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COS101

INTRODUCTION TO COMPUTING SCIENCE

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MODULE 1 HISTORY AND EVOLUTION OF COMPUTING

Module Introduction

This module introduces the history and evolution of computer science from the pre-mechanical era to the present. It covers the history of computing and the evolution of computer technology, capturing key milestones in computing development.

Unit 1 Brief History of Computing
Unit 2 Classification of Computers

In each unit, a particular topic was explored in detail and highlighted with self-assessment exercises at the end of the unit. Finally, resources for further reading were captured at the end of each unit.

Unit 1 Brief history of computing

Unit Structure

1.1 Introduction
1.2 Learning outcomes
1.3 Pre-mechanical era (Abacus, early Computing devices)
1.4 Mechanical era (Pascaline, Analytical Engine)
    1.4.1 Characteristics of the Mechanical Era
    1.4.2 Key Inventors and Their Contributions
    1.4.3 Pascaline (Mechanical Calculator)
    1.4.4 Jacquard Loom (Mechanical Era of Computing)
1.5 Electromechanical era (Mark I)
    1.5.1 Limitations of the Electromechanical Era
    1.5.2 Transition to Electronic
    1.5.3 Connection to Babbage
1.6 The five generations of the computing era
    1.6.1 First Generation Computers
    1.6.2 Second Generation Computers
    1.6.3 Third Generation Computers
    1.6.4 Fourth Generation Computers
    1.6.5 Fifth Generation Computers
1.7 Self-Assessment Exercise(s)
1.8 Summary
1.9 References/Further Reading/Web Sources
1.10 Possible Answers to Self-Assessment Exercises



1.1 Introduction

Welcome to this course and congratulations on taking the first step into the fascinating world of computing! Every smartphone, laptop, automated system, and digital service you use today has a story that began long before the invention of the modern computer. Understanding that story helps you appreciate how today's technologies evolved and why computing continues to shape every aspect of modern life. In this unit, you will explore the fascinating journey of computing from simple manual counting devices to today's intelligent computer systems. Along the way, you will discover the important inventions, pioneering individuals, and technological developments that transformed computers into indispensable tools for education, business, healthcare, communication, and everyday life.

As you learn, consider this question: How might today's computers have looked if early inventors such as John Napier, Blaise Pascal, Charles Babbage, and Ada Lovelace had never pursued their ideas? Reflecting on this question will help you appreciate that every technological breakthrough builds upon earlier innovations.



1.2 Learning Outcome

By the end of this unit, you will be able to:

- explain the evolution of computing from the pre-mechanical era to the fifth generation of computers
- describe the major characteristics and contributions of key computing devices and inventors across the different eras of computing
- differentiate between the five generations of computers based on their technologies, features, and applications
- assess the significance of historical computing developments in shaping modern computer systems and emerging technologies such as Artificial Intelligence.



1.3 Pre-Mechanical Era of Computing

The pre-mechanical era of computing refers to the period before 1450 AD, when humans performed calculations without machines, using

simple manual tools and techniques. This era marked the foundation of information technology, where humans transitioned from spoken means of communicating to the use of early tools like the abacus. The characteristics of the pre-mechanical era are:

i. No electronic or mechanical devices
ii. calculations are done manually
iii. the system of that age depended on human intelligence and physical aids
iv. they have limited speed and accuracy
v. they are used mainly for counting, trade and record keeping.

Abacus early computing device

The Abacus is an early computing tool developed to assist humans in counting and performing basic arithmetic operations. These devices existed before modern computers and laid the foundation for today's computing systems. It is a calculating device used for performing arithmetic operations such as addition, subtraction, multiplication and division.

Structure of Abacus

It is a rectangular frame with vertical rods and wires with beads that slide along the rods. It has a horizontal bar that divides the upper and lower sections. Fig. 1 shows the image of a typical Abacus machine.

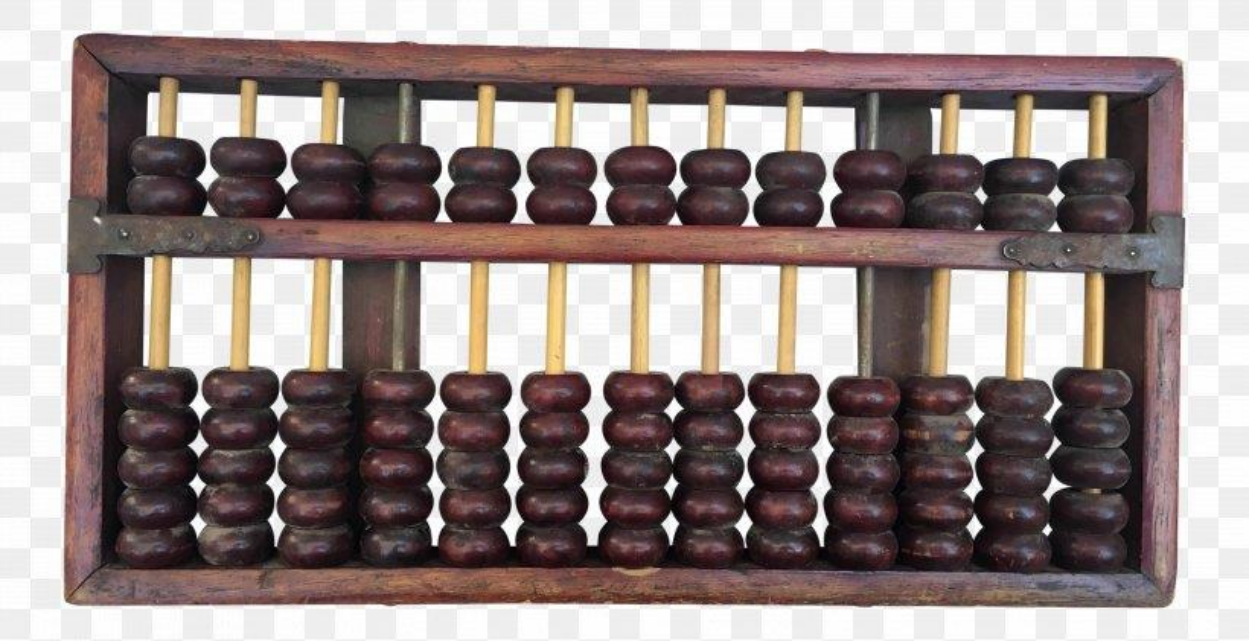


Fig. 1: Image of an Abacus machine

An abacus works by making each bead represent a numerical value; each bead can be moved upward or downward to represent numbers. Calculations are done by manipulating the beads.

1.4 Mechanical Era

The Mechanical Era of Computing refers to the period (approximately 1450 – 1840) when computation began to shift from purely manual methods to mechanical devices. This era marked a major transition from simple counting tools to more sophisticated machines capable of performing automatic calculations. During this period, inventors designed machines that used gears, levers, and wheels to perform arithmetic operations. These devices reduced human effort and improved accuracy in calculations, especially in commerce, navigation, and astronomy.

1.4.1 Characteristics of the Mechanical Era

- Use of mechanical components (gears, cogs, dials)
- Ability to perform basic arithmetic operations (addition, subtraction, multiplication, division)
- Reduction of human computational errors
- Early concept of automation in computation
- Foundation for later programmable computers

1.4.2 Key Inventors and Their Contributions

1. Napier's Bones (1617)
   Napier's Bones is an early mechanical calculating device invented in 1617 by John Napier. It was designed to simplify multiplication, division, and square root calculations using a set of numbered rods. It consists of a set of rectangular rods (often made of bone, wood, or ivory). Each rod is inscribed with numbers arranged in a special pattern that allows users to perform calculations through simple addition.

Structure of Napier's Bone
Each rod represents a digit 0-9; numbers are arranged in diagonal sections of 10 rods for digits 0-9 with 1 index rod. The rods are placed side by side to represent a number as shown in Fig. 1.

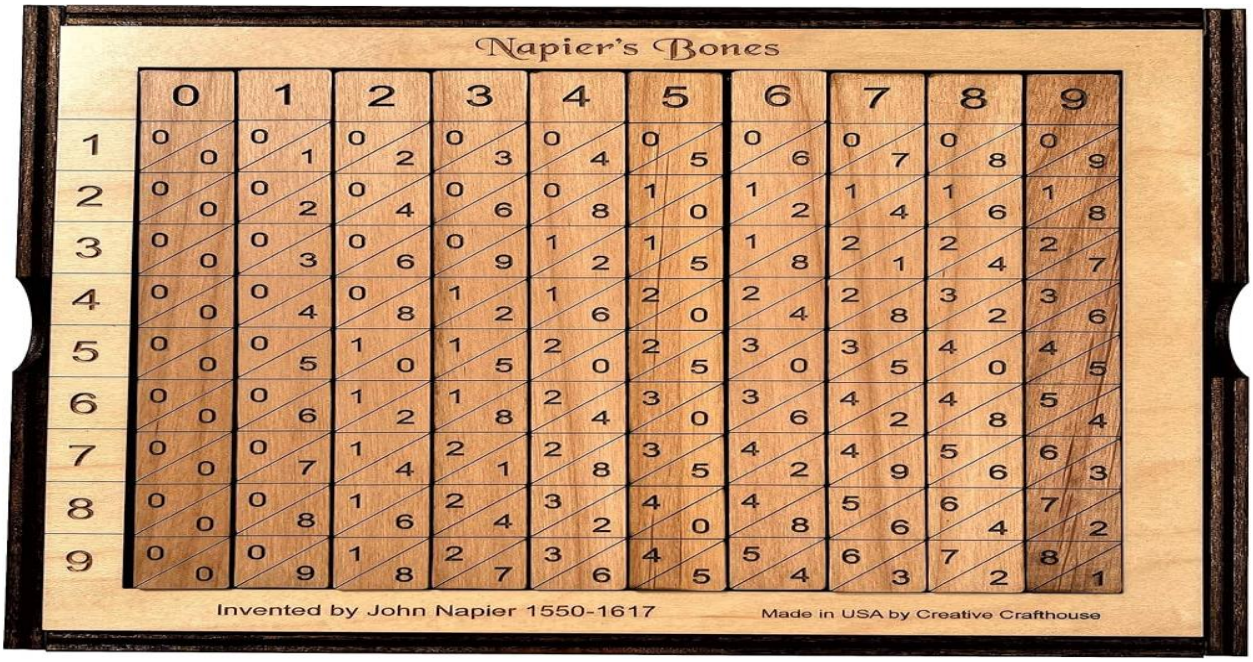


Fig. 2: Image of John Napier's bone

How It Works (Multiplication Example)
To multiply, you:

1. Select rods corresponding to the digits of the number
2. Arrange them side by side
3. Locate the row corresponding to the multiplier
4. Add numbers along the diagonals to get the result

Example: 467 × 3

- Arrange rods for 4, 6, 7
- Look at row 3
- Read diagonally and sum values:
    - Result = 1401

Main Characteristics

- Simplifies long multiplication
- Reduces calculation errors
- Requires only basic addition skills
- Portable and easy to use

Importance in Computing History

- One of the first tools to mechanise arithmetic
- Introduced the concept of algorithmic computation
- Influenced later devices like the slide rule and mechanical calculators
- Marked a transition from manual to semi-automated computation

1.4.3 Pascaline (Mechanical Calculator)

The Pascaline is one of the earliest mechanical calculators, invented in 1642 by Blaise Pascal. It was designed to help his father, a tax collector, perform accurate and fast arithmetic calculations**.** The Pascaline is a gear-driven calculating machine that performs addition and subtraction automatically using a system of interlocking wheels and gears as shown in Fig. 3.

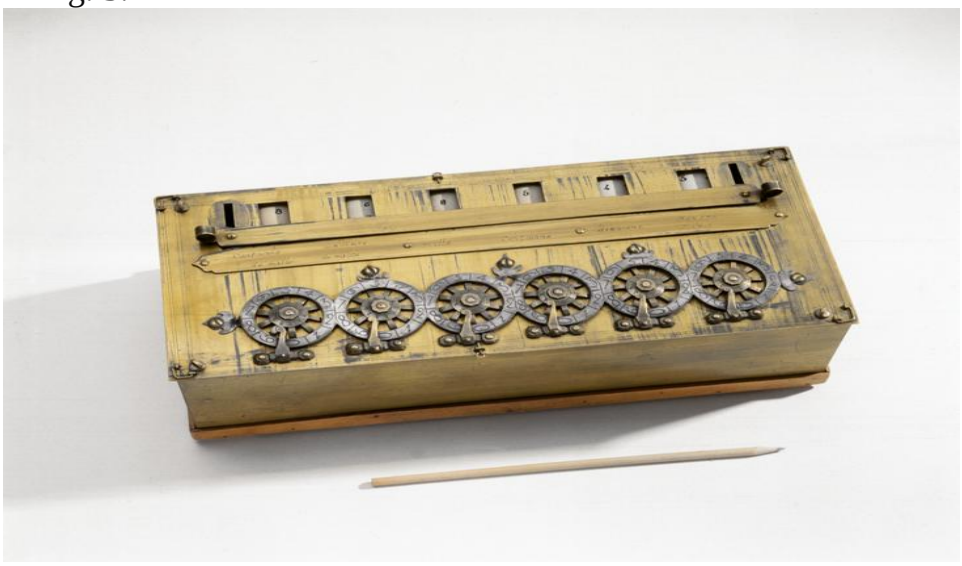


Fig. 3: Blaise Pascal machine

1.4.4 Jacquard Loom (Mechanical Era of Computing)

The Jacquard Loom is a revolutionary mechanical weaving machine invented in 1801 by Joseph Marie Jacquard. It is one of the most important devices of the Mechanical Era because it introduced programmability. The Jacquard Loom is a mechanical loom that uses punched cards to automatically control the pattern of woven fabric. Instead of manually selecting threads, the machine follows instructions encoded on cards.

The loom uses a series of punched cards; each card represents a row of the design pattern, and the holes in the card determine which threads are lifted. A sequence of cards automatically creates complex textile patterns. The Jacquard loom is the first machine to use programmable instructions to produce complex woven patterns. It reduced manual labour in textile production, and it is highly innovative for industrial manufacturing.

Importance in Computing History

The Jacquard Loom is significant because:

- It introduced the idea of input via punched cards
- Inspired early computer pioneers like Charles Babbage
- Influenced later computing systems that used punched cards, such as those by Herman Hollerith

1.4.5 Differential Engine

A differential engine is a mechanical calculator designed to tabulate polynomial functions. It was conceived by Charles Babbage in the 1820s, though the first working version was built later (e.g., the Swedish difference engine by Per Georg Scheutz in the 1850s). The machine uses the method of finite differences: for a polynomial of degree n*n*, the n*n*th difference is constant. By repeatedly adding differences, the engine generates successive values of the polynomial without multiplication or division—only addition.
Example for f(x)=x2*f*(*x*)=*x*2:

- Values: 0, 1, 4, 9, 16, ...
- First differences: 1, 3, 5, 7, ...
- Second difference: 2, 2, 2, ...

Given the constant second difference (2), starting values, and a mechanism to add columns of numbers, the machine cranks out f(x)*f*(*x*).
Babbage designed it to eliminate human errors in mathematical tables (navigation, engineering, finance). Hand-calculated tables often contained mistakes; a mechanical computer would produce reliable results.
Babbage's engines

- Difference Engine No. 1: designed but never fully built (a small section was constructed in 1832, proving the concept).
- Difference Engine No. 2: a refined design from the 1840s; never built by Babbage. In 1991, the Science Museum in London built a working replica from Babbage's drawings – it works perfectly.
- Analytical Engine: a later, more ambitious design (a general-purpose computer), but that’s distinct from the differential engine.

The differential engine is considered a direct precursor to modern computing. Babbage’s work influenced later mechanical and electronic calculators. The principle of finite differences is still used in numerical analysis and in some areas of digital signal processing.

