REN, TYPE, CLS

Common DOS Commands:

Command	Function
DIR	List files and directories
CD	Change directory
MD / MKDIR	Make directory
RD / RMDIR	Remove directory
COPY	Copy files
DEL	Delete files
REN	Rename files
TYPE	Display file content
CLS	Clear screen
FORMAT	Format disk
DATE	Display/change date
TIME	Display/change time
VER	Show OS version

(B) Windows

- **Developer:** Microsoft
- **Interface:** GUI (Graphical User Interface)

- **Type:** Multi-user, multi-tasking

Windows Versions:

Version	Year
Windows 1.0	1985
Windows 3.1	1992
Windows 95	1995
Windows 98	1998
Windows XP	2001
Windows Vista	2006
Windows 7	2009
Windows 8	2012
Windows 10	2015
Windows 11	2021

(C) Linux

- **Developer:** Linus Torvalds (1991)
- **Type:** Open source, multi-user, multi-tasking
- **Distributions:** Ubuntu, Fedora, CentOS, Debian, Red Hat, Kali Linux
- **Free** to use and modify

(D) macOS

- **Developer:** Apple Inc.
- **For:** Apple Mac computers only
- **Based on:** UNIX
- **Versions:** Catalina, Big Sur, Monterey, Ventura, Sonoma

(E) Mobile Operating Systems

OS	Developer	For
Android	Google	Smartphones, tablets
iOS	Apple	iPhone, iPad
HarmonyOS	Huawei	Huawei devices

15.5 Booting Process

Booting is the process of starting a computer and loading the OS into memory.

Types:

- **Cold Boot:** Starting from OFF state (pressing power button)
- **Warm Boot:** Restarting (Ctrl+Alt+Del or Restart)

Boot Process Steps:

1. Power ON
2. BIOS/UEFI executes
3. POST (Power-On Self Test)
   - Checks CPU, RAM, keyboard, display
4. Bootstrap Loader loads
5. Operating System loaded into RAM
6. Desktop/Login screen appears
7. Computer ready for use

15.6 User Interface

Type	Full Form	Description	Example
CLI	Command Line Interface	Text-based, user types commands	MS-DOS, Linux Terminal
GUI	Graphical User Interface	Visual, uses icons, menus, windows, mouse	Windows, macOS
NUI	Natural User Interface	Touch, gesture, voice	Smartphones, Alexa

GUI Elements:

- **Desktop:** Main working area
- **Icons:** Small pictures representing files/programs
- **Taskbar:** Bar at bottom showing running programs
- **Start Menu:** Access to all programs
- **Windows:** Rectangular areas showing programs/files
- **Dialog Box:** Pop-up requesting user input

- **Menu:** List of options
- **Toolbar:** Row of buttons for quick actions

Chapter 16: Programming Languages

16.1 Definition

A **programming language** is a set of instructions and syntax used to create software programs.

16.2 Classification of Programming Languages

```
Programming Languages
    Low-Level Languages
        Machine Language (1st Generation - 1GL)
        Assembly Language (2nd Generation - 2GL)
    High-Level Languages (3rd Generation - 3GL)
        FORTRAN, COBOL, BASIC, C, C++, Java, Python
        ...
    Very High-Level Languages (4th Generation - 4GL)
        SQL, MATLAB, R
    Natural Languages (5th Generation - 5GL)
       AI-based (Prolog, LISP, Mercury)
```

16.3 Machine Language (1GL)

Feature	Description
Representation	Binary (0s and 1s)
Understanding	Directly understood by computer
Speed	Fastest execution
Portability	Machine-dependent (non-portable)
Difficulty	Very difficult to program
Error-prone	Highly error-prone
Debugging	Very difficult
Example	10110000 01100001

16.4 Assembly Language (2GL)

Feature	Description
Representation	Mnemonics (short codes like ADD, SUB, MOV)
Translator	Assembler (converts to machine code)
Speed	Fast (close to machine code)
Portability	Machine-dependent
Difficulty	Difficult but easier than machine language

Example:

```
MOV AX, 5     ; Move 5 to register AX
MOV BX, 3     ; Move 3 to register BX
ADD AX, BX    ; Add BX to AX (AX = 8)
```

16.5 High-Level Languages (3GL)

Feature	Description
Representation	English-like statements
Translator	Compiler or Interpreter
Speed	Slower than low-level (needs translation)
Portability	Machine-independent (portable)
Difficulty	Easy to learn and use
Debugging	Easy

Important High-Level Languages:

Language	Year	Developer	Use
FORTRAN	1957	John Backus (IBM)	Scientific computing
COBOL	1959	Grace Hopper	Business applications
BASIC	1964	Kemeny & Kurtz	Education, beginners
Pascal	1970	Niklaus Wirth	Education, structured programming
C	1972	Dennis Ritchie	System programming, OS
C++	1983	Bjarne Stroustrup	Object-oriented programming
Java	1995	James Gosling (Sun)	Platform-independent, web, mobile
Python	1991	Guido van Rossum	AI, ML, web, scripting

JavaScript	1995 Brendan Eich	Web development
C#	2000 Microsoft	Windows applications
Swift	2014 Apple	iOS development
Kotlin	2011 JetBrains	Android development
R	1993 Ihaka & Gentleman	Statistical computing
PHP	1995 Rasmus Lerdorf	Web development (server-side)

Full Forms:

- FORTRAN: FORmula TRANslation
- COBOL: COmmon Business Oriented Language
- BASIC: Beginner's All-purpose Symbolic Instruction Code
- HTML: HyperText Markup Language
- SQL: Structured Query Language
- PHP: Hypertext Preprocessor

16.6 4th Generation Languages (4GL)

- Non-procedural languages
- Closer to human language
- Focus on WHAT to do, not HOW to do
- Examples: SQL, MATLAB, SAS, Report generators

SQL Example:

```
SELECT name, marks FROM students WHERE marks > 80;
```

16.7 5th Generation Languages (5GL)

- Based on Artificial Intelligence
- Uses natural language processing
- Computer solves problems based on constraints
- Examples: Prolog, LISP, Mercury

16.8 Comparison of Language Levels

Feature	Machine	Assembly	High-Level
Readability	None	Low	High
Speed	Fastest	Fast	Slower
Portability	None	None	High
Debugging	Very Hard	Hard	Easy
Memory Use	Efficient	Efficient	Less efficient
Translator	Not needed	Assembler	Compiler/Interpreter

Chapter 17: Language Translators

17.1 Definition

Language translators are system software that convert source code written in a programming language into machine code.