Analytical Engine (1837)
The Analytical Engine is the later and far more ambitious design by Charles Babbage (from the 1830s onward). While the Difference Engine could only tabulate polynomials, the Analytical Engine was designed to be a general-purpose mechanical computer, the conceptual predecessor of every modern computer.

Differences between the Analytical engine and the Differential engine

Feature	Difference Engine	Analytical Engine
Purpose	Special-purpose (polynomials only)	General-purpose (any calculation)
Programmability	Fixed operation (hard-wired)	Fully programmable via punched cards
Memory	Minimal (only holds current values)	Separate "Store" (memory) – up to 1,000 40-digit numbers
Processing	Simple addition loop	Arithmetic "Mill" (CPU) – addition, subtraction, multiplication, division
Control	Mechanical sequencing	Conditional branching, loops (via punched cards)

Major components of the Analytical machine

Memory (The Store): Thousands of registers made from metal wheels that held decimal numbers.

Processor (The Mill): It performed arithmetic operations on numbers fetched from the store.

The reader: it used punched cards (inspired by Joseph Jacquard's Loom) to input programs and data.

The Printer/Plotter: It is the output of results on paper or as a curve.
Babbage envisioned three types of punched cards:

- Operation cards – Chose which operation (+, -, ×, ÷)
- Variable cards – Selected which memory addresses to use
- Number cards – Supplied constant values

The machine supported conditional branching (if-then logic) and looping making it Turing-complete in theory.

Ada Lovelace's Role

Ada Lovelace, mathematician and Babbage's collaborator, wrote the first published algorithm intended to be executed by the Analytical Engine. Her notes on the computation of Bernoulli numbers describe a sequence

of operations—making her widely recognised as the first computer programmer**.**

Why It Was Never Built in Babbage's Lifetime

- Funding: The British government withdrew support after the Difference Engine delays.
- Precision machining: Required metal parts with tolerances impossible for 19th-century workshops.
- Scale: Would have been enormous: ~15 meters long, all steam-powered.

1.5 Electromechanical Era

The electromechanical era (roughly the 1930s to 1940s) bridged purely mechanical calculators (like Babbage's engines) and fully electronic computers (like ENIAC). These machines used relays, electrically controlled mechanical switches, to perform logic and arithmetic.

Main Characteristics

- Relays as logic gates: A relay is a coil of wire that, when energised, pulls a metal contact to close (or open) a circuit. This on/off action can represent binary 1/0.
- Slow switching: Relays have moving parts, so they can only switch about 10 to 100 times per second (vs. millions in electronic computers).
- Reliable for their time: Slower than electronics, but more reliable than earlier purely mechanical gears.
- Programmability: Many used punched tape, plugboards, or stored programs (limited).

Notable Electromechanical Computers

Machine	Year	Built By	Significance
Zuse Z3	1941	Konrad Zuse (Germany)	First working program-controlled, fully automatic digital computer; used binary arithmetic; 2,600 relays
Harvard Mark I (ASCC)	1944	Howard Aiken / IBM (USA)	51 feet long; 765,000 components; 3,000 relays; decimal; used paper tape
Bell Labs Model II	1943	George Stibitz (USA)	One of first remote computing demonstrations (teletype to New York)

Machine	Year	Built By	Significance
Zuse Z4	1945	Konrad Zuse	Survived WWII; later sold to ETH Zurich; most advanced relay computer

How the Z3 Worked

- Binary floating-point arithmetic (unusual for its time)
- Programs stored on punched film stock (not electronic memory)
- No conditional branching originally (added in later designs)
- 2,600 relays, clock speed ~5–10 Hz
- Power consumption ~4 kW

1.5.1 Limitations of the Electromechanical Era

- Mechanical wear: Relays failed after thousands of operations (contact pitting, spring fatigue).
- Noise and heat: Large relay banks were deafening and required cooling.
- Speed ceiling: Moving metal can only switch so fast (milliseconds vs. microseconds for vacuum tubes).
- Size: Mark I occupied a whole room, wiring miles of cable.

1.5.2 Transition to Electronic

The Harvard Mark II (1947) was the last major relay computer. By then:

- Vacuum tubes offered thousands of times faster switching (microseconds)
- ENIAC (1946) showed electronic computing was possible (though unreliable at first)
- Transistors (1947) would soon make both relays and tubes obsolete

However, relay computers remained in use for industrial control (traffic lights, elevators, telephone exchanges) into the 1960s because they were rugged and immune to electronic noise.

1.5.3 Connection to Babbage

The electromechanical era directly realised Babbage's vision: programmable, general-purpose computation using stored numbers. The main advances were:

- Replacing mechanical gears with relays (faster, less friction)
- Replacing hand-cranked power with electric motors
- Using binary (Z3) instead of decimal (Babbage)

1.6 The five-generation era

The evolution of digital computing is often divided into generations. Each generation is 11ecognized11n11 by dramatic improvements over the previous generation in the technology used to build computers, the internal 11ecognized11n of computer systems, and programming languages. Although not usually associated with computer generations, there has been a steady improvement in algorithms, including algorithms used in computational science. The following history has been 11ecognize using these widely 11ecognized generations.

1.6.1 First Generation (1940-1956)

First-generation computers used glass tubes (vacuum tubes) that controlled the flow of electricity like valves. They were the only electronic switching devices available at that time. The computers of that generation are extremely fragile, generate extreme heat, and burn out constantly.

Programming: No keyboards or screens. People used machine language (direct binary 1s and 0s) and plugged wires into patch panels or fed punch cards.

Memory**:** Magnetic drums or delay lines (slow and limited).
Other features are:
- Very Big
- Very expensive
- Consumes electricity
- Generate a lot of heat
- They relied on machine language for performance
- Solve one problem at a time
- Input was based on punched cards and paper tape

1.6.2 Second Generation (1956-1963)

The invention of the transistor at Bell Labs (1947) replaced the vacuum tube. It was solid-state (no glass, no heating filament).

Features of second-generation computers are:
- They used Transistors
- Smaller, faster, cheaper and more energy-efficient computers
- Still relied on punched cards for input and output
- Transition from binary machine language to symbolic or assembly language
- High-level programming languages were also developed, such as

BASIC, COBOL and FORTRAN
- The first set of computers that stored their instructions in memory

1.6.3 Third Generation (1964-1971)

The third generation of computers involved wiring individual transistors together; engineers (notably Jack Kilby and Robert Noyce) figured out how to etch many transistors onto a single silicon chip and connect them internally. Other features are:
- Development of integrated circuit
- interactions were done through
- introduction of keyboards and monitors
- development of an operating system
- Smaller and cheaper computers

1.6.4 Fourth Generation (1971-Date)

The fourth generation of computers is the evolution of the CPU (Central Processing Unit), which was integrated onto a single chip. Intel released the 4004 (1971), a 4-bit CPU for calculators, which was quickly followed by the 8008 and 8080. The Personal Computer (PC) was born. Machines like the Altair 8800 (1975), Apple II (1977), and IBM PC (1981) brought computing to desks and homes. Other features are:
- Availability of microprocessor
- Thousands of integrated circuits were built onto a single silicon chip
- Intel 4004 chip and IBM computers introduced
- Smaller computers were linked together to form networks
- This development led to the Internet
- Development of Graphical User Interface (GUI)

1.6.5 Fifth Generation (Present and Future): Artificial Intelligence

- Based on Artificial Intelligence
- With the use of voice recognition, processing and superconductors
- Parallel processing and superconductors, which are helping to make artificial
  intelligence a reality.
- Quantum computation and molecular technology will radically change the face of computers in the years to come.
- The goal is to develop devices that will respond to natural language and be capable of learning.

Click on the link to watch a short video on this topic or scan the QR code with your phone;
https://youtu.be/pNWL59tB7Z0



Summary Table of the Five Generations

Generation	Period	Key Technology	Characteristics	Example Machines
First	1940–1956	Vacuum Tubes	Very large, heat-intensive, unreliable, used machine language	ENIAC, UNIVAC I, IBM 701
Second	1956–1963	Transistors	Smaller, more reliable, less heat, used assembly/high-level languages	IBM 1401, CDC 1604, UNIVAC 1107
Third	1964–1971	Integrated Circuits (ICs)	Multiple transistors on one chip, smaller/faster/cheaper, operating systems	IBM System/360, PDP-8, PDP-11
Fourth	1971–Present	Microprocessors	A complete CPU on a single chip, personal computers, networks, GUIs	Altair 8800, Apple II, IBM PC, Macintosh
Fifth	Present & Future	Artificial Intelligence (AI) & Parallel Processing	Natural language, learning, problem-solving, quantum computing (emerging)	Autonomous systems, LLMs, robots, expert systems

1.7 Self-Assessment Exercises

1. Which early computing device was primarily used for counting and performing basic arithmetic operations?
A. Analytical Engine
B. Pascaline
C. Abacus
D. ENIAC
2. Which invention first introduced the concept of programmability using punched cards?
A. Napier's Bones
B. Pascaline
C. Jacquard Loom
D. Difference Engine
3. Which generation of computers introduced the microprocessor and led to the development of personal computers?
A. First Generation
B. Second Generation
C. Third Generation
D. Fourth Generation
4. Which of the following technologies is most closely associated with the Fifth Generation of computers?
A. Vacuum tubes
B. Integrated circuits
C. Artificial Intelligence and parallel processing
D. Transistors



1.8 Summary

In this unit, you explored the evolution of computing from the pre-mechanical era to the fifth generation of computers. You learned about the key inventions, inventors, and technologies that shaped each stage of computer development, and how these innovations laid the foundation for modern computing and emerging technologies such as Artificial Intelligence.

1.9 References/Further Reading/Web Sources

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1.10 Possible Answers to Self-Assessment Exercises

1. C. Abacus
2. C. Jacquard Loom
3. D. Fourth Generation
4. C. Artificial Intelligence and parallel processing

Unit 2 Classification of Computers

Unit Structure

2.1 Introduction
2.2 Learning outcomes
2.3 Categories of Computers
2.4 Classification Based on Purpose
2.4.1 Special-Purpose Computers
2.4.2 General-Purpose Computers
2.4.3 General Attributes of General-Purpose Computers
2.5 Classification Based on Data Handled
2.5.1 Analog Computers
*2.5.*2 Digital Computers
2.5.3 Hybrid Computers
2.6 Classification Based on Size and Processing Power
2.6.1. Supercomputers
2.6.2 Mainframe Computers
2.6.3 Minicomputers
2.6.4 Microcomputers
2.7 Self-Assessment Exercises
2.8 Summary
2.9 References/Further Reading/ Web Sources
2.10 Possible solutions to Self-Assessment Exercises



2.1 Introduction

Computers are all around us, but did you know that they are designed for different purposes and tasks? Why is a smartphone suitable for personal use while a supercomputer is used to predict weather patterns or support scientific research? Understanding these differences will help you appreciate how computers are selected to meet specific needs. In this unit, you will explore the various categories of computers based on their purpose, the type of data they process, and their size and processing power. As you work through the unit, think about the different computers you use or encounter daily and consider why each one is designed for its particular role.



2.2 Learning Outcomes

By the end of this unit, you will be able to:

- classify computers according to their purpose, the type of data they process, and their size and processing power

- differentiate between special-purpose and general-purpose computers, highlighting their features and applications
- compare analog, digital, and hybrid computers based on their characteristics and areas of use
- distinguish among supercomputers, mainframe computers, minicomputers, and microcomputers, identifying their capabilities and typical applications.



2.3 Categories of Computers

Computers can be classified based on purpose, data handled, size, and processing power. These categories help in understanding their design, capability, and application.

2.4 Classification Based on Purpose

Computer classification based on purpose is of two categories: special-purpose computers and general-purpose computers. Such computers may even be designed and built to handle only one job. In such machines, the steps or operations that the computer follows may be built into the hardware. Most of the computers used for military purposes fall into this class. Other examples of special-purpose computers include:

- Computers designed specifically to solve navigational problems.
- Computers designed for tracking airplanes or missiles
- Computers used for process control applications in industries such as oil refinery, chemical manufacture, steel processing and power generation
- Computers are used as robots in factories like vehicle assembly plants and glass industries.

2.4.1 Special-Purpose Computers

Special-purpose computers are designed to perform specific tasks or a limited range of functions. They are optimised for efficiency, reliability, and dedicated operations. Key features include:

1. Dedicated Functionality: Designed to perform a single or narrow set of tasks.
2. High Efficiency: Optimised to execute assigned tasks quickly and accurately.
3. Limited Programmability: Software is usually fixed; minimal or no reprogramming is possible.
4. Embedded Design: Often built into other devices or systems to perform automatic operations.
5. Reliability: Stable and dependable performance for long periods.

6. Cost-Effective: Less expensive than general-purpose computers for dedicated tasks.
7. Minimal User Interaction: Operates automatically with little or no human intervention.

Examples: Calculators, ATM machines, traffic light controllers, washing machine controllers, and medical diagnostic equipment.

2.4.2 General-Purpose Computers

General-purpose computers are designed to perform a wide variety of tasks. Theoretically, a general-purpose computer can be adequate by means of some easily alterable instructions to handle any problems that can be solved by computation. In practice, however, there are limitations imposed by memory size, speed and the type of input/output devices. They can run different programs and are suitable for multiple applications across various domains. Key features include:

1. Versatility: Can perform many different types of tasks using different software.
2. Programmability: Can be programmed to execute a variety of instructions for different applications.
3. User Interaction: Requires human input to operate and execute tasks.
4. High Storage and Processing Capability: Can handle large amounts of data and complex computations.
5. Flexibility: Can adapt to new tasks or applications by installing new software.
6. Multi-tasking: Can run multiple programs simultaneously.

Examples: Desktops, laptops, tablets, and smartphones.

Examples of areas where general-purpose computers are employed include the following:

- Payroll
- Banking
- Billing
- Sales analysis
- Cost accounting
- Manufacturing scheduling
- Inventory control

2.4.3 General Attributes of General-Purpose Computers

General-purpose computers are more flexible than special-purpose computers. Thus, the former can handle a wide spectrum of problems.

- They are less efficient than the special-purpose computers due to such problems as the following:
- They have inadequate storage
- They have low operating speed
- Coordination of the various tasks and subsections may take time
- General-purpose computers are more complex than special-purpose computers.

2.5 Classification Based on Data Handled

Computers can also be classified based on the type of data they process. The main categories include: Analog computers, Digital computers and Hybrid computers.

2.5.1 Analog Computers

It measures rather than counts. This type of computer sets up a system model. The common type represents its variables in terms of electrical voltage and sets up a circuit that is analogous to the equation connecting them. The answer can be obtained either by using a voltmeter to read the required variable or by feeding the voltage into a plotting device. Analog computers store data as physical variables rather than numerical quantities. In theory, analog computers give an exact answer because the answer has not been approximated to the nearest digit. Whereas when we try to obtain the answers using a digital voltmeter, we often find that the accuracy is less than that obtainable from an analog computer.

It is almost never used in business systems. It is used by scientists and engineers to solve systems of partial differential equations. It is also used in control and monitoring systems in areas such as hydrodynamics and rocketry in production. Process continuous data that vary smoothly over a range and are suitable for measuring physical quantities.

- Examples: speedometers, temperature controllers, and voltmeters.

2.5.2 Digital Computers

Digital computers represent their variables as digits. The data it deals with, whether representing numbers, letters or other symbols, is converted into binary form on input to the computer. The data undergoes processing, after which the binary digits are converted back to alphanumeric form for human use. It usually processes discrete data

using binary digits (0 and 1) and consistently provides accurate, precise results.

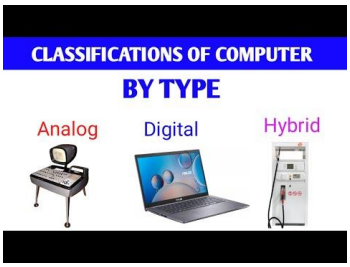
- Examples: desktops, laptops, tablets, and smartphones.

2.5.3 Hybrid Computers

Hybrid computers combine features of both analog and digital computers and typically process both continuous (analog) and discrete (digital) data. It is often used in specialised fields where high speed and precision are required.

In some cases, the computer user may wish to obtain the output from an analog computer as processed by a digital computer or vice versa. To achieve this, he set up a hybrid machine in which the two are connected, with the analog computer regarded as a peripheral of the digital computer. In such a situation, a hybrid system seeks to leverage the advantages of both digital and analog elements within the same machine. This kind of machine is usually a special-purpose device which is built for a specific task. It needs a conversion element which accepts analog inputs and outputs digital values. Such converters are called digitisers. There is also a need for a converter from analog to digital. It has the advantage of providing real-time responses continuously. Complex calculations can be handled by digital elements, thereby requiring large memory and yielding accurate results after programming. They are mainly used in aerospace and process control applications. Other examples include medical equipment such as electrocardiogram (ECG) machines, Computed Tomography (CT) scanners, industrial process controllers, and flight simulators.

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https://youtu.be/bQvhOylLArI



2.6 Classification Based on Size and Processing Power

In the past, the capacity of computers was measured solely by physical size. Today, however, physical size alone is not a good measure of capacity because modern technology has enabled greater compactness.

A better measure of capacity today is the volume of work (processing power) that a computer can handle. The volume of work a given computer can handle is closely tied to the computer's cost and memory size. Therefore, most authorities today accept the rental price as the standard for ranking computers. Computers are categorised based on size, processing power and typical usage; they are:

- Supercomputers
- Mainframe Computers
- Minicomputers
- Microcomputers

2.6.1. Supercomputers: Supercomputers are extremely powerful and fast computers. They are used for complex scientific calculations and large-scale simulations. They have large systems and are used by many people for a variety of purposes, for complex scientific calculations and large-scale simulations. Examples are: Weather forecasting systems, space research, and nuclear simulations.

2.6.2 Mainframe Computers: Mainframe computers are large computers with high processing power and storage. They usually support multiple users and applications simultaneously. It is often called “big iron” and is a high-performance, ultra-reliable, and secure computer used by large organisations for massive, real-time data processing, transaction handling, and enterprise-level applications.

- Examples: Banks, insurance companies, government databases.

2.6.3 Minicomputers: Minicomputers are often referred to as Mini PCs.

They are often medium-sized, energy-efficient desktop computers with moderate processing capabilities, designed for basic tasks like web browsing, media playback, and office applications. It usually supports multiple users but is smaller than mainframes.

- Examples: Small businesses, laboratories, and manufacturing control systems.

2.6.4 Microcomputers: This is a small, relatively inexpensive computer that uses a single microprocessor for its central processing unit (CPU). It is designed for individual use, including laptops, tablets, and smartphones, as well as embedded devices like the Raspberry Pi. They are Small, inexpensive computers designed for individual use. Types include desktops, laptops, tablets, and smartphones.

Examples: Personal computers, office PCs, mobile devices.

Click on the link to watch a short video on this topic or scan the QR code with your phone;
https://youtu.be/vvrdgwDnMQA



2.7 Self-Assessment Exercises

1. Which type of computer is specifically designed to perform a single task or a limited range of functions?

A. General-purpose computer
B. Digital computer
C. Special-purpose computer
D. Hybrid computer

2. Which type of computer processes discrete data using binary digits (0 and 1)?

A. Analog computer
B. Digital computer
C. Hybrid computer
D. Mainframe computer

3. Which category of computer is most suitable for handling large-scale scientific simulations and weather forecasting?

A. Microcomputer
B. Minicomputer
C. Mainframe computer
D. Supercomputer

4. A bank that processes millions of customer transactions simultaneously is most likely to use a:

A. Tablet computer
B. Microcomputer
C. Mainframe computer
D. Analog computer



2.8 Summary

In this unit, you learned that computers can be classified by their purpose, the type of data they process, and their size and processing capabilities. You explored the characteristics and applications of special-purpose and general-purpose computers, as well as analog, digital, and hybrid computers. You also examined the categories of computers by processing power, from microcomputers to supercomputers. Understanding these classifications provides a solid foundation for selecting the right computer for different tasks and appreciating the diverse roles computers play in modern society.



2.9 References/Further Reading/Web Sources

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2.10 Possible Answers to Self-Assessment Exercises

1. C. Special-purpose computer
2. B. Digital computer
3. D. Supercomputer
4. C. Mainframe computer

MODULE 2 BASIC COMPONENTS OF A COMPUTER SYSTEM

Unit 1 General Overview of a Computer System
Unit 2 Computer System Operation

Unit 1 General Overview of a Computer System

Unit Structure

1.1 Introduction
1.2 Learning outcomes
1.3 Definitions of Computer/computing system/computer science
1.3.1 Computer
1.3.2 Computing System
1.4 Computer system
1.4.1 The Hardware
1.4.2 Software
1.4.3 Computer user
1.5 Computing Environment
1.6 Characteristics of a computer system
1.6.1 Speed
1.6.2 Accuracy
1.6.3 Diligence
1.6.4 Automation
1.6.5 Versatility
1.6.6 Storage Capacity
1.6.7 Versatility
1.6.8 Multitasking
1.6.9 No Intelligence
1.6.10 No Emotion
1.7 Self-Assessment Exercise(s)
1.8 Summary
1.9 References/Further Reading/Web Sources
1.10 Possible Solutions to Self-Assessment Exercises



1.1 Introduction

Think about the many ways computers support your daily activities, from sending messages and browsing the internet to processing examination results and managing financial transactions. Have you considered what makes these systems work so efficiently and why computers are trusted in so many aspects of modern life?

In this unit, you will explore the basic concepts of computing, the components of a computer system, and the characteristics that make computers powerful tools for solving problems. As you study, relate these concepts to the technologies you use every day and discover how they work together to process information accurately and efficiently.



1.2 Intended Learning Outcomes

By the end of this unit, you will be able to:

- define fundamental computing concepts, including computer, computing system, data, information, algorithm, hardware, software, and ICT
- describe the components of a computer system and explain the functions of hardware, software, users, and the computing environment
- differentiate between data and information and explain the role of algorithms and programs in computer operations
- identify and explain the major characteristics of a computer system and their importance in everyday applications.



1.3 Main Content

1.3 Definitions Computer/computing system/computer science

Computing Science is the academic discipline that studies computation, computers, and information processing. It concerns how computers work, how problems are solved using algorithms, and how software and hardware systems are designed and applied in real-life situations.

In today's digital age, Computing Science plays a central role in education, business, healthcare, governance, science, and everyday human activities. Virtually all modern systems rely on computer-based technologies for efficiency and accuracy.

A computer, as shown in Fig. 1, is essentially a tool or machine used to process data and produce required information. It is capable of:

- taking input data through the keyboard (input unit),
- storing the input data in a hard disk or other medium,
- processing it in the central processing unit (CPU) and
- giving out the result (output) on the screen or the Visual Display Unit (VDU).



(DATA) (INFORMATION)

Fig. 1: A schematic diagram to define a computer

1.3.1 Computer

A computer is any machine or device which, under the control of a stored program, can accept data in a prescribed form, process the data, and supply the results as information in a specified form.

A computer is an electronic device that accepts data as input, processes it, and produces the result as output.

Computer science is the study of theory, experimentation, and engineering that form the basis for the design and use of computers.

It is the scientific and practical approach to computation and its applications and the systematic study of the feasibility, structure, expression, and mechanization of the methodical procedures (or algorithms) that underlie the acquisition, representation, processing, storage, communication of, and access to information.

1.3.2 The Computing System

The computing system consists of the computer system, the user, and the environment in which the computer is operated.

1.4 The Computer System

The computer system is made up of the hardware and the software.

1.4.1 The Hardware

The computer hardware comprises the input unit, the processing unit and the output unit.

The input unit comprises those media through which data is fed into the computer. Examples include the keyboard, mouse, joystick, trackball and scanner.

The processing unit consists of the Arithmetic and Logic Unit (ALU), the control unit, and the main memory. The main memory, also known as primary memory, consists of Read Only Memory (ROM) and Random Access Memory (RAM).

The output unit consists of the media through which data, instructions for processing the data (program), and the result of the processing operation are displayed to the user. Examples of output units include the monitor (Visual Display Unit) and the printer.

1.4.2 Software

Computer software is a set of instructions that enables a computer to perform a task or a set of tasks. A program is a set of instructions that perform a task. A series of programs linked together makes up software. Computer programs could be categorised into system software, utility software, and application programs.

1.4.3 Computer User

Computer users are different categories of personnel who operate the computer. We have expert users and casual users. The expert users could be further categorised into computer engineers, computer programmers and computer operators.

1.5 The Computing Environment

The computing environment includes the building housing the other elements of the computing system, namely the computer and the users, the furniture, auxiliary devices such as the voltage stabilizer, the Uninterruptible Power Supply System (UPS), the fans, the air conditioners, etc. The schematic diagram of the computing system is presented in Fig. 2a. to Fig. 2d.

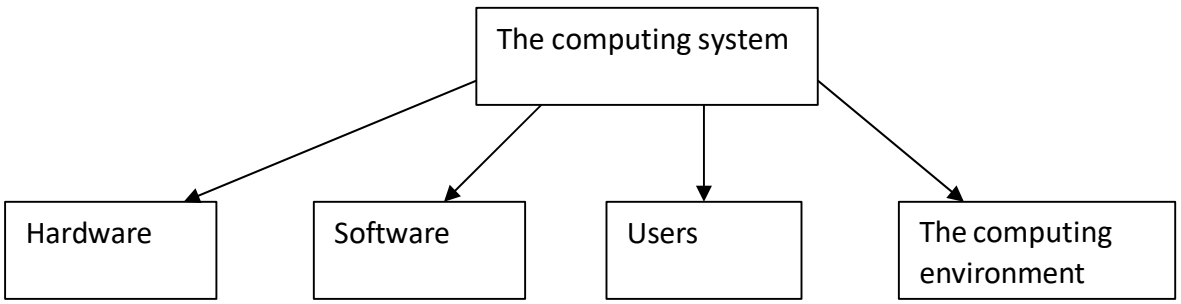


Fig 2a: A Schematic diagram of the computing system

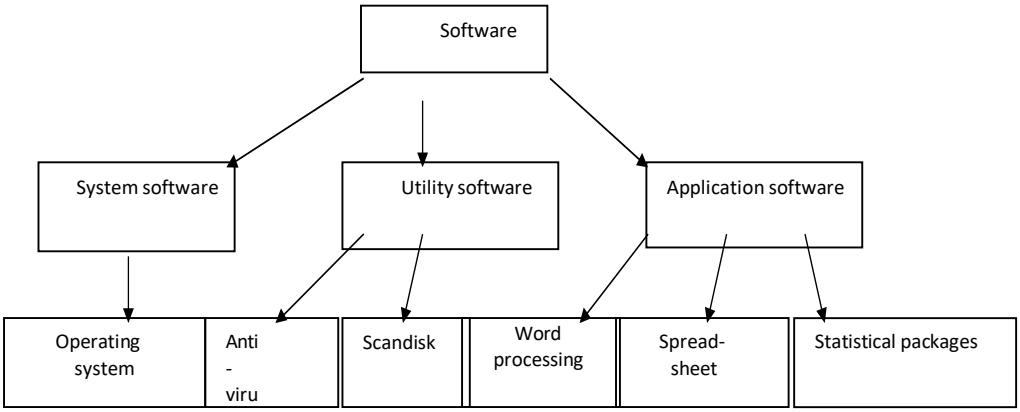

Software
System software
Utility software
Application software
Operating system
Anti - viru
Scandisk
Word processing
Spread-sheet
Statistical packages

Fig. 2b: Computer software

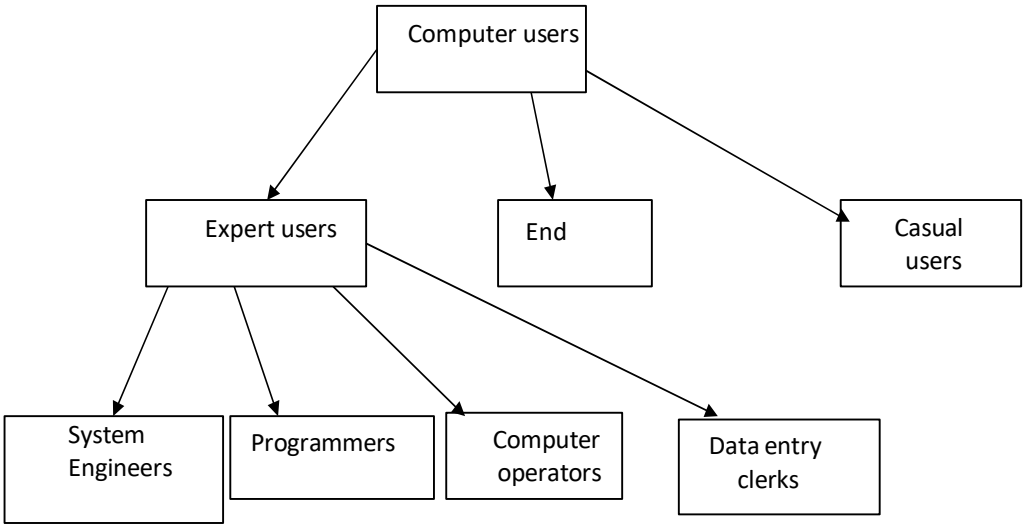


Fig. 2c: Computer users

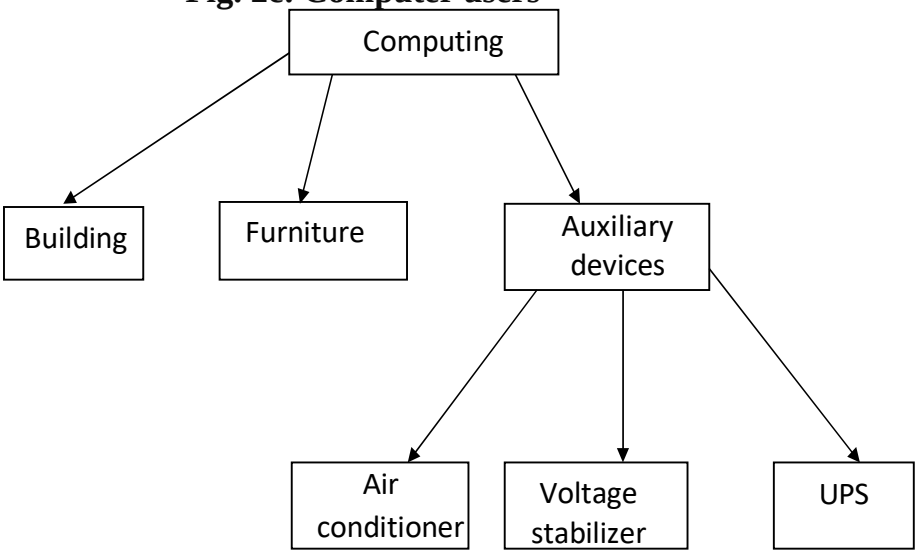


Fig. 2d: Computing environment

Data
Data are raw facts and figures that have not yet been processed.

Examples:
- Numbers: 45, 2026
- Text: "COS 101"
- Symbols and images

Information
Information is data that has been processed, organised, or structured in a way that makes it meaningful and useful to the user.
Example:
- Data: 45, 50, 60
- Information: The average score of students is 51.7

Algorithm
An algorithm is a finite, step-by-step procedure for solving a problem or performing a task.

Characteristics of an algorithm:
- Clearly defined steps
- Finite (must end)
- Well-defined input and output

Program
A program is a set of instructions written in a programming language that tells the computer how to perform a specific task.