17.2 Types of Translators

(A) Assembler

Feature	Description	
Input	Assembly language program	
Output	Machine code (object code)	
Translation	One assembly instruction	One machine instruction
Process	One-to-one translation	

```
Assembly Code     [ASSEMBLER]      Machine Code
(ADD AX, BX)                       (10110011...)
```

(B) Compiler

Feature	Description
Input	High-level language program (source code)
Output	Machine code (object code)
Process	Translates **entire** program at once
Errors	Shows **all errors after** complete scanning

Speed	Execution is **faster** (already translated)
Memory	Requires more memory
Languages	C, C++, Java, FORTRAN, COBOL

```
Source Code  [COMPILER]  Object Code  [Execute]  Output
(Entire program at once)
```

(C) Interpreter

Feature	Description
Input	High-level language program (source code)
Output	Immediate execution (line by line)
Process	Translates **one line at a time**
Errors	Shows error on the **first error** found, stops
Speed	Execution is **slower** (translates each time)
Memory	Requires less memory
Languages	Python, BASIC, JavaScript, Ruby, PHP

```
Source Code  [INTERPRETER]  Output
(One line at a time)
```

17.3 Compiler vs Interpreter

Feature	Compiler	Interpreter
Translation	Entire program at once	Line by line
Speed of Translation	Slower (whole program)	Faster (one line)
Speed of Execution	**Faster**	**Slower**
Error Detection	After complete compilation	Immediately on each line
Object Code	**Generated** (can reuse)	**Not generated**
Memory	More	Less
Re-translation	Not needed for same input	Needed every time
Debugging	Harder (all errors at once)	Easier (one error at a time)
Examples	C, C++, Java	Python, BASIC, JavaScript

17.4 Linker and Loader

Linker:

- Combines multiple object files into a single executable file
- Links library functions with the program

Loader:

- Loads the executable program into main memory (RAM)
- Prepares the program for execution

```
Source  [Compiler]  Object Code  [Linker]  Executable  [Loader]  RAM  [Exe
```

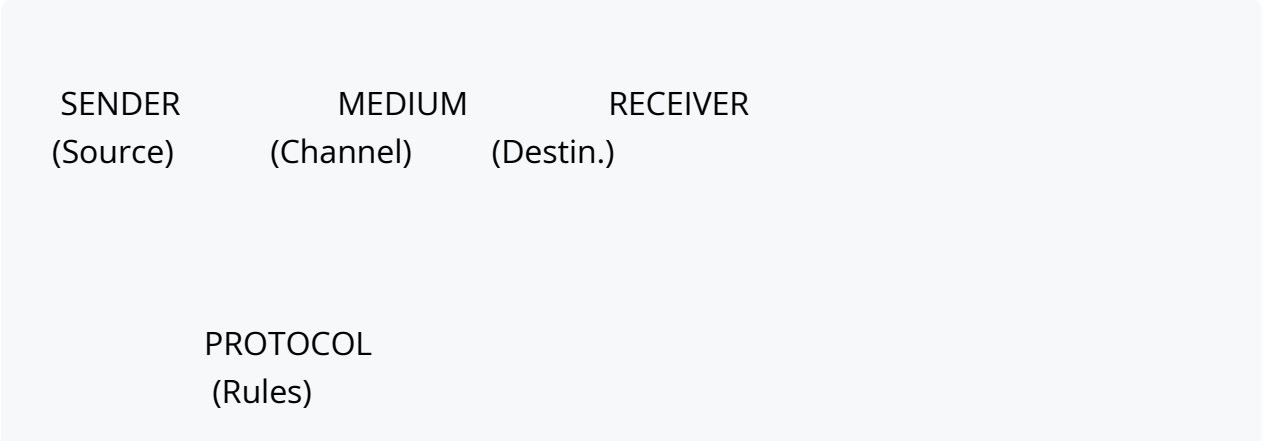
UNIT 5: DATA COMMUNICATION & NETWORKING

Chapter 18: Data Communication Basics

18.1 Definition

Data Communication is the transfer of data from one device to another through a communication medium.

18.2 Components of Data Communication



MESSAGE

Five Components:

Component	Description	Example
Sender	Device that sends data	Computer, Phone
Receiver	Device that receives data	Computer, Printer
Message	Data being transmitted	Text, Audio, Video
Medium	Path through which data travels	Cable, Wireless
Protocol	Rules governing communication	TCP/IP, HTTP

18.3 Data Transmission Modes

(A) Based on Direction:

Simplex:
Sender → Receiver
(One direction only)
Example: TV broadcast, Radio, Keyboard

Half-Duplex:
Device A ↔ Device B
(Both directions, but one at a time)
Example: Walkie-Talkie

Full-Duplex:
Device A ⇄ Device B
(Both directions simultaneously)
Example: Telephone, Video Call

Mode	Direction	Simultaneous	Example
Simplex	One-way only	No	TV, Radio, Keyboard
Half-Duplex	Both ways, one at a time	No	Walkie-talkie
Full-Duplex	Both ways, simultaneously	Yes	Telephone, Internet

(B) Based on Synchronization:

Mode	Description
Synchronous	Data sent in continuous stream with clock synchronization
Asynchronous	Data sent character by character with start/stop bits

(C) Based on Bit Transmission:

Mode	Description
Serial	Bits sent one after another on single wire
Parallel	Multiple bits sent simultaneously on multiple wires

18.4 Transmission Media

Transmission Media
- Guided (Wired)
  - Twisted Pair Cable
    - UTP (Unshielded)
    - STP (Shielded)
  - Coaxial Cable
  - Fiber Optic Cable
- Unguided (Wireless)
  - Radio Waves
  - Microwaves
  - Infrared
  - Bluetooth
  - Wi-Fi
  - Satellite

Guided (Wired) Media:

Medium	Description	Speed	Distance	Use
Twisted Pair	Two insulated copper wires twisted together	10 Mbps - 10 Gbps	Short (100m)	LAN, Telephone
Coaxial Cable	Central copper conductor with insulation and shield	10 Mbps - 1 Gbps	Medium (500m)	Cable TV, older LAN

Fiber Optic	Glass/plastic fibers carrying light signals	10 Gbps - 100+ Gbps	Long (100+ km)	Internet backbone, WAN

Comparison:

Feature	Twisted Pair	Coaxial	Fiber Optic
Cost	Cheapest	Moderate	Most expensive
Speed	Moderate	Moderate	Highest
Bandwidth	Low	Medium	Very High
Distance	Short	Medium	Long
Interference	High	Medium	None
Security	Low	Medium	Highest
Installation	Easy	Moderate	Difficult

Unguided (Wireless) Media:

Medium	Frequency	Range	Use
Radio Waves	3 KHz - 1 GHz	Long	AM/FM Radio, TV
Microwaves	1 GHz - 300 GHz	Line of sight	Satellite, Cellular
Infrared	300 GHz - 400 THz	Short (few meters)	Remote control, IrDA
Bluetooth	2.4 GHz	10-100 meters	Short-range device connection
Wi-Fi	2.4/5/6 GHz	30-100 meters	Wireless LAN
Satellite	Various	Global	GPS, TV, Internet

18.5 Modem

MODEM = MOdulator + DEModulator

Function	Description
Purpose	Converts digital signals to analog and vice versa
Modulation	Digital → Analog (for transmission over phone lines)
Demodulation	Analog → Digital (for computer processing)
Types	External, Internal, USB, Wireless

Computer [Digital] MODEM [Analog] Phone Line [Analog] MODE

Chapter 19: Computer Networks

19.1 Definition

A **Computer Network** is a collection of interconnected computers and devices that can **share data, resources, and information**.

19.2 Advantages of Networking

1. **Resource Sharing** (printer, scanner, files)
2. **Data Sharing** (databases, files)
3. **Communication** (email, chat, video conference)
4. **Cost Reduction** (shared resources reduce costs)
5. **Reliability** (backup and redundancy)
6. **Scalability** (easy to add new devices)
7. **Centralized Management** (easier administration)

19.3 Types of Networks (By Size/Area)

PAN LAN MAN WAN

(Personal) (Local) (Metro) (Wide)

Type	Full Form	Coverage	Speed	Example
PAN	Personal Area Network	1-10 meters	Low-Medium	Bluetooth devices
LAN	Local Area Network	Building/Campus	High (100 Mbps - 10 Gbps)	Office network, School lab
MAN	Metropolitan Area Network	City	Moderate-High	Cable TV network, City Wi-Fi
WAN	Wide Area Network	Country/Globe	Variable	Internet, ATM networks

(A) PAN (Personal Area Network)

- Covers very small area (personal workspace)
- Connects personal devices
- Examples: Bluetooth headset, wireless keyboard, smartphone to laptop

(B) LAN (Local Area Network)

- Covers small area (room, building, campus)
- High data transfer rate
- Owned by single organization
- Examples: Office network, Computer lab, Home network

(C) MAN (Metropolitan Area Network)

- Covers a city or large campus
- Interconnects several LANs
- Examples: Cable TV network, City-wide Wi-Fi

(D) WAN (Wide Area Network)

- Covers large geographical area (country, continent, world)
- Uses telephone lines, satellites, fiber optics
- Lower speed than LAN
- Example: **Internet** is the largest WAN

19.4 Network Components/Devices

Device	Function
NIC (Network Interface Card)	Connects computer to network, has MAC address
Hub	Connects multiple devices; broadcasts data to all ports (dumb device)
Switch	Connects devices; sends data only to intended recipient (smart device)

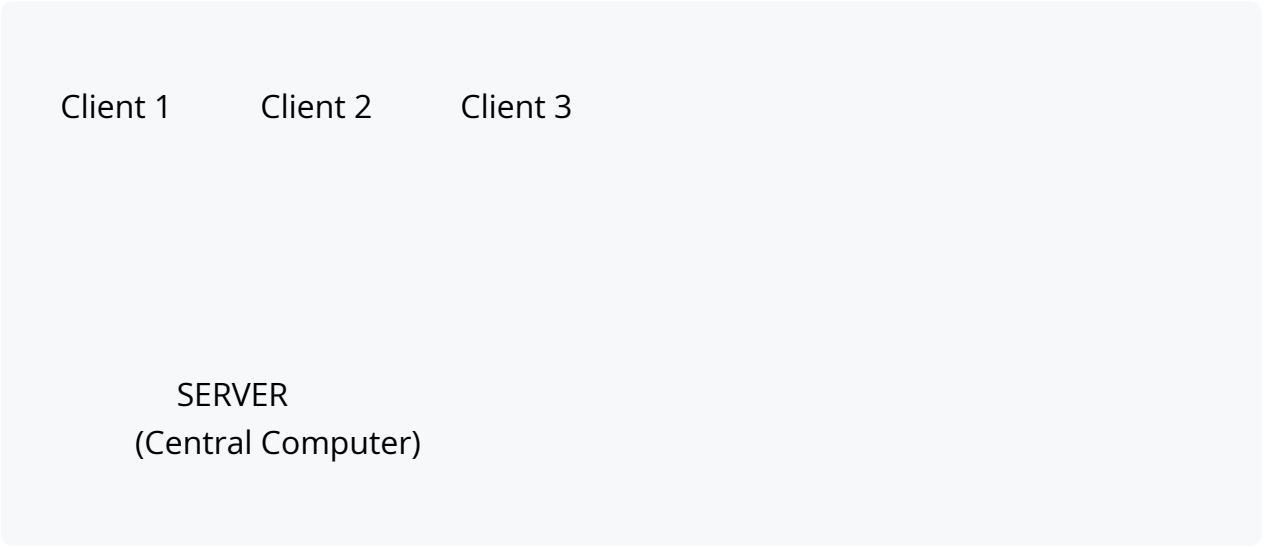
Router	Connects different networks; directs data packets using IP addresses
Bridge	Connects two similar LANs
Gateway	Connects two different types of networks (protocol conversion)
Modem	Modulates/demodulates signals for communication
Repeater	Amplifies/regenerates weak signals over long distances
Access Point	Provides wireless connectivity to a wired network
Firewall	Security device that filters network traffic