Software
Software refers to all programs and related data that enable a computer to perform tasks.
Types of software include:
- System software (e.g., operating systems)
- Application software (e.g., word processors)

Hardware
Hardware consists of the physical components of a computer system that can be seen and touched.
Examples include:
- Keyboard
- Monitor
- Central Processing Unit (CPU)
- Printer

Human-ware
Human-ware refers to the people who interact with and manage computer systems, such as users, programmers, system analysts, and administrators.

Computer System
A computer system is an integrated combination of hardware, software, data, procedures, and human-ware working together to process information.

Information and Communication Technology (ICT)
ICT refers to technologies used for the collection, storage, processing, and communication of information. It includes computers, networks, mobile devices, and the Internet.
Units of Data
- Bit: The smallest unit of data (0 or 1)
- Byte: 8 bits
- Kilobyte (KB): 1024 bytes
- Megabyte (MB): 1024 KB
- Gigabyte (GB): 1024 MB

1.6 Main Characteristics of a Computer System

The following are the major characteristics of a computer system
Computer

A computer is an electronic device that accepts data as input, processes it according to a set of instructions, stores it, and produces meaningful output. A computer is a powerful electronic device designed to process data efficiently. Its effectiveness is largely due to certain inherent features known as characteristics of a computer**.** These characteristics distinguish computers from humans and other machines.

A computer system possesses several distinctive characteristics that differentiate it from manual and other electronic systems. These characteristics explain why computers are widely used in various fields with definite characteristics that make them unique, among which are:

1.6.1 Speed

Computers operate at extremely high speeds. The speed of a computer refers to how fast it can process data and execute instructions. It reflects the amount of work that a computer can perform within a time frame. Computers operate electronically and perform operations at very high speeds compared to humans. It can execute millions to billions of operations per second

Measurement of Speed
Computer speed is commonly measured in:
- Hertz (Hz): Number of cycles per second (CPU clock speed)
- Kilohertz (KHz) = 1,000 operations/sec

- Megahertz (MHz) = 1 million operations/sec
- Gigahertz (GHz) = 1 billion operations/sec

For very fast operations:
- Milliseconds (ms) = 10^{-3} seconds
- Microseconds (μs) = 10^{-6} seconds
- Nanoseconds (ns) = 10^{-9} seconds

Example:
A computer can calculate thousands of mathematical operations in less than a second.

1.6.2 Accuracy
Accuracy refers to a computer's ability to produce correct, precise results when processing data, provided the input and instructions are correct. Computers produce highly accurate results when given correct data and instructions. A computer does not make mistakes on its own except when supplied with wrong data.

- Errors usually arise from:
  - Incorrect input (Garbage In, Garbage Out – GIGO)
  - Faulty programs

1.6.3 Diligence (Consistency)

Diligence is the ability of a computer to perform repetitive tasks continuously over a long period of time without getting tired, bored or losing accuracy and concentration. Unlike humans, computers do not get tired or bored; they can perform repetitive tasks continuously and maintain the same level of performance over time.
Main Features of Diligence

1. No Fatigue: Works continuously without rest
2. Consistency: Produces uniform results every time
3. High Efficiency: Maintains performance regardless of workload
4. Reliability in Repetition: Ideal for routine and repetitive operations

Example:
A computer can process payroll for thousands of employees without fatigue.

1.6.4 Automation

Automation is the ability of a computer to perform tasks automatically once it has been programmed and started without further human intervention. Computers can work automatically once programmed; they

operate without constant human intervention and can follow pre-defined instructions (programs).

After a computer is given a program (set of instructions) and the required data (input), it can execute the task on its own and run to completion without additional human control or intervention.
Importance of Automation
Automation enables:

- Faster data processing
- Increased productivity
- Reduction of human effort
- Efficient handling of large tasks

Example**:**
Automated systems in banks process transactions without manual input.

1.6.5 Versatility

Versatility of a computer system is its ability to perform a wide variety of tasks and switch efficiently from one job to another. A computer is not limited to a single function; it can perform a wide variety of tasks and can be used in different fields, such as education, Medicine, Business, engineering, and so on.

Key Features of Versatility

1. Multi-purpose Use: Can be used in different fields
2. Task Switching: Easily switches from one job to another
3. Wide Application Range: Applicable in various industries
4. Adaptability: Can be reprogrammed for new tasks

Example:
The same computer can be used for typing documents, playing games, and data analysis.

1.6.6 Storage Capacity

Computers can store large amounts of data and retrieve it quickly. Storage capacity refers to a computer system's ability to store large amounts of data and information for present or future use. A computer can store data either temporarily (in primary memory like RAM) or permanently (in secondary storage like a hard drive or SSD), and the stored data can be retrieved quickly or accurately when needed at any time.

- Types of storage:
  - Primary storage (RAM)
  - Secondary storage (Hard disk, SSD or cloud storage)

1.6.7 Reliability

The reliability of a computer system is its ability to perform its operations correctly and consistently over a long period of time without failure. Computers are highly reliable machines because they can perform tasks repeatedly with consistent results and have a low failure rate when properly maintained.

A reliable computer produces accurate results consistently, operates without frequent breakdowns, and can be trusted to perform tasks under the same conditions every time.

Example:
Used in critical systems such as banking and air traffic control.
Also, in an examination system where the accurate computation of results is of utmost importance.

1.6.8 Multitasking

Multitasking is the ability of a computer system to execute multiple tasks or programs simultaneously. A computer achieves multitasking by rapidly switching the CPU between tasks (context switching) and by allocating system resources efficiently.

Although tasks may not run literally at the same instant (on a single CPU), the speed of switching makes it appear simultaneous.
Computers can perform multiple tasks at the same time.

- Example:
  - Playing music while typing a document
  - Running multiple applications simultaneously

1.6.9 No Intelligence (Lack of Common Sense)

No intelligence means a computer cannot think, reason, or make decisions on its own. It operates strictly according to the instructions provided by humans. Computers follow programs blindly and cannot improvise.

- They cannot learn, understand context, or make judgments like humans.
- Any “smart” behaviour comes from programming or artificial intelligence models created by humans.

Computers do not think or make decisions on their own.

- They only follow instructions given to them
- Cannot act beyond programmed logic

Key Point:
Computers depend entirely on human input and programs.

1.6.10 No Emotions

The no emotions feature means that a computer cannot feel happiness, sadness, anger, or any other human emotion. It operates purely on logic and instructions.

Computers have no feelings or emotions.

- They do not get tired, angry, or happy
- Decisions are purely logical

Click on the link to watch a short video on this topic or scan the QR-code with your phone;
https://youtu.be/zV34VW5X7AY



1.7 Self-Assessment Exercises

1. Which of the following best defines information?

A. Raw facts and figures that have not been processed
B. A collection of computer hardware components
C. Processed data that is meaningful and useful to users
D. A set of programming instructions

2. Which component of a computer system is responsible for executing calculations and logical operations?

A. Input Unit
B. Arithmetic and Logic Unit (ALU)
C. Output Unit
D. Monitor

3. Which characteristic enables a computer to perform repetitive tasks continuously without becoming tired or losing accuracy?

A. Automation
B. Reliability
C. Diligence
D. Multitasking

4. Which of the following is an example of system software?

A. Spreadsheet application
B. Web browser
C. Operating system
D. Presentation software



1.8 Summary

In this unit, you learned the fundamental concepts of computing, including the meanings of computer, computing system, data, information, algorithms, hardware, software, and ICT. You also examined the components of a computer system and the roles of users and the computing environment. Finally, you explored the key characteristics of computers, such as speed, accuracy, diligence, automation, versatility, storage capacity, reliability, multitasking, and their dependence on human instructions.



1.9 References/Further Reading/Web Sources

Brookshear, J. G., & Brylow, D. (2020). *Computer Science: An Overview* (13th ed.). Pearson Education.

Forouzan, B. A., & Mosharraf, F. (2017). *Foundations of Computer Science* (3rd ed.). McGraw-Hill Education.

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1.10 Possible Answers to Self-Assessment Exercise

1. C. Processed data that is meaningful and useful to users
2. B. Arithmetic and Logic Unit (ALU)
3. C. Diligence
4. C. Operating system

Unit 2 Computer System Operation

Unit Structure

2.1 Introduction
2.2 Learning Outcomes
2.3 Overview of System Operation
2.4 The fundamental cycle
2.5 The Basic Instruction Cycle (Fetch–Decode–Execute Cycle)
2.6 Self-Assessment Exercise(s)
2.7 Summary
2.8 References/Further Reading/Web Sources
2.9 Possible Answers to Self-Assessment Exercises



2.1 Introduction

Welcome to this unit. Every time you send a message, browse the internet, save a document, or watch a video, your computer performs thousands of operations in the blink of an eye. But have you ever stopped to think about how these operations happen? How does the computer receive information, process it, store it, and produce the results you see on your screen? In this unit, you will explore the concept of system operation, the stages of the Information Processing Cycle, and the basic functions performed by every computer system. You will also discover how the CPU executes instructions through the Fetch–Decode–Execute Cycle, giving you a clearer understanding of what happens behind the scenes whenever a computer performs a task.



2.2 Learning Outcomes

By the end of this unit, you will be able to:

- **explain** the concept of system operation and describe how the components of a computer system work together to process information
- **describe** the stages of the Information Processing Cycle and the four fundamental functions of a computer system
- **differentiate** between the Information Processing Cycle and the Fetch–Decode–Execute (Instruction) Cycle
- **illustrate** how the CPU executes program instructions using the Fetch–Decode–Execute Cycle and relate it to everyday computing activities.



2.3 Overview of System Operation

A system is a collection of interrelated components that work together to achieve a common goal. In computing, a system consists of hardware, software, data, procedures, and users working together to process information efficiently and accurately.

Every computer system is designed to transform raw data into meaningful information. This transformation is achieved through a sequence of coordinated activities known as **system operation**. System operation describes how the various components of a computer system communicate and interact to receive data, process it according to programmed instructions, store it when necessary, and present useful results to users.

Although the operation of a computer may appear complex, it follows a simple and continuous pattern:

Input → Processing → Storage → Output → Feedback
Behind this seemingly straightforward sequence is a highly coordinated interaction between the computer's hardware and software. The hardware performs physical operations, while the software provides the instructions that direct every activity the computer performs.

Understanding system operation helps learners appreciate how computers solve problems, automate tasks, and support decision-making in homes, schools, businesses, hospitals, industries, and government organisations.

2.4 Concept of System Operation

System operation refers to the sequence of activities through which a computer system receives data (input), processes it according to programmed instructions, stores it when necessary, and produces meaningful information (output). In many systems, feedback is also provided to monitor performance and improve future operations.

At its core, every computer system follows a logical workflow that ensures:

- Data is correctly received from input devices or other sources.
- Instructions are accurately interpreted and executed.
- Information is processed efficiently and reliably.
- Results are presented in a useful form to the user.
- Data and results are stored for future retrieval where necessary.
- Feedback is provided to confirm successful processing or identify errors that require correction.

Whether sending an email, printing a document, processing examination results, or withdrawing money from an Automated Teller Machine (ATM), the same basic operational principles apply.

2.5 The Fundamental Instruction Cycle

The operation of every computer system follows a continuous cycle known as the **Information Processing Cycle**. This cycle illustrates how data flows through the system from the moment it is entered until meaningful information is produced and stored.

The cycle consists of five major stages:
Input → Processing → Output → Storage → Feedback
Each stage plays an important role in ensuring that the computer performs its tasks accurately and efficiently.

The Five Stages of the Information Processing Cycle

Stage	Description	Examples
Input	Data and instructions are entered into the computer system.	Keyboard, mouse, touchscreen, scanner, microphone, webcam, sensors
Processing	The CPU performs calculations, comparisons, logical operations, and decision-making based on program instructions.	Calculating totals, sorting records, spell checking, image processing
Output	The processed information is presented to the user or another device.	Monitor, printer, speakers, projector
Storage	Data, instructions, and results are saved for immediate or future use.	RAM, SSD, hard disk, flash drive, cloud storage
Feedback	The system reports the outcome of processing or requests corrective action where necessary.	Error messages, confirmation notifications, progress indicators

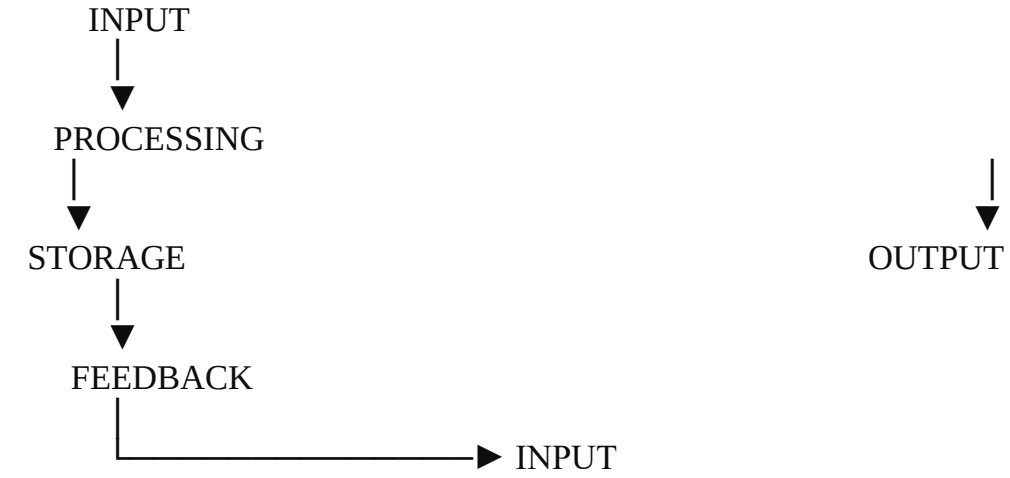
The process is continuous because the output of one operation often becomes the input to another, allowing computers to perform complex tasks efficiently.

The Four Fundamental Functions of a Computer System

Regardless of their size or purpose, all computer systems repeatedly perform four essential functions:

Function	Description	Examples
Input	Accepting data and instructions from users or external devices.	Keyboard, mouse, touchscreen, scanner, camera
Processing	Executing instructions and transforming data into meaningful information.	Arithmetic calculations, logical comparisons, data sorting
Storage	Saving data temporarily or permanently for future use.	RAM, SSD, hard disk, USB flash drive
Output	Delivering processed information to users or other devices.	Monitor, printer, speakers, projector

These functions work together continuously throughout the computer's operation.



2.6 The Basic Instruction Cycle (Fetch–Decode–Execute Cycle)

While the Information Processing Cycle describes how a computer system handles data, the **Instruction Cycle** explains how the **Central Processing Unit (CPU)** executes individual program instructions.

Every program consists of thousands or even millions of instructions stored in the computer's memory. The CPU processes these instructions one after another using a repetitive sequence known as the **Fetch–Decode–Execute Cycle**.

The cycle consists of the following stages:

Step 1: Fetch
The Control Unit retrieves the next instruction from the computer's main memory (RAM) and places it into the processor for execution.

Step 2: Decode
The Control Unit interprets the instructions to determine the operation that must be performed, such as addition, subtraction, comparison, or data movement.

Step 3: Execute
The CPU carries out the instructions. This may involve:

- Performing arithmetic calculations.
- Comparing data.
- Moving information between memory locations.
- Receiving input from devices.
- Sending results to output devices.

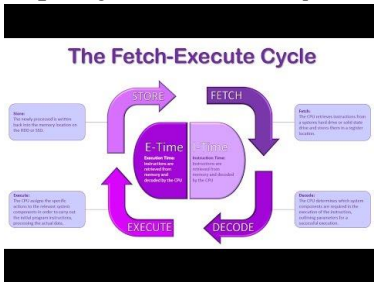
Step 4: Store (where necessary)
If the instruction produces new data or results, the CPU stores them in memory or secondary storage for later use.