Hub vs Switch vs Router:

Feature	Hub	Switch	Router
Intelligence	Dumb	Smart	Smartest
Data Sending	Broadcast to all	To specific device	Between networks
Layer	Physical (Layer 1)	Data Link (Layer 2)	Network (Layer 3)
Address Used	None	MAC Address	IP Address
Collision	More collisions	No collisions	No collisions
Cost	Cheapest	Moderate	Most expensive

19.5 Network Architecture

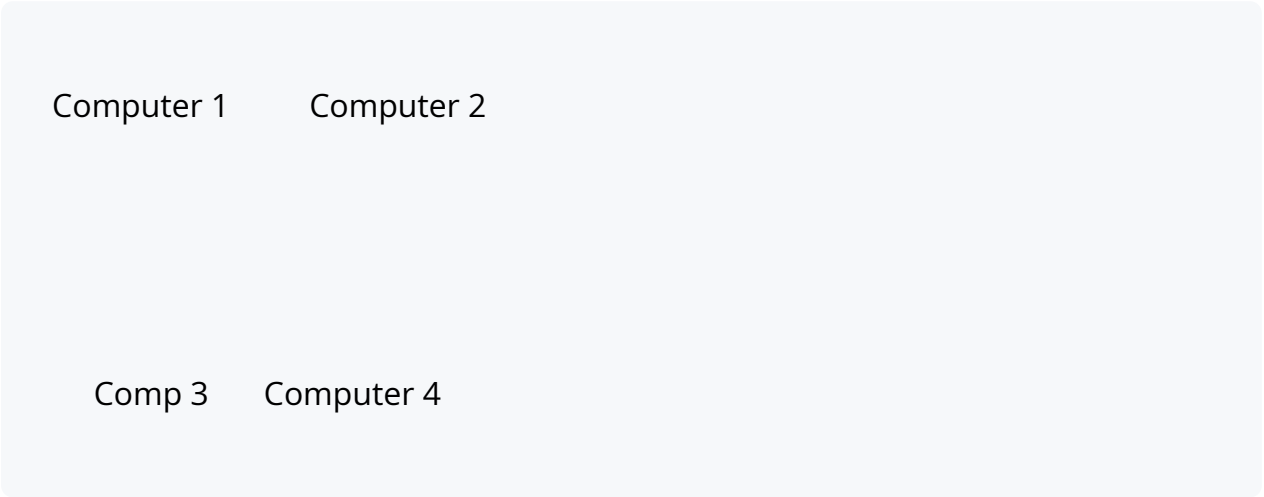
(A) Client-Server Architecture



Feature	Description

Server	Powerful computer that provides services/resources
Client	Computer that requests services from server
Centralized	Data and resources on server
Security	Better (centralized control)
Cost	Higher (requires server)
Example	Website server, Email server, Database server

(B) Peer-to-Peer (P2P) Architecture



Feature	Description
No server	All computers are equal (peers)
Decentralized	Each computer can be client and server
Security	Lower
Cost	Lower (no dedicated server)
Example	File sharing (BitTorrent), Home network

Client-Server vs Peer-to-Peer:

Feature	Client-Server	Peer-to-Peer
Server	Required	Not required
Security	High	Low
Cost	High	Low
Management	Centralized	Decentralized
Scalability	High	Limited
Performance	High	Depends on peers

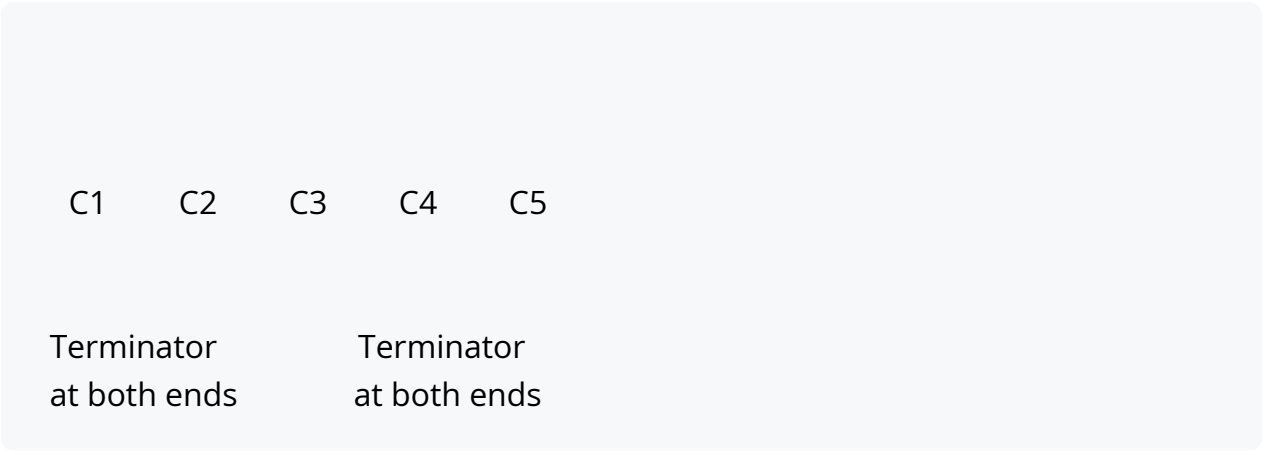
Chapter 20: Network Topologies

20.1 Definition

Network Topology is the arrangement or layout of computers and devices in a network. It describes how devices are connected.

20.2 Types of Topologies

(A) Bus Topology



Feature	Description
Structure	All devices connected to a single cable (backbone/bus)
Terminator	Required at both ends of cable
Data Flow	Data travels in both directions along the cable
Failure	If backbone fails, entire network fails
Cost	Low (less cable)
Installation	Easy
Best For	Small networks, temporary setups

Advantages:

- Easy to install and configure
- Less cable required
- Cost-effective for small networks
- Easy to add new devices

Disadvantages:

- If backbone cable fails, entire network goes down
- Difficult to troubleshoot
- Performance decreases as more devices are added
- Limited cable length
- Not suitable for large networks

(B) Star Topology

Feature	Description
Structure	All devices connected to a central hub/switch
Central Device	Hub or Switch
Failure	If central device fails, entire network fails
Node Failure	If one device fails, others are not affected
Cost	Moderate (more cable, hub/switch needed)
Best For	Office LANs, school networks

Advantages:

- Easy to install and manage
- Easy to add/remove devices
- Easy to troubleshoot
- Failure of one node doesn't affect others

- Better performance than bus

Disadvantages:

- If central hub/switch fails, entire network fails
- Requires more cable than bus topology
- Cost of hub/switch
- Performance depends on central device

Most commonly used topology today!

(C) Ring Topology

Feature	Description
Structure	Each device connected to exactly two other devices, forming a circle
Data Flow	Data travels in one direction (unidirectional)
Token	Uses token passing protocol
Failure	If one device or link fails, entire network can fail
Cost	Moderate
Best For	Networks requiring orderly data access

Advantages:

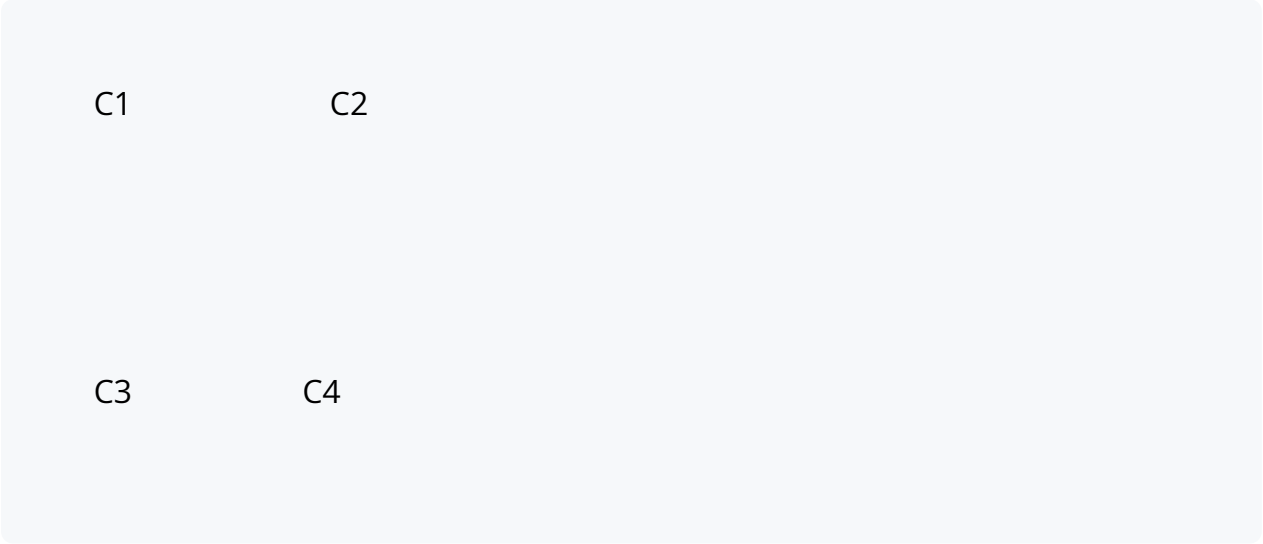
- Equal access for all devices (no collisions)

- Orderly data transmission (token passing)
- Performance doesn't degrade much under load
- No need for central device

Disadvantages:

- If one device fails, entire network may fail
- Difficult to add/remove devices
- Difficult to troubleshoot
- Slower (data must pass through all nodes)

(D) Mesh Topology



Feature	Description
Structure	Every device connected to every other device
Connections	For n devices: n(n-1)/2 connections
Redundancy	Multiple paths between devices
Failure	Highly fault-tolerant
Cost	Very expensive
Best For	Critical networks requiring high reliability

Types:

- **Full Mesh:** Every device connected to every other device
- **Partial Mesh:** Some devices connected to all, others to only a few

Advantages:

- Very reliable (multiple paths)
- Fault-tolerant
- Easy to troubleshoot
- Data can take multiple paths
- High security and privacy

Disadvantages:

- Very expensive (lots of cables)
- Complex installation and management
- Difficult to add new devices
- Many connections needed

(E) Tree (Hierarchical) Topology

Feature	Description
Structure	Combination of star and bus topology
Hierarchy	Tree-like structure with root node
Levels	Multiple levels of hierarchy
Best For	Large networks with departments

(E) Hybrid Topology

- Combination of two or more topologies
- Example: Star-Bus, Star-Ring
- Used in large enterprise networks
- Flexible and scalable

20.3 Topology Comparison Summary

Feature	Bus	Star	Ring	Mesh
Cable	Least	Moderate	Moderate	Most
Cost	Lowest	Moderate	Moderate	Highest
Installation	Easy	Easy	Moderate	Complex
Fault Tolerance	Low	Moderate	Low	Highest
Speed	Low	High	Moderate	High
Troubleshooting	Hard	Easy	Hard	Easy
Scalability	Limited	Good	Limited	Complex

Chapter 21: Internet & Its Services

21.1 What is Internet?

The **Internet** is a global network of interconnected computer networks that uses **TCP/IP** protocol to communicate.