Step 5: Repeat
The CPU immediately fetches the next instruction and repeats the cycle until the program has finished executing.

This sequence occurs billions of times every second in modern processors, enabling computers to perform multiple operations with remarkable speed and accuracy.

Note: The Fetch–Decode–Execute Cycle is often referred to as the **Instruction Cycle** because it describes how the CPU processes each instruction contained in a program. It forms the fundamental operating principle of every digital computer.

Click on the link to watch a short video on this topic or scan the QR code with your phone;
https://youtu.be/xs5oq-i_rTc



2.7 Self-Assessment Exercises

1. Which of the following best describes system operation?

A. The process of manufacturing computer hardware
B. The sequence through which a computer receives, processes, stores, and produces information
C. The installation of software on a computer
D. The maintenance of computer equipment

2. Which stage of the Information Processing Cycle is responsible for performing calculations and logical operations?

A. Input
B. Storage
C. Processing
D. Feedback

3. During the Fetch–Decode–Execute Cycle, what happens during the Decode stage?

A. The CPU stores the processed data.
B. The Control Unit interprets the instruction to determine the required operation.
C. The CPU retrieves data from an output device.
D. The processor displays the results on the monitor.

4. Which of the following correctly represents the basic sequence of the Fetch–Decode–Execute Cycle?

A. Decode → Execute → Fetch
B. Fetch → Store → Execute
C. Fetch → Decode → Execute
D. Input → Output → Storage



2.6 Summary

In this unit, you learned that every computer system operates through a coordinated process involving input, processing, storage, output, and feedback. You also explored the four fundamental functions of a computer system and examined how the CPU executes instructions using the Fetch–Decode–Execute Cycle. Understanding these concepts provides a solid foundation for appreciating how computers process data accurately, efficiently, and continuously.



2.8 References/Further Reading/ Web Sources

David A. Patterson and John L. Hennessy (2021) Computer Organisation and Design: The Hardware/Software Interface, 6th Edition.

Andrew S. Tanenbaum (2012) Structured Computer Organisation, 6th edition, Pearson Education.



2.9 Possible Solution to Self-Assessment Exercises

1. B. The sequence through which a computer receives, processes, stores, and produces information
2. C. Processing
3. B. The Control Unit interprets the instruction to determine the required operation.
4. C. Fetch → Decode → Execute

MODULE 3 COMPUTER SYSTEM ELEMENTS

Unit 1 Input Devices
Unit 2 Output Devices
Unit 3 Processing Unit
Unit 4 Auxiliary Devices
Unit 5 Computer Hardware Components
Unit 6 Computer Software Components

Unit 1 Input Devices

Units Structure

1.1 Introduction
1.2 Intended learning outcomes
1.3 The Computer Keyboard
1.3.1 Function keys
1.3.2 Alphanumeric Keys
1.3.3 Cursor Control Keys
1.3.4 Numeric Key Pad
1.3.5 Shift Key
1.3.6 Caps Lock Key
1.3.7 Num Lock Key
1.3.8 Control Key
1.3.9 Escape Key
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1.4 The Mouse
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1.8 Summary
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1.10 Possible Answers to Self-Assessment Exercises



1.1 Introduction

Welcome to this unit. Think about the last time you used a computer to type a document, click an icon, scan a photograph, or play a game. How did the computer receive your instructions? Before a computer can process information, it must first receive data through input devices. In this unit, you will explore the various devices used to enter data and

instructions into a computer, with particular emphasis on the computer keyboard and its different keys. You will also learn about other common input devices such as the mouse, joystick, and scanner, and discover how each contributes to efficient interaction with a computer system. As you study this unit, consider how these devices make computing faster, easier, and more user-friendly in everyday life.

1.2 Learning outcomes

By the end of this unit, you will be able to:

- define an input device and explain its role in computer operations
- identify the major types of input devices and describe their functions
- distinguish between the different sections and special keys of a computer keyboard
- demonstrate appropriate use of common input devices for entering data and controlling computer operations.

1.3 The Computer Keyboard

A computer keyboard is identical to the conventional typewriter keyboard. However, it has more keys than the typewriter keyboard. A computer keyboard can be a dummy type or an intelligent type. A computer keyboard is considered to be intelligent if, in addition to performing the routine functions characteristic of a typewriter keyboard, it can initiate a series of actions for a computer to carry out by merely pressing a key or combination of two or more keys. Thus, an intelligent computer keyboard has a set of keys that, when one is pressed, cause the computer to perform a specific function. Fig. 1 shows an image of a computer keyboard. For example, pressing a key may cause the computer to display a menu from which the user is prompted to select one.



Fig. 1: Image of a Computer Keyboard

The intelligent computer keyboard has four major divisions: Function keys, Alphanumeric keys, Numeric keys, and Control keys.

In addition to the four types of keys, there are some special or important keys such as the following:
(a) Return or Enter key
(b) Escape key denoted by ESC
(c) Control key denoted by CTRL
(d) Alternate key denoted by ALT
(e) Delete key denoted by DEL
(f) Insert key denoted by INS
(g) Backspace key
(h) Shift key.

1.3.1 Function Keys

The effects of the function keys are software-package-dependent. That is, they mean different translations depending on which software package one is running on the computer. The function keys are traditionally labeled F1, F2, F3, F4, F5, F6, F7, F8, F9, F10, F11 and F12. The function keys are often arranged to the left of the main keyboard in two columns or they are arranged in a row above the main keyboard. In most software packages, the function key F1 is used to run the HELP program. WordPerfect, for example, uses F3 for the HELP program and F1 to cancel the last command issued. The function keys F7 and F12 are used to save a text and block a section of a text, respectively, in WordPerfect. Function keys can be programmed to carry out the functions desired by a programmer. For example, the function key F10 may be programmed to display menus. Thus, the functions of the function keys can be determined by the user or programmed by the software package in use at any time.

1.3.2 Alphanumeric Keys

The Alphanumeric keys can be likened to the conventional typewriter keys. They contain alphabetic characters, numeric characters and special characters such as comma, full stop, open bracket, close bracket, asterisk, semicolon, colon, question mark, and so on. Usually, each key has a character on the lower part and another on the upper part. The SHIFT key is used by the programmer to switch the lower- and uppercase characters on or off.

1.3.3 Cursor Control Keys

The cursor marks the active or current spot on the screen. It is an indicator that tells the user where in the midst of a document the system

is pointing to. It may be a rectangular bar of light or a blinking underscore. When a text is being typed, the cursor moves as the carriage on a keyboard moves, and characters are typed in. The cursor control keys include four directional arrow keys.

Table 2: Control Keys and their Functions

Control Key	Functions
	Moves the cursor one line up.
	Moves the cursor one line down
	Moves the cursor one character to the right
	Move the cursor one character to the left.
Home	Moves the cursor to the beginning of a line or page
End	Move the cursor to the bottom left of a page or to the end of the current line in most text editors.
PGDN	Moves the cursor to the top of the next page in the document or text. For example, pressing this key while on page 5 of the text will place the cursor at the top of page 6 of the text.
PGUP	Moves the cursor to the top of the previous page. For example, if you are on page 3 of a document, pressing this key will place the cursor at the top of page 2 of the document.

Other cursor control keys are Home, Page Up, Page Down, and End. These keys may be part of the numeric keypad or separate from it. Moving the cursor around on the screen is one of the most common tasks in an application program. In fact, cursor movement is so important in an application such as word processing that it can usually be accomplished by additional key-driven commands. The control keys and their functions are documented in Table 2.

1.3.4 The Numeric Keypad

The numeric keypad contains a set of keys required for typing or entering number digits 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 into the computer store. A numeric key is often activated by pressing the Numlock Key. The numeric keypad is also used in combination with the Alternate (Alt) key to produce extended characters. Extended characters are characters not normally found on most keyboards. For example, to produce the character alpha, denoted ‘α, one holds down the Alt key and presses 224;

to produce the character beta, denoted by 'β, one holds down the Alt key and presses 255; and to produce the pound sterling sign denoted by '£', one holds down the Alt key and presses 156.

1.3.5 The Shift Key

When the shift key is pressed, the capital letters on the alphanumeric keys are activated. It also serves as the activator of characters that are at the upper part of each alphanumeric key. The Shift key has no effect on itself; its effect is realised when some other keys are pressed. Thus, if one presses the shift key and then the 'equals' sign key, the 'plus' sign, which is at the upper part of the 'equal' sign, is activated, and it then appears on the screen.

1.3.6 The Caps Lock Key

The Caps Lock shifts all alphabetic characters into the uppercase (capital letters). Thus, all characters typed are in lower case (small letters) when not pressed.

1.3.7 The Num Lock Key

The Num Lock key activates the numeric keypad. Neither the Num Lock key nor the Caps Lock key affects the function keys.

1.3.8 The Control Key (Ctrl)

The control key is often used in most text modes to perform block operations like mass deletion, insertion and so on. For example, Ctrl + Y deletes a line in most text documents. It can also be used in combination with other keys to move the cursor to different locations in a text or document. In some application packages, the Alt, Ctrl and Shift keys are used in combination with the function keys to perform several operations.

1.3.9 The Escape Key (Esc)

The escape key cancels an operation in progress. For example, when one is editing a file or issuing a command, Esc cancels any changes one might have made or terminates the command.

1.3.10 The Return or Enter Key

The return key serves as one of the most important keys on most keyboards. It is used to signal to the computer the end of an input or

command. It performs two functions depending on the program it is used with. For example, suppose you are asked to respond to an operating system command at the prompt or other entries; the operating system will wait until the return key is pressed before continuing. Pressing the return key also positions the cursor at the beginning of the next line (in text mode), which is the equivalent of pressing the carriage return on a typewriter.

1.3.11 The Insert Key (Ins)

Pressing the insert key puts one's keyboard in insert mode; pressing it again returns to overstrike (type over) mode. In the insert mode, the characters one types are inserted at the cursor position, the character at the cursor position and all characters to the right shift to make room for them. In overstrike or type-over mode, newly typed characters overwrite the characters at the current cursor position. In most applications, the insert mode is indicated by a symbol in the status line.

1.3.12The Back Space Key

The backspace key deletes the characters to the left of the cursor when pressed, and all other characters to the right of the cursor are shifted one space to the left.

The Spacebar

The spacebar is the longest key found on most keyboards. It erases characters at the cursor position or gives a blank space when pressed.

1.3.13 The Tab Key

The tab key moves the cursor by five spaces to the right when pressed. The number of positions moved depends on the software or the Tab Set by the operator. The Tab is normally pressed to insert paragraphs during typing. In some programs, when this key is pressed in combination with the shift key, the same number of positions is moved backwards.

The Print Screen Key (Prtsc)
When the Print Screen key is pressed in combination with the Shift key, whatever is on the screen will be printed to a printer. The same effect can be achieved by pressing the key alone on some keyboards.

1.4 The Mouse

A computer mouse is a handheld input device used to control cursor movement on a computer screen and interact with graphical user

interfaces. It looks like the electrical clipper in a barber's shop. It consists of a pointing device that is very sensitive to movements. It has a roller ball and two or more buttons which can be pressed to make a selection. By moving the mouse on a flat, smooth surface and clicking one or both buttons on its upper surface, a computer connected to it can be sensitised and commanded to carry out specific tasks. Fig. 2 below shows the image of a mouse.

A mouse can be used to draw diagrams on the computer screen more effectively and efficiently than the computer keyboard. Generally, the keyboard and the mouse do complement each other. For example, the mouse can be used to highlight an item in a menu list, while the keyboard Enter Key can be pressed to activate the command associated with the highlighted item.

A mouse is the primary input device for modern computers that feature operating systems with a graphical user interface, such as Windows 98 or Windows XP. While keyboards obviously excel at entering text, numbers, and symbols, your mouse is the tool you'll use to tell your computer what to do with all the data you've entered.
Key Parts of a Mouse

- Left Button → Selects items
- Right Button → Opens context menus
- Scroll Wheel → Scrolls through pages
- Optical Sensor → Detects movement
- Cable/Wireless Receiver → Connects to the compute



Fig. 2: Image of a mouse

1.5 Joystick

Joysticks are almost exclusively used with game software and help the user more effectively control the actions of computer-simulated airplanes or arcade-style games.

All modern PC operating systems (Windows 98, Windows XP, and the Macintosh) rely on an on-screen pointer to select and execute commands.

A mouse is simply an input device designed to help the user control the on-screen pointer as naturally and efficiently as possible.

Fig. 3 shows an image of a joystick.



Fig. 3: Image of a Joystick

The pointer on the screen mimics the movements of your mouse. As you move your mouse, a ball encased in the bottom of your mouse rolls on the desk and, in turn, sends signals to the computer as to which direction to move the pointer on the screen. Move the mouse side to side, or up and down, and the on-screen pointer moves in a similar manner.

Once you have the mouse positioned to select the command or data you want to act on, you use the mouse buttons to execute the command. The mouse controls the on-screen pointer, allowing you to select program icons, manipulate property sheets, and access data.

1.6 Scanner

The scanner uses the pictures and pages of text as input. It scans the picture or a document. The scanned picture or document is then converted into a digital format and is displayed on the screen as an output. It uses optical character recognition techniques to convert images into digital ones. Some of the common types of scanners are as follows: Types of Scanner: i) Flatbed Scanner: It has a glass pane and a moving optical CIS or CCD array. The light illuminates the glass pane, and then the image is placed on it. The light moves across the glass pane and scans the document, and thus produces its digital copy. You will need a transparency adapter while scanning transparent slides. ii) Handheld Scanner:



Fig. 4: Scanner

1.7 Self-Assessment Exercise

TRUE or FALSE Response

1. An input device enables users to enter data and instructions into a computer system.
2. The **Function keys (F1–F12)** perform the same function in every software application.
3. The **Caps Lock** key allows you to type all alphabetic characters in uppercase without holding down the **Shift** key.
4. A **scanner** converts printed text and images into digital format for processing by a computer.
5. A **joystick** is mainly designed for entering large amounts of text into a computer.
6. The **Enter (Return)** key is commonly used to confirm a command or move the cursor to the beginning of the next line in text editing.

1.8 Summary

In this unit, you learnt that input devices serve as the communication link between users and computers by enabling users to enter data and instructions into the system. You examined the computer keyboard, its sections, and the functions of key combinations. You also explored other commonly used input devices, including the mouse, joystick, and scanner, together with their features and applications. Understanding these devices provides the foundation for effective computer operation and improves users' ability to interact efficiently with modern computer systems.



1.9 References/Further Reading/Web Sources

Akinyokun, O.C. (1999). *Principles and Practice of Computing Technology*. Ibadan: International Publishers Limited.

Balogun, V.F., Daramola, O. A., Obe, O.O., Ojokoh, B.A., and Oluwadare, S.A. (2006). *Introduction to Computing: A Practical Approach.* Akure: Tom- Ray Publications.

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Larry Long (1984). *Introduction to Computers and Information Processing*. Prentice-Hall Inc. New Jersey.



1.10 Possible Answers to Self-Assessment Exercise

1. True
2. False
3. True
4. True
5. False
6. True

Unit 2 Output Devices

Unit Structure

2.1 Introduction
2.2 Intended Learning Outcomes
2.3 Printers
2.3.1 Laser Printer
2.3.2 Ink-jet Printer
2.3.3 Dot-Matrix Printer
2.4 Monitors
2.4.1 Cathode Ray Tube Monitor
2.4.2 Liquid Crystal Display (LCD) Monitor
2.4.3 Organic LED (OLED) Monitor
2.3.4 Touchscreen Monitor
2.5 Speaker and Sound
2.5.1 Components for Sound on Your PC
2.5.2 Sound Cards
2.6 Self-Assessment Exercises
2.7 Summary
2.8 References/Further Reading/Web Sources
2.9 Possible Answers to Self-Assessment Exercises



2.1 Introduction

Take a moment to look around you. Whether you are reading information on a monitor, printing a document, or listening to music through speakers, you are interacting with computer output devices. These devices transform processed data into forms that people can see, hear, or use, enabling communication between the computer and the user. In this unit, you will explore the different types of output devices, including printers, monitors, speakers, and sound cards. As you work through the unit, consider how each device serves a unique purpose and why selecting the appropriate output device is important for different computing tasks. By the end of the unit, you will have a solid understanding of how computers present information effectively in everyday life.



2.2 Learning outcomes

By the end of this unit, you will be able to:

- explain the functions of common computer output devices
- distinguish between different types of printers and monitors based on their features and applications

- describe the components required for computer sound output and their functions
- select appropriate output devices for different computing tasks and user needs.

2.3 Printers

A printer is an output device that produces text and graphics on a physical medium such as paper. Printed information is often called hard copy because the information exists physically and is a more permanent form of output than that presented on a VDU (Monitor). Printers can be grouped into impact and non-impact printers. A printer is the computer component that lets you create copies of information stored on your computer onto paper. The printed material is often called the hard copy, to differentiate it from the data stored on a disk or held in the computer's memory.

There are three basic types of printers available for use with personal computers:

2.3.1 Laser Printers

These combine a magnetic roller with powdered ink called toner to transfer high-quality characters or images onto a page. The image is as shown in Fig. 1



Fig. 1: Image of a laser printer

2.2.2 Inkjet Printers

These have small nozzles that actually spray fast-drying ink onto the page to form characters or images. Inkjet printers spray fine, quick-drying ink through small nozzles to produce characters and images on paper. Although the results are not quite as sharp as those of laser printers, inkjet printers provide very good quality output at a lower cost. The image is shown in Fig. 2



Fig. 2: Image of an inkjet printer

2.2.3 Dot-matrix Printers

These use a print head to strike an inked ribbon against paper, like a typewriter, creating characters out of a series of dots. Dot-matrix printers are the cheapest printers available. They create text and images on the page by hammering several small pins against an inked ribbon. The more pins used, the better the image. The 9-pin and 24-pin are common options. The 24-pin printers produce higher-quality output but are somewhat slower than the 9-pin printers.

Print quality for dot-matrix printers is often described in terms of mode: draft mode (low resolution), near-letter-quality mode (medium resolution), or letter-quality mode (high resolution). The speed depends on the mode, with the draft mode being the fastest.

The type of printer you choose depends on your budget and the type of output you need. For example, if all you need to print are grocery lists, you may be happy with a dot-matrix printer. In general, dot-matrix printers are noisier, slower, and produce a poorer-quality image than do laser or inkjet printers, but they are also less expensive. If you need to print newsletters, brochures, or illustrated reports, you will probably want a high-quality laser printer. Laser printers cost more than other printers, but they may be worth the price because they are fast, quiet, and produce high-quality text and graphics. Fig. 3 shows the image of a dot-matrix printer.

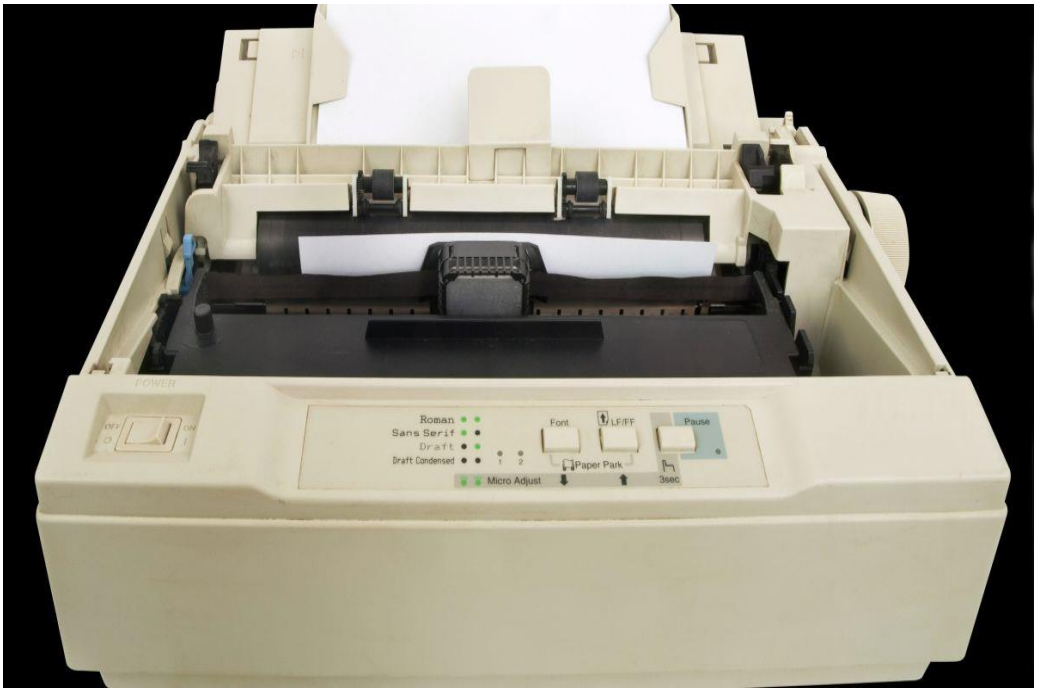


Fig. 3: Image of a Dot-matrix printer

2.4 Monitors

The monitor does not do any processing itself. It only displays the information the video card tells it to. A monitor (or display screen) is the primary output device of a computer. It visually presents the results of processing text, images, videos, and graphical user interfaces, allowing the user to see and interact with the computer. A monitor is an output device of a computer system that displays information generated by the computer in a visual form.

A monitor (also called a Visual Display Unit – VDU) is a hardware component that shows processed data (information) from the computer to the user. It converts electronic signals from the system unit into text, images, videos, and graphical output.

2.4 Types of Monitors

2.4.1 Cathode Ray Tube (CRT) Monitor

A CRT monitor is a type of computer display device that uses a Cathode Ray Tube (CRT) to produce images on a screen. It was the earliest widely used monitor technology before LCD and LED displays became popular. An image of a CRT monitor is shown in Fig. 4.



Fig. 4: Image of a CRT monitor

2.4.2 Liquid Crystal Display (LCD) Monitor

An LCD monitor is a type of flat-panel display screen that uses liquid crystal technology to show images when light passes through it. Fig. 5 shows an image of an LCD monitor.



Fig. 5: LCD monitor

2.4.3 Organic LED (OLED) Monitor

An OLED monitor is a type of display screen that uses Organic Light Emitting Diodes (OLEDs) to produce light directly from each pixel**.** Fig. 6 shows an OLED monitor



Fig. 6: Image of OLED monitor

2.4.4 Touchscreen Monitor

A touchscreen monitor is a type of computer display that serves as both an output device (displays information) and an input device (receives commands via touch). Instead of using a mouse or keyboard for all

operations, users can interact directly with what is displayed on the screen by touching it with fingers or a stylus.

2.5 Speakers and Sound

The built-in speakers in most PC cases are used only to play system sounds, such as warning beeps and action indicators. To play more sophisticated sounds on your PC, you need a set of external speakers. Usually, speakers come in pairs, with a plug that connects them to your sound card. Arrange the speakers with one on the left and one on the right of your desk or work area to get a stereo effect.

Optionally, some speakers come with a *subwoofer*. This improves the bass (low notes) sound. If you have a subwoofer with your speakers, it should go on the floor under your desk.

Sound is one of the favorite options on today's PCs. In fact, sound is a standard feature of most new PCs.

Everyone has their own uses for sound. You may just want to play a few music CDs with your CD-ROM drive while you are working, or you may use multimedia applications for presentations or educational programs. You may just like the sound of your jet engines roaring as you punch the throttle in a flight simulator.

2.5.1 Components for Sound on Your PC

To produce sound on your PC, you need a sound card and speakers. The *sound card* is an expansion card that plugs into a slot on your motherboard. This card processes all sound-related instructions and then sends the sounds to the speakers for playback.

2.5.2 Sound Cards

Sound cards plug into an expansion slot in your PC. The card has a set of connectors displayed on the back of the PC; you can plug a microphone and speakers into them. Some cards include an optional connector for a *line input*, which connects to another input source, such as the output of a tape player or portable CD player. Other optional connectors can include a joystick connector and a MIDI connector (for connecting a MIDI keyboard). The card may include a volume control that adjusts the volume of the speakers and/or headphones.



2.7 Self-Assessment Exercises

1. Which of the following is an example of an output device**?**

A. Keyboard
B. Scanner
C. Monitor
D. Mouse

2. Which type of printer uses toner **to produce high-quality text and graphics?**

A. Inkjet printer
B. Dot-matrix printer
C. Laser printer
D. Thermal printer

3. Which monitor technology produces images by allowing each pixel to emit its own light?

A. CRT
B. LCD
C. OLED
D. Plasma

4. What is the primary function of a sound card **in a computer?**

A. To display images on the monitor
B. To store audio files permanently
C. To process audio signals and send them to speakers or headphones
D. To connect the computer to the internet



2.8 Summary

In this unit, you learned that output devices present processed information to users in visual, printed, and audio forms. You explored the different types of printers, monitors, speakers, and sound cards, together with their features, functions, advantages, and typical applications. Understanding these devices will help you choose the most suitable output device for different computing needs.



2.9 References/Further Reading/Web Sources

Akinyokun, O. C, (1999). *Principles and Practice of Computing Technology*. Ibadan: International Publishers Limited.

Balogun, V. F., Daramola, O. A., Obe, O. O., Ojokoh, B. A., and Oluwadare, S. A., (2006). *Introduction to Computing: A Practical Approach*. Akure: Tom-Ray Publications.



2.10 Possible Answers to Self-Assessment Exercises

1. C. Monitor
2. C. Laser printer
3. C. OLED
4. C. To process audio signals and send them to speakers or headphones

Unit 3 Processing Device

Unit Structure

3.1 Introduction
3.2 Learning outcomes
3.3 Definition of Processing Device
3.4 Function of Central Processing Unit
3.5 Components of CPU
3.5.1 Arithmetic and Logic Unit
3.5.2 Control Unit
3.5.3 Registers
3.5.4 CPU Performance Factors
3.5.5 Importance of the CPU
3.6 Motherboard
3.6.1 Functions of the Motherboard
3.6.2 Major Components of the motherboard
3.6.3 Importance of the motherboard
3.7 Self-Assessment Exercises
3.8 Summary
3.9 References/Further Reading/Web Sources
3.10 Possible Answers to Self-Assessment Exercises



3.1 Introduction

Welcome to this unit. Every time you open an application, play a game, browse the internet, or type a document, a remarkable process takes place inside your computer within seconds. Behind these everyday activities are two essential components that work together to ensure the computer performs accurately and efficiently: The Central Processing Unit (CPU) and the motherboard. In this unit, you will explore the CPU, often regarded as the processing centre of the computer, and examine how its components execute instructions and manage system operations. You will also learn about the motherboard, the platform that connects all hardware components and enables them to communicate effectively. As you progress through the unit, consider how these components work together to deliver the speed, reliability, and performance that modern computing depends upon.



3.2 Learning outcomes

By the end of this unit, you will be able to:

- identify the major components of the Central Processing Unit (CPU) and the motherboard
- explain the functions of the CPU, its internal components, and the motherboard in a computer system
- illustrate how the Arithmetic Logic Unit (ALU), Control Unit (CU), registers, and motherboard work together during the execution of computer instructions
- analyse the factors that influence CPU performance and evaluate the importance of the motherboard in ensuring efficient computer operation.



3.3 Definition of Central Processing Unit

Central Processing Unit is otherwise known as the heart of the computer. Where all manipulations are done, the main operation is being carried out. It is as important to a computer as the heart is to the body. It stands between the input and output devices and receives incoming data and instructions, works upon the data and sends it to the destination unit. It consists of the arithmetic and logic unit, the control unit and the memory unit. The Central Processing Unit (CPU) is the core component of a computer system responsible for executing instructions and controlling all operations. It is often referred to as the *brain of the computer* because it performs processing and decision-making functions.

3.4 Functions of the CPU

- Fetches instructions from memory
- Decodes instructions to determine required actions
- Executes arithmetic and logical operations
- Controls and coordinates the activities of other components

3.5 Components of the CPU

3.5.1 Arithmetic Logic Unit (ALU)

- Performs arithmetic operations such as addition, subtraction, multiplication, and division
- Performs logical operations such as comparisons (>, <, =), AND, OR, NOT

3.5.2 Control Unit (CU)

- Directs all operations of the computer system
- Controls data flow between the CPU, memory, and input/output devices
- Ensures instructions are executed in the correct sequence

3.5.3 Registers

- Small, high-speed memory locations within the CPU
- Temporarily store data, instructions, and intermediate results during processing
- Examples: Accumulator, Instruction Register, Program Counter

3.5.4 CPU Performance Factors

- Clock Speed: Measured in Hertz (Hz), indicates how fast the CPU executes instructions
- Word Size: Number of bits processed at a time (e.g., 32-bit, 64-bit)
- Number of Cores: Determines how many tasks can be processed simultaneously

3.5.5 Importance of the CPU

- Determines overall system performance
- Essential for multitasking and efficient processing
- Enables execution of software and applications

Click on the link to watch a short video on this topic or scan the QR-code with your phone;
https://youtu.be/FB8bphbLuX0



3.6 Motherboard/ System Board

The motherboard (also called the *system board* or *main board*) is the main circuit board of a computer system. It serves as the central platform that connects and allows communication between all major hardware components as displayed in Fig. 1. It is contained inside the CPU and all vital computer part are plugged directly to the system board.

Other items such as the hard disk are attached to the system board, either directly or via cables. These boards are getting smaller and smaller as the components become more integrated

3.6.1 Functions of the Motherboard

- Holds and connects major components of the computer
- Provides pathways (buses) for data and power transfer
- Allows communication between the CPU, memory, storage, and peripherals
- Supports expansion and upgrading of system components

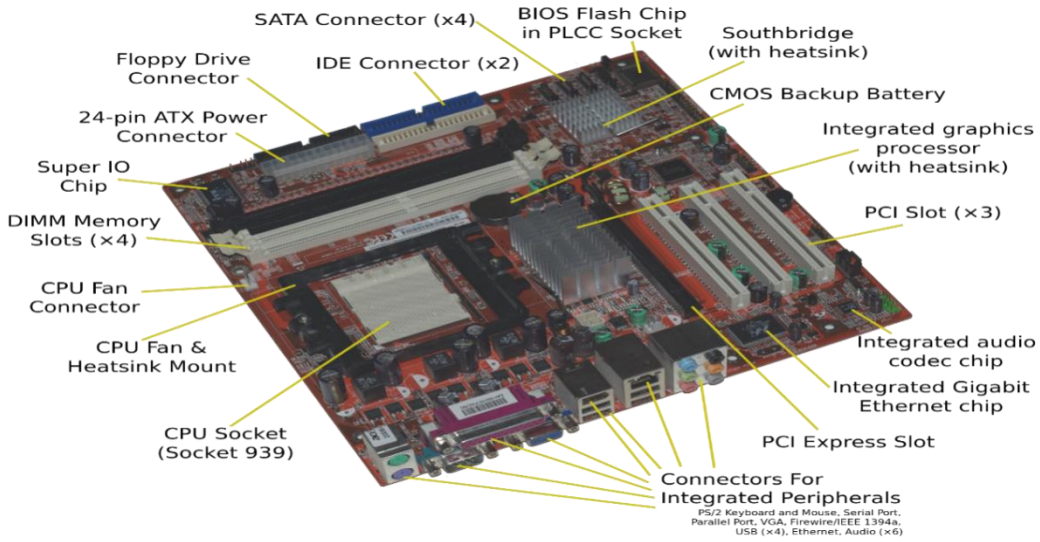


Fig. 1: Motherboard of a system

3.6.2 Major Components on the Motherboard

a. CPU Socket
- Holds the processor securely in place
- Determines the type of CPU the motherboard can support

b. Memory Slots (RAM Slots)
- Accommodate Random Access Memory (RAM) modules
- Determine the maximum memory capacity of the system

c. Chipset
- Controls data flow between the CPU, memory, and peripheral devices
- Acts as a traffic controller within the system

d. Expansion Slots
- Allow installation of expansion cards
- Examples: Graphics card, sound card, network card

e. BIOS/UEFI Chip
- Stores firmware that initializes hardware during startup
- Performs Power-On Self-Test (POST)

f. Power Connectors
- Supply electrical power from the power supply unit (PSU) to components

g. Input/Output Ports

- Provide external connectivity
- Examples: USB ports, HDMI, Ethernet, audio ports

3.6.3 Importance of the Motherboard

- Determines system compatibility and expandability
- Influences system performance and stability
- Acts as the backbone of the computer system



3.7 Self-Assessment Exercises

1.Which component of the computer is commonly referred to as the brain of the computer**?**

A. Motherboard
B. Hard Disk Drive
C. Central Processing Unit (CPU)
D. Random Access Memory (RAM)

2. Which component of the CPU is responsible for performing arithmetic calculations and logical comparisons?

A. Control Unit (CU)
B. Arithmetic Logic Unit (ALU)
C. Register
D. Cache Memory

3. Which motherboard component stores the firmware that starts the computer and performs the Power-On Self-Test (POST)?

A. Chipset
B. CPU Socket
C. BIOS/UEFI Chip
D. Expansion Slot

4. Which of the following factors directly affects the processing capability of a CPU?

A. Monitor size
B. Number of CPU cores



3.8 Summary

In this unit, you learned that the CPU is the processing centre of the computer, responsible for executing instructions through its Arithmetic Logic Unit, Control Unit, and registers. You also explored the motherboard, its major components, and its role in connecting and coordinating all hardware devices. Together, the CPU and motherboard form the foundation that enables a computer system to operate efficiently and reliably.