- **Full Form (informal):** International Network
- **Also called:** Network of Networks, Information Superhighway
- **Developed from:** ARPANET (1969, US Department of Defense)
- **WWW invented by:** Tim Berners-Lee (1991)

21.2 History of Internet

Year	Event
1969	**ARPANET** launched (4 nodes) by US DoD
1972	Email introduced by Ray Tomlinson
1974	TCP/IP protocol developed by Vint Cerf & Bob Kahn

1983 ARPANET adopted TCP/IP

1986 NSFNET created

1990 ARPANET decommissioned

1991 **WWW** created by Tim Berners-Lee

1993 First graphical browser (Mosaic)

1995 Internet commercialized

1998 Google founded

2004 Facebook launched

2005 YouTube launched

2007 iPhone launched (mobile internet revolution)

21.3 Internet Terminology

Term	Definition
WWW	World Wide Web — Collection of web pages accessible via internet
URL	Uniform Resource Locator — Address of a web page (e.g., https://www.google.com)
HTTP	HyperText Transfer Protocol — Protocol for web communication
HTTPS	HTTP Secure — Encrypted web communication
HTML	HyperText Markup Language — Language for creating web pages
IP Address	Internet Protocol Address — Unique numerical address of a device
Domain Name	Human-readable address (e.g., google.com)
DNS	Domain Name System — Converts domain names to IP addresses
ISP	Internet Service Provider — Company providing internet access
Browser	Software to access web (Chrome, Firefox, Edge)
Search Engine	Tool to search web content (Google, Bing, Yahoo)
Web Server	Computer that hosts websites
Web Page	Single page on the internet
Website	Collection of related web pages
Hyperlink	Clickable link to another web page
Download	Transfer data FROM internet TO computer
Upload	Transfer data FROM computer TO internet
Bandwidth	Data transfer capacity (measured in Mbps, Gbps)

21.4 Internet Protocols

Protocol	Full Form	Use
TCP/IP	Transmission Control Protocol / Internet Protocol	Foundation of internet communication
HTTP	HyperText Transfer Protocol	Web page transfer
HTTPS	HTTP Secure	Secure web communication
FTP	File Transfer Protocol	File transfer
SMTP	Simple Mail Transfer Protocol	Sending emails
POP3	Post Office Protocol v3	Receiving emails
IMAP	Internet Message Access Protocol	Accessing emails on server
DNS	Domain Name System	Domain to IP mapping
DHCP	Dynamic Host Configuration Protocol	Automatic IP assignment
Telnet	Terminal Network	Remote login
SSH	Secure Shell	Secure remote login

21.5 Internet Services

(A) Email (Electronic Mail)

- Sending/receiving messages electronically
- Providers: Gmail, Yahoo Mail, Outlook
- Uses SMTP (send) and POP3/IMAP (receive)
- Can send attachments (files, images)

Components of Email Address:

```
username @ domain.com

                Domain name
          @ symbol (at)
     User's name/ID
```

(B) World Wide Web (WWW)

- Collection of web pages linked by hyperlinks

- Accessed through web browsers
- Uses HTTP/HTTPS protocol
- Created by Tim Berners-Lee (1991)

(C) File Transfer Protocol (FTP)

- Transferring files between computers
- Upload and download files
- Uses FTP client software

(D) Search Engines

- Used to search for information on the web
- Examples: Google, Bing, Yahoo, DuckDuckGo
- Use web crawlers to index web pages

(E) Social Media

- Platforms for online social interaction
- Examples: Facebook, Instagram, Twitter/X, LinkedIn

(F) E-Commerce

- Buying and selling goods/services online
- Examples: Amazon, Flipkart, eBay
- Types: B2B, B2C, C2C, C2B

(G) Video Conferencing

- Real-time audio/video communication
- Examples: Zoom, Google Meet, Microsoft Teams, Skype

(H) Cloud Storage

- Storing files on remote servers
- Examples: Google Drive, Dropbox, OneDrive, iCloud

(I) VoIP (Voice over IP)

- Making phone calls over internet
- Examples: Skype, WhatsApp calls, Google Voice

(J) Online Education

- Learning through internet
- Platforms: Coursera, Udemy, NPTEL, Khan Academy, BYJU'S

21.6 Internet Connection Types

Type	Speed	Description
Dial-up	56 Kbps	Uses phone line (very slow, obsolete)
DSL	1-100 Mbps	Digital Subscriber Line (over phone line)
Cable	10-1000 Mbps	Through cable TV lines
Fiber Optic	100 Mbps - 10 Gbps	Fastest, uses light signals
Wi-Fi	Variable	Wireless connection
Satellite	1-100 Mbps	Via satellite (remote areas)
Mobile (4G/5G)	10 Mbps - 10 Gbps	Cellular network

21.7 Intranet vs Extranet vs Internet

Feature	Intranet	Extranet	Internet
Access	Organization only	Selected partners	Public (everyone)
Scope	Private	Semi-private	Global
Security	High	High	Variable
Users	Employees	Partners, vendors	Anyone
Example	Company portal	B2B portal	www.google.com

UNIT 6: EMERGING TECHNOLOGIES

Chapter 22: Multimedia

22.1 Definition

Multimedia is the integration of multiple forms of media — **text, graphics, audio, video, and animation** — to communicate information.