3.9 References/Further Reading/ Web Sources

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3.10 Possible Answers to Self-Assessment Exercises

1. C. Central Processing Unit (CPU)
2. B. Arithmetic Logic Unit (ALU)
3. C. BIOS/UEFI Chip
4. B. Number of CPU cores

Unit 4 Auxiliary Devices

Unit Structure

4.1 Introduction
4.2 Learning outcomes
4.3 The Air Conditioner
4.4 The Voltage Stabilize
4.5 The Line Voltage Transformer
4.6 The Uninterruptible Power Supply System (UPS)
4.7 Self-Assessment Exercises
4.8 Summary
4.9 References/Further Reading/Web Sources
4.10 Possible Answers to Self-Assessment Exercises



4.1 Introduction

Computers perform best when they operate in a safe and stable environment. Factors such as excessive heat, dust, power fluctuations, and unexpected power outages can affect their performance, shorten their lifespan, and even lead to the loss of valuable data. Protecting a computer therefore involves more than installing software—it also requires the right environmental conditions and power protection devices. In this unit, you will explore the importance of air conditioners, voltage stabilizers, line voltage transformers, and Uninterruptible Power Supply (UPS) systems in maintaining reliable computer operations. As you study the unit, think about the different ways these devices work together to keep computer systems running safely, efficiently, and without interruption.



4.2 Learning outcomes

By the end of this unit, you will be able to:

- identify the environmental and power protection devices used to safeguard computer systems
- explain the functions of air conditioners, voltage stabilizers, line voltage transformers, and Uninterruptible Power Supply (UPS) systems
- differentiate between the roles of a voltage stabilizer, a line voltage transformer, and a UPS in protecting computer equipment
- evaluate the importance of providing a suitable operating environment and stable power supply for the safe and efficient operation of computer systems.



4.3 The Air Conditioner

A computer is an electronic device that generates heat while operating. Every computer is designed to function efficiently within a specified temperature range. If the surrounding temperature becomes too high or too low, the computer may not perform optimally and prolonged exposure to unsuitable temperatures can damage its internal components. In addition to controlling temperature, maintaining a clean environment is essential for a computer's proper functioning. Air contains dust particles that may settle inside the computer system. Dust accumulation can block ventilation openings, reduce cooling efficiency, and cause components to overheat. In some cases, conductive dust particles may interfere with electronic circuits, resulting in short circuits or hardware failure. An air conditioner therefore helps to create a suitable working environment for computer systems by regulating temperature, controlling humidity, and reducing airborne dust. This is particularly important in computer laboratories, server rooms, data centres, and offices where computers operate continuously.

Importance of Air Conditioning in a Computer Environment

An air conditioner helps to:

- Maintain a suitable operating temperature for computer systems.
- Prevent overheating of internal components.
- Reduce humidity that may damage electronic circuits.
- Minimise the amount of dust circulating in the environment.
- Improve the reliability and lifespan of computer equipment.
- Provide a comfortable working environment for users.

4.4 The Voltage Stabilizer

Computers require a steady and reliable supply of electricity to function correctly. However, electrical power supplied from the national grid may fluctuate due to voltage surges, drops, or sudden spikes. Such fluctuations can affect computer performance and may damage sensitive electronic components. A voltage stabilizer is an electrical device that regulates incoming voltage and supplies a constant output voltage to connected equipment. It protects computers against over-voltage and under-voltage conditions, thereby improving the safety and stability of computer operations. If power is interrupted suddenly while a computer is processing data, unsaved work may be lost, files may become corrupted, and the operating system may shut down improperly. Although modern operating systems are more resilient than earlier ones, unexpected power interruptions can still lead to data loss and hardware problems.

Functions of a Voltage Stabilizer

A voltage stabilizer:

- Maintains a constant voltage supply to the computer.
- Protects computer components from voltage fluctuations.
- Reduces the risk of hardware damage caused by power surges.
- Improves the stability and reliability of computer operation.
- Extends the lifespan of electronic equipment.



Fig. 1: The Voltage Stabilizer

4.5 The Line Voltage Transformer

Computer equipment is manufactured to operate within specific voltage ranges. Different countries use different standard electrical voltages. For example, many countries in North America use approximately **110–120 volts**, while countries such as Nigeria use approximately **220–240 volts**. A line voltage transformer is an electrical device used to increase (step up) or decrease (step down) voltage so that electrical equipment receives the correct operating voltage. Using the wrong voltage without an appropriate transformer may damage the equipment.

Modern computers are, however, designed with universal power supply units (PSUs) that automatically accept input voltages ranging from approximately **100V to 240V AC**. These power supplies detect the incoming voltage and adjust automatically, eliminating the need for external voltage transformers in most personal computers.

Functions of a Line Voltage Transformer

A line voltage transformer:

- Converts electrical voltage to the level required by a device.
- Protects equipment from damage caused by incorrect voltage.
- Enables electrical devices to operate safely in countries with different voltage standards.
- Ensures stable power delivery where automatic power supplies are unavailable.



Fig. 2: Line Voltage Transformer

4.6 The Uninterruptible Power Supply System (UPS)

An Uninterruptible Power Supply (UPS**)** is an auxiliary power device that provides temporary electrical power to a computer when the main electricity supply fails. It also conditions incoming electrical power by filtering voltage fluctuations and protecting connected devices from sudden surges and spikes.

A UPS contains rechargeable batteries that automatically supply power whenever there is a power outage. This allows users enough time to save their work properly and shut down the computer safely, preventing data loss and reducing the risk of hardware damage.

Unlike a voltage stabilizer, which only regulates voltage, a UPS both regulates voltage and provides backup power during electricity failures.

Functions of a UPS

A UPS is capable of:

- Conditioning the incoming electrical supply by regulating voltage.
- Protecting the computer against voltage surges, spikes, and fluctuations.
- Storing electrical energy in rechargeable batteries while mains power is available.
- Supplying temporary backup power during power outages.
- Allowing users to save their work and shut down the computer safely.
- Reducing the risk of data loss and hardware damage caused by sudden power failure.

Advantages of Using a UPS

- Prevents unexpected shutdowns.
- Protects valuable data from being lost.
- Increases the lifespan of computer hardware.
- Ensures continuity of work during short power interruptions.
- Provides cleaner and more stable electrical power to connected devices.



Fig. 3: Uninterruptible Power Supply System (UPS)

4.7 Self-Assessment Exercises

1. Which device helps maintain a suitable operating temperature and reduce dust in a computer environment?

A. Voltage stabilizer
B. Air conditioner
C. Line voltage transformer
D. UPS

2. A line voltage transformer is mainly used to:

A. Store electrical energy for later use
B. Convert electrical voltage to the level required by a device
C. Cool the internal components of a computer
D. Remove dust from electronic components

TRUE or FALSE Response

3. A voltage stabilizer provides backup power to a computer during a power outage for several hours.

4. An Uninterruptible Power Supply (UPS) only stores electrical energy and cannot protect a computer against voltage surges or fluctuations.

4 8 Summary

In this unit, you learned that maintaining an appropriate operating environment and providing a stable power supply are essential for the reliable performance of computer systems. You examined the functions of air conditioners, voltage stabilizers, line voltage transformers, and UPS devices, and how each helps protect computer equipment from heat, dust, voltage fluctuations, and power failures, thereby improving system reliability and extending hardware lifespan.



4.9 References/Further Reading/Web Sources

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4.10 Possible Answer to Self-Assessment Exercises

1. B. Air conditioner
2. B. Convert electrical voltage to the level required by a device
3. False
4. False

Unit 5 Hardware Components

Unit Structure

5.1 Introduction
5.2 Learning Outcome(s)
5.3 The System Unit
5.4 The Front of the System Unit
5.4.1 Lights
5.4.2 Key Lock
5.4.3 Turbo Button
5.4.4 Reset Button
5.4.5 Power On/Off
5.4.6 Floppy disk drive
5.5 The Back of the System Unit
5.5.1 The Fan Housing
5.5.2 Power ‘in’ and ‘out’ button
5.5.3 Joystick Port
5.5.4 Serial Port
5.5.5 Sound Port
5.5.6 Keyboard Port
5.5.7 Network Adapter
5.5.8 Monitor Port
5.5.9 Bays for Expansion
5.6 Inside the System Unit
5.6.1 The Fan House
5.6.2 The Disk Drive Controller Card
5.6.3 The Display Adapter Card
5.6.4 Expansion Slot
5.6.5 RAM Chip
5.6.6 ROM Chip
5.6.7 Empty RAM chip slot
5.6.8 Central Processing Unit
5.6.9 Power Supply unit
5.6.10 Hard disk drive
5.6.11 The Motherboard
5.7 CPU Speed
5.8 Generation of CPUs
5.9 Self-Assessment Exercise(s)
5.10 Summary
5.11 References/Further Reading/Web Sources
5.12 Possible Answers to Self-Assessment Exercises



5.1 Introduction

Have you ever looked at the system unit and wondered what is inside it or how all its components work together to make a computer function? Although the monitor, keyboard, and mouse are the parts we use every day, the real processing takes place inside the system unit. In this unit, you will explore both the external features and the internal components of the system unit, discover the role of the CPU, memory, motherboard, storage devices, and ports, and learn how these parts work together to process data efficiently. As you progress through the unit, you will develop a clearer understanding of the hardware that forms the foundation of every computer system.



5.2 Learning outcome(s)

By the end of this unit, you will be able to:

- identify the major external and internal components of the system unit and describe their functions
- explain how the CPU, motherboard, memory, storage devices, and other components work together within the system unit
- differentiate between various ports, expansion slots, memory types, and storage devices used in a computer system
- evaluate the importance of the system unit and its internal components in determining computer performance and efficient operation.



5.3 The System Unit

The system unit is the main unit of a PC. It is the computer itself while other units attached to it are regarded as peripherals. It could be viewed as the master conductor orchestrating your PC's operation. It is made up of several components like the motherboard, processor, buses, memory, power supply unit, etc. This unit (the system unit) has been confused over the years by novices as the CPU. This is not true. The CPU (Central Processing Unit) or simply processor is a component within the system unit and is not the only thing that makes up the system unit. Hence, it will be wrong to equate the system unit with the CPU.

5.4 The Front of the System Unit

5.4.1 Lights

Your unit may display a variety of coloured lights on the front panel, including power and turbo signals, and light to indicate if the hard or floppy disk is being read or written to.

5.4.2 Key Lock

You can stop intruders from tampering with your PC by using the lock on the front panel. Turning the key prevents the keyboard from working.

5.4.3 Turbo Button

Some PCs offer a choice of speeds at which they can run. A turbo switch is usually left so the computer runs at its fastest speed.

5.4.4 Reset Button

If your PC "freezes" and won't respond to any command, try starting it up again using the reset button. Pressing the reset button loses all the work you have not saved in that session, so use it only as a last resort.

5.4.5 Power On/Off

All PCs have main power switch on the system unit. Sometimes this control is placed on the outside back panel.

5.4.6 Floppy Disk Drives

Either, or both, of two standard types of floppy disk drive may be found at the front of the system unit. Some systems also have internal CD-ROM or tape drives as shown in Fig. 1.



Fig.1: CD-ROM or DVD drive

5.5 The Back of the System Unit

5.5.1 The Fan Housing

The electronic components in your PC generate a lot of heat. To prevent overheating, a fan at the back of the unit removes hot air from the system.

5.5.2 Power "in" and "out" Sockets

Cables plugged into these sockets carry power from the electrical outlet to the system unit and from the system unit to the monitor.

5.5.3 The Joystick Port

Using a joystick is often much better than pressing keys to control movements when playing a computer game.

5.5.4 Serial Ports

Serial ports often connect the PC to the modem or mouse. Most PCs are fitted with two serial ports that may be labeled "S101" and "S102", "Serial 1" and "Serial 2", or "COM 1" and "COM 2".

5.5.5 Sound Jacks

If you have a sound fitted inside your system unit, you will see a jack or jacks at the back. These can be used to connect your PC to speakers, a microphone, or an external sound source.

5.5.6 The Keyboard Port

The cable from your keyboard ends in a round connector that plugs into the keyboard port.

5.5.7 The Network Adapter

If an expansion card is fitted to link your PC with other PCs in your office you will see a network connector at the back of the system unit.

5.5.8 The Monitor Port

A cable from your monitor plugs into this port, carrying display information to the monitor.

5.5.9 Bays for Expansion Cards

PCs are easily expanded, perhaps to provide modem, sound or faster graphics. You can plug cards into expansion slots inside the PC. The

expansion card slot is located at the back of your machine, allowing you to connect items.

5.6 Inside the System Unit

The brain behind everything that happens in your PC is contained within the system unit. Inside the unit are the impressive electronics that run programs, handle instructions, and determine the results. Most of the more important items are described in Fig. 2 below.



Fig. 2: Inside the system unit

5.6.1 The Battery

A small battery powers a clock to keep track of the time when the PC is turned off. It also maintains low electricity to certain RAM chips that record which components are installed.

5.6.2 The Disk Drive Controller Card

This card controls the PC's disk drive motors and transfers data. The serial and parallel ports at the back of the card link internal PC components with external devices such as a mouse and a printer.

5.6.3 The Display Adapter Card (Video Card)

All the information your computer will display is stored in its memory. To be useful, you need to see the information. The display adapter card is the link between the PC's memory and the monitor.

5.6.4 Expansion Slots

These long narrow connectors allow you to plug in expansion cards (also known as adapter cards), which offer extra options not available on a basic PC.

5.6.5 ROM Chips

Read-only memory (ROM) chips have data written on them during manufacturing that tells the CPU what to do when the PC is switched on. The data is always there, even when you switch the PC off.

5.6.6 RAM Chips

When a computer is switched on and running a program, RAM (Random Access Memory) is used to hold the program and its data. But when the PC is switched off, anything held in RAM is lost. It is shown in Fig. 4.