22.2 Components of Multimedia

Component	Description	Formats
Text	Written content	TXT, DOC, PDF, HTML
Graphics/Images	Pictures, diagrams, photos	JPEG, PNG, GIF, BMP, TIFF, SVG
Audio	Sound, music, voice	MP3, WAV, AAC, FLAC, OGG
Video	Moving images with sound	MP4, AVI, MOV, MKV, WMV, FLV
Animation	Simulated motion of objects	GIF, SWF, SVG animation

22.3 Applications of Multimedia

- Education (E-learning, interactive content)
- Entertainment (Games, movies, music)
- Business (Presentations, advertising)
- Medicine (Medical imaging, training)
- Virtual Reality (VR) and Augmented Reality (AR)
- Web design

Chapter 23: Artificial Intelligence (AI)

23.1 Definition

Artificial Intelligence is the simulation of **human intelligence** in machines programmed to **think and learn** like humans.

Coined by: John McCarthy (1956)

23.2 Types of AI

Type	Description	Example
Narrow/Weak AI	Designed for specific task	Siri, Alexa, Chess AI

General/Strong AI	Can perform any intellectual task like humans	Not yet achieved
Super AI	Surpasses human intelligence	Hypothetical/future

23.3 Applications of AI

Application	Description
Virtual Assistants	Siri, Alexa, Google Assistant
Self-driving Cars	Tesla, Waymo
Medical Diagnosis	AI detecting diseases from scans
Natural Language Processing	ChatGPT, Google Translate
Image Recognition	Face unlock, Google Photos
Robotics	Industrial robots, surgical robots
Recommendation Systems	Netflix, YouTube, Amazon suggestions
Gaming	AI opponents in video games
Fraud Detection	Banking, credit card fraud
Speech Recognition	Voice typing, voice commands

23.4 Related Fields

Field	Description
Machine Learning (ML)	Machines learn from data without explicit programming
Deep Learning	ML using neural networks with many layers
Natural Language Processing	Computers understanding human language
Computer Vision	Computers interpreting images/videos
Robotics	Designing and building robots
Expert Systems	AI systems that mimic expert decisions

Chapter 24: Cloud Computing

24.1 Definition

Cloud Computing is the delivery of computing services — servers, storage, databases, networking, software — over the **internet** ("the cloud").

24.2 Service Models

Cloud Computing Service Models
    IaaS (Infrastructure as a Service)
        Provides: Virtual machines, storage, networks
        Examples: AWS EC2, Google Compute, Azure VMs

    PaaS (Platform as a Service)
        Provides: Platform for developing & deploying apps
        Examples: Google App Engine, Heroku, Azure App Service

    SaaS (Software as a Service)
        Provides: Ready-to-use software applications
        Examples: Gmail, Google Docs, Microsoft 365, Dropbox

Model	You Manage	Provider Manages	Example
IaaS	OS, Apps, Data	Hardware, Network	AWS, Azure
PaaS	Apps, Data	OS, Hardware, Network	Heroku
SaaS	Nothing (just use)	Everything	Gmail, Office 365

24.3 Deployment Models

Model	Description	Example
Public Cloud	Shared resources, open to public	AWS, Google Cloud, Azure
Private Cloud	Dedicated to single organization	Company's own cloud
Hybrid Cloud	Combination of public and private	Most enterprises
Community Cloud	Shared by organizations with common concerns	Government cloud

24.4 Advantages of Cloud Computing

- **Cost Savings** (pay-per-use, no upfront investment)
- **Scalability** (easily scale up or down)
- **Accessibility** (access from anywhere)
- **Automatic Updates** (provider handles maintenance)

- **Disaster Recovery** (data backed up automatically)
- **Collaboration** (multiple users work simultaneously)

24.5 Popular Cloud Providers

- Amazon Web Services (AWS)
- Microsoft Azure
- Google Cloud Platform (GCP)
- IBM Cloud
- Oracle Cloud

Chapter 25: Cyber Security

25.1 Definition

Cyber Security is the practice of protecting computers, networks, programs, and data from **unauthorized access, attacks, and damage**.

25.2 Types of Cyber Threats

Threat	Description
Virus	Self-replicating program that infects files
Worm	Self-replicating, spreads without host file
Trojan Horse	Disguised as legitimate software
Ransomware	Encrypts data, demands payment
Spyware	Secretly monitors user activity
Adware	Displays unwanted advertisements
Phishing	Fake emails/websites to steal information
Hacking	Unauthorized access to systems
Identity Theft	Stealing personal information
DDoS Attack	Overwhelming server with traffic
Keylogger	Records keyboard strokes
Man-in-the-Middle	Intercepting communication

25.3 Virus vs Worm vs Trojan

Feature	Virus	Worm	Trojan
Host Required	Yes	No	Yes (appears useful)
Self-replication	Yes	Yes	No
Spreads through	Infected files	Networks	User downloads
User Action	Required	Not required	Required
Damage	Corrupts files	Network congestion	Steals data, backdoor

25.4 Security Measures

Measure	Description
Antivirus	Software that detects and removes viruses
Firewall	Monitors and controls network traffic
Encryption	Converts data to coded form
Password	Authentication mechanism
Two-Factor Authentication (2FA)	Extra security layer (OTP, biometric)
Backup	Regular data backup
VPN	Virtual Private Network for secure connection
SSL/TLS	Secure internet communication (HTTPS)
Biometric Security	Fingerprint, face, iris recognition
Access Control	Restricting who can access what
Security Patches	Regular software updates

25.5 Important Concepts

Encryption:

```
Plain Text      [Encryption Key]      Cipher Text      [Decryption Key]      Plain Text
"Hello"                               "Xk#9m"                                "Hello"
```

Types of Encryption:

Type	Description
Symmetric	Same key for encryption and decryption (AES, DES)
Asymmetric	Different keys — public key (encrypt) + private key (decrypt) (RSA)

Digital Signature:

- Electronic equivalent of handwritten signature
- Verifies authenticity and integrity of message
- Uses asymmetric encryption

Firewall Types:

Type	Description
Hardware Firewall	Physical device between network and internet
Software Firewall	Program installed on computer
Cloud Firewall	Cloud-based firewall service

25.6 Cyber Laws in India

- **IT Act 2000** (Information Technology Act)
- Amended in **2008**
- Covers: Cyber crimes, digital signatures, electronic commerce
- Section 66: Computer-related offenses
- Section 67: Publishing obscene material electronically
- Section 43: Penalty for unauthorized access

IMPORTANT SHORT NOTES FOR REVISION

Quick Reference Tables

Computer Pioneers

Person	Contribution
Charles Babbage	Father of Computer (Analytical Engine)
Ada Lovelace	First Computer Programmer
Alan Turing	Father of Computer Science & AI
John von Neumann	Stored Program Concept

Tim Berners-Lee	Invented WWW
Vint Cerf	Father of Internet
Dennis Ritchie	Created C Language
Bill Gates	Co-founded Microsoft
Steve Jobs	Co-founded Apple
Linus Torvalds	Created Linux
James Gosling	Created Java
Guido van Rossum	Created Python
Grace Hopper	COBOL development
John McCarthy	Coined term "Artificial Intelligence"

Important Abbreviations

Abbreviation	Full Form
CPU	Central Processing Unit
ALU	Arithmetic Logic Unit
CU	Control Unit
RAM	Random Access Memory
ROM	Read Only Memory
BIOS	Basic Input/Output System
POST	Power-On Self Test
HDD	Hard Disk Drive
SSD	Solid State Drive
USB	Universal Serial Bus
HDMI	High Definition Multimedia Interface
NIC	Network Interface Card
LAN	Local Area Network
WAN	Wide Area Network
MAN	Metropolitan Area Network
ISP	Internet Service Provider
URL	Uniform Resource Locator
DNS	Domain Name System
HTTP	HyperText Transfer Protocol
FTP	File Transfer Protocol

TCP/IP	Transmission Control Protocol/Internet Protocol
SMTP	Simple Mail Transfer Protocol
HTML	HyperText Markup Language
CSS	Cascading Style Sheets
AI	Artificial Intelligence
ML	Machine Learning
IoT	Internet of Things
VPN	Virtual Private Network
GUI	Graphical User Interface
CLI	Command Line Interface
OS	Operating System
DBMS	Database Management System
DPI	Dots Per Inch
FLOPS	Floating Point Operations Per Second
MIPS	Millions of Instructions Per Second

PRACTICE QUESTIONS

Short Answer Questions

Q1. What is a computer? List its characteristics.

Q2. Who is called the Father of Computer and why?

Q3. Differentiate between hardware and software.

Q4. Explain the five generations of computers.

Q5. What is the difference between RAM and ROM?

Q6. Convert the following:

- (a) 101110_2 to Decimal
- (b) 75_{10} to Binary
- (c) $2F_{16}$ to Binary

- (d) 110101_2 to Hexadecimal

Q7. Perform binary addition: 1011 + 1101

Q8. Find the 1's complement and 2's complement of 101100.

Q9. What are logic gates? Explain AND, OR, NOT gates with truth tables.

Q10. State and verify De Morgan's theorems.

Q11. Differentiate between Compiler and Interpreter.

Q12. Explain different types of network topologies.

Q13. What is the difference between LAN, MAN, and WAN?

Q14. What is cloud computing? Explain IaaS, PaaS, SaaS.

Q15. What is cyber security? Explain types of cyber threats.

Answers to Conversion Questions (Q6)

(a) 101110_2 to Decimal: $= 1×2^5 + 0×2^4 + 1×2^3 + 1×2^2 + 1×2^1 + 0×2^0$ $= 32 + 0 + 8 + 4 + 2 + 0 = \mathbf{46_{10}}$

(b) 75_{10} to Binary:

```
75 ÷ 2 = 37 R 1
37 ÷ 2 = 18 R 1
18 ÷ 2 = 9  R 0
9  ÷ 2 = 4  R 1
4  ÷ 2 = 2  R 0
2  ÷ 2 = 1  R 0
1  ÷ 2 = 0  R 1
```

Answer: 1001011_2

(c) $2F_{16}$ to Binary:

```
2    0010
```

```
F   1111
```

Answer: $00101111_2 = 101111_2$

(d) 110101_2 to Hexadecimal:

```
0011  0101
 3    5
```

Answer: 35_{16}

HOW TO CONVERT THIS TO PDF

Fastest Method (30 seconds):

1. Press Ctrl + P (Windows) or Cmd + P (Mac)
2. Select "Save as PDF" as destination
3. Click "Save"
   Done!

Other Methods:

Method 1: Google Docs

1. Go to docs.google.com
2. Create new document
3. Copy-paste all content
4. File Download PDF

Method 2: Microsoft Word

1. Open Word
2. Paste content

3. File Save As PDF

Method 3: Online Converters

md2pdf.netlify.app
dillinger.io
markdowntopdf.com
Paste content Export PDF

Method 4: Notion

1. Create account at notion.so
2. Paste content
3. Export as PDF

This covers the **COMPLETE SYLLABUS** for **BCA Semester 1 - Computer Fundamentals** with:

25 Chapters covering all topics **Detailed explanations** with examples **Diagrams and tables** for visual learning **Number system conversions** with step-by-step solutions **Boolean algebra & logic gates** with truth tables **Hardware & software** complete coverage **Networking & Internet** concepts **Emerging technologies** (AI, Cloud, Cyber Security) **Important abbreviations & pioneers** **Practice questions** with solutions **Quick revision notes**