5.6.7 Empty RAM Chip Slots

These slots let you expand your computer's memory by adding extra RAM chips or modules. Some PCs work even faster because they are equipped with Cache Memory. Cache memory consists of expensive, very fast memory chips that store the data or instructions the CPU will access next. Cache memory can significantly speed up your computer's performance. A figure of a RAM chip is shown in Fig. 3.

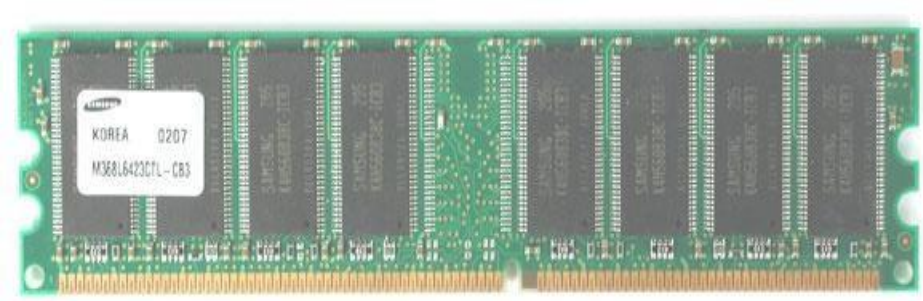


Fig. 3: A RAM chip

5.6.8 The Central Processing Unit (CPU)

The microprocessor, or central processing unit (CPU), is the computer's most important single item. It does all the PC's thinking and runs the programs (series of instructions) that you request. Fig. 4 shows a sample Intel processor.

Fig. 4: An Intel processor



5.6.9 The Power Supply Unit

All the components in a PC need an electrical supply. Most need a 5-volt supply, although floppy disk drive motors require 12 volts. If the components were connected to normal household current, they would blow up, so the power supply unit converts high-voltage electrical current to a low voltage.

5.6.10 The Hard Disk Drive

The hard disk is your computer's main permanent storage unit, holding large amount of data and programs. Unlike data held in RAM, the information on the hard disk is not affected when the PC is turned off – it remains there unless you instruct the PC to overwrite it or the hard disk is damaged. Fig.5 shows the figure of a hard drive.



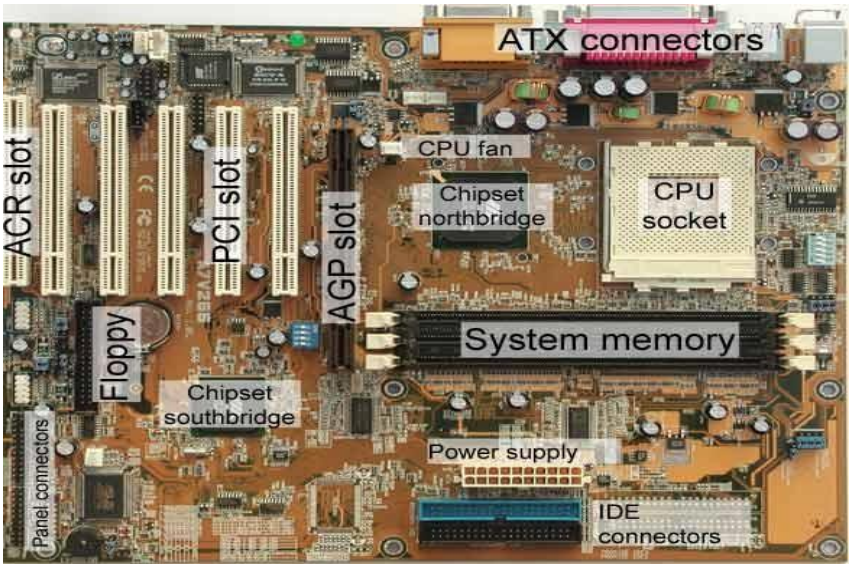
Fig. 5: The hard drive (Hard disk)

5.6.11 The Motherboard

All the electronic components in a PC are mounted on a piece of fiberglass called the motherboard as displayed on Fig. 6. Fiberglass cannot conduct electricity, so each component is insulated from all the

others. Thin lines of metal on the surface of the fiberglass connect pins from one component to another, forming the computer's electrical circuits.

Fig. 6: Components of a motherboard Intel CPUs



The earliest PCs were equipped with an Intel CPU called the 8088. The next generation of PCs used a CPU known by the number "80286" and were called "PC/AT" computers. Subsequently, PCs have been supplied with more and more powerful CPUs – the 80386, the 80486, and the more recent and impressive of all, the Intel Pentium (I, II, III, IV& M). All these PC processors belong to a family called 80 x 86. In general, you can run the same software on PCs containing different CPUs within this family. From the outside, the chips look different only in sizes and number of pin-put inside. An 80486 has over one million components to the 3,500 that were in the first 8088. Because of these differences, the latest Pentiums runs over ten times faster.

What is the CPU

The CPU is certainly the most important PC component. CPU stands for *Central Processing Unit*. Let us briefly study that name:

- It is a processor, because it processes (moves and calculates) *data.*
- It is central, because it is the centre of PC data processing.
- It is a unit because it is a chip which contains millions of transistors.

5.7 CPU Speed

The speed of a CPU is measured in megahertz (MHz). A computer has a central clock that keeps all the components in time with each other; one hertz is similar to a clock tick and megahertz is equal to one million ticks per second. If your PC runs at 333 or 400 MHz, the central clock ticks 333 or 400 million times per second. As you might imagine, the faster the clock ticks, the faster the computer runs.

Without the CPU, there would be no PC. Like all other hardware components, CPUs are continually undergoing further development. You can see the explosive technological development in data processing most clearly in the development of newer and faster CPUs. The CPUs have for years doubled their performance about every 18 months and there are no indications that this trend will stop.

When we now look at all the CPUs from a broader perspective, we can see that

- The CPU history is closely tied to the companies IBM and, especially, *Intel*.
- The CPUs have their roots back to Intel's chip *4004* from 1971.
- The *compatibility* concept has been important throughout the development.

5.8 Generations of CPUs

There are CPUs of many brand names (IBM, Texas, Cyrix, AMD), and often they make models which overlap two generations. This can make it difficult to keep track of CPUs. Here is an attempt to identify the various CPUs according to generations:

History of CPUs
The following table shows the different CPU generations.

Table 1: Different Generations of the CPU

PC	**CPUs**	**Year**	**Number of Transistors**
1st Generation	8086 and 8088	1978-81	29,000
2nd Generation	80286	1984	134,000

3rd Generation	80386DX and 80386SX	1987-88	275,000
4th Generation	80486SX, 80486DX, 80486DX2 and 80486DX4	1990-92	1,200,000
5th Generation	Pentium Cyrix 6X86 AMD K5 IDT WinChip C6	1993-95 1996 1996 1997	3,100,000 -- -- 3,500,000
Improved 5th Generation	Pentium MMX IBM/Cyrix 6x86MX IDT WinChip2 3D	1997 1997 1998	4,500,000 6,000,000 6,000,000
6th Generation	Pentium Pro AMD K6 Pentium II AMD K6-2	1995 1997 1997 1998	5,500,000 8,800,000 7,500,000 9,300,000
Improved 6th Generation	Mobile Pentium II Mobile Celeron Pentium III AMD K6-3 Pentium III CuMine	1999	27,400,000 18,900,000 9,300,000 ? 28,000,000
7th Generation	AMD original Athlon AMD Athlon Thunderbird Pentium 4	1999 2000 2001	22,000,000 37,000,000 42,000,000

5.9 Self-Assessment Exercises

1. Which of the following best describes the system unit?

A. The monitor used to display information
B. The main computer case that houses the major internal components
C. A device used only for storing files
D. The keyboard used to enter data

2. Which component is responsible for performing calculations and executing program instructions?

A. Hard Disk Drive
B. Motherboard
C. Central Processing Unit (CPU)
D. Power Supply Unit

3. Which memory loses its contents when the computer is switched off?

A. ROM
B. Cache Memory
C. RAM
D. Hard Disk

4. What is the primary function of the motherboard?

A. To print documents
B. To store permanent files only
C. To connect and allow communication among all major computer components



5.10 Summary

In this unit, you examined the system unit and its major external and internal components. You learnt the functions of the CPU, motherboard, RAM, ROM, storage devices, expansion slots, power supply, and other essential hardware. You also explored the various ports and connectors that enable communication between the computer and peripheral devices. Understanding these components provides a solid foundation for appreciating how computer hardware works together to deliver reliable and efficient performance.



5.11 References/Further Reading/Web Sources

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5.12 Possible Answers to Self-Assessment Exercises

1. **B.** The main computer case that houses the major internal components
2. Central Processing Unit (CPU)
3. **C.** RAM
4. **C.** To connect and allow communication among all major computer components

Unit 6 System Software

Unit Structure

6.1 Introduction
6.2 Learning outcomes
6.3 Computer Software
6.3.1 Classification of Computer Software
6.3.2 System Software
6.3.3 Operating System
6.4 Types of Operating Systems
6.4.1 Batch Operating System
6.4.2 Time Sharing Operating System
6.4.3 Real Time Operating System
6.4.4 Multiprogramming Operating System
6.4.5 Distributed Operating System
6.4.6 Network Operating System
6.5 Operating System Components
6.5.1 Process Management
6.5.2 Memory Management
6.5.3 Memory Hierarchy
6.5.4 I/O System
6.5.5 File Management
6.5.6 Protecting System
6.5.7 Networking
6.5.8 Command Interpreter System
6.6 Application Software
6.7 Utility Software
6.8 Language Translator
6.8.1 Assembler
6.8.2 Interpreter
6.8.3 Compiler
6.9 Self-Assessment Exercises
6.10 Summary
6.11 References/Further Reading/Web Sources
6.12 Possible Answers to Self-Assessment Exercises



6.1 Introduction

Welcome to this unit! Have you ever stopped to think about what makes a computer perform useful tasks? While the hardware provides the physical structure of a computer, it is the software that gives it life and tells it what to do. From starting the computer and managing files to creating documents, browsing the internet, and running specialised applications, software makes every computer operation possible.

In this unit, you will explore the different categories of computer software, understand the important role of operating systems, and examine how application software, utility software, and language translators support users and programmers. As you progress through the unit, you will discover how these software components work together to ensure that computer systems operate efficiently, securely, and effectively in everyday life.



6.2 Learning outcomes

By the end of this unit, you will be able to:

- define computer software and distinguish between system software, application software, utility software, and language translators
- describe the functions and characteristics of operating systems and their major components
- differentiate between the various types of operating systems, application software, utility software, and language translators based on their functions and applications
- evaluate the importance of different categories of software in supporting computer operations and solving real-world problems.



6.3 Computer Software

The physical components of the computer are called the hardware while all the other resources or parts of the computer that are not hardware, are referred to as the software. The software is the set of programs that make the computer system active. In essence, the software is the set of programs that run on the computer.

Then, what is a program? A program is a series of coded instructions showing the logical steps the computer follows to solve a given problem.

6.3.1 Classification of Computer Software

The computer software could be divided into two major groups, namely system software (programs), application software (programs) and a sub-group; utility as shown in Fig. 1

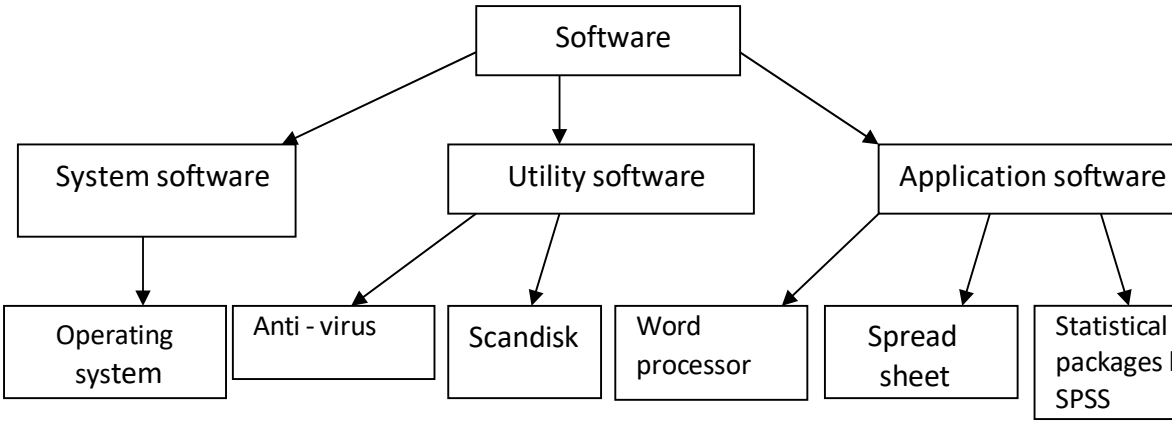


Fig. 1: figure describing Software and its various classifications

6.3.2 System Software

This refers to the suits of programs that facilitate the optimal use of the hardware systems and/or provide a suitable environment for the writing, editing, debugging, testing and running of user programs. Usually, every computer system comes with a collection of these suits of programs which are provided by the hardware manufacturer.

6.3.3 Operating Systems

An operating system is a program that acts as an interface between a user of a computer and the computer hardware. The purpose of an operating system is to provide an environment in which a user may execute programs.

The operating system is the first component of the systems programs that interest us here. Systems programs are programs written for direct execution on computer hardware in order to make the power of the computer fully and efficiently accessible to applications programmers and other computer users. Systems programming is different from application programming because the former requires an intimate knowledge of the computer hardware as well as the end users' needs. Moreover, systems programs are often large and more complex than application programs, although that is not always the case. Since systems programs provide the foundation upon which application programs are built, it is most important that systems programs are reliable, efficient and correct. In a computer system the hardware provides the basic computing resources. The applications programs define the way in which these resources are used to solve the computing problems of the user. The operating system controls and coordinates the use of the hardware among the various systems programs and application programs for the various users.

The basic resources of a computer system are provided by its hardware, software and data. The operating system provides the means for the proper use of these resources in the operation of the computer system. It simply provides an environment within which other programs can do useful work.

An operating system can be view as a resource allocator. A computer system has many resources (hardware and software) that may be required to solve a problem: CPU time, memory space, file storage space, input/output devices, etc. The operating system acts as the manager of these resources and allocates them to specific programs and users as necessary for their tasks. Since there may be many, possibly conflicting, requests for resources, the operating system must decide which requests are allocated resources to operate the computer system fairly and efficiently. An operating system is a control program. This program controls the execution of user programs to prevent errors and improper use of the computer. Operating systems exist because they are a reasonable way to solve the problem of creating a usable computing system. The fundamental goal of a computer system is to execute user programs and solve user problems.

The primary goal of an operating system is convenience for the user. Operating systems exist because they are supposed to make it easier to compute with an operating system than without an operating system. This is particularly clear when you look at the operating system for small personal computers.

A secondary goal is the efficient operation of computer system. This goal is particularly important for large, shared multi-user systems. Operating systems can attain this goal. It is known that sometimes these two goals, convenience and efficiency, are contradictory. While there is no universally agreed definition of the concept of an operating system, we offer the following as a reasonable starting point:

A computer's operating system (OS) is a group of programs designed to serve two basic purposes:

- to control the allocation and use of the computing system's resources among the various users and tasks.
- to provide an interface between the computer hardware and the programmer that simplifies and makes feasible the creation, coding, debugging, and maintenance of application programs.

Specifically, we can imagine that an effective operating system should accomplish all of the following:

- Facilitate creation and modification of program and data files through an editor program.

- Provide access to compilers to translate programs from high-level languages to machine language.
- Provide a loader program to move the complied program code to the computer's memory for execution.
- Provide routines that handle the intricate details of I/O programming.
- Assure that when there are several active processes in the computer, each will get fair and non-interfering access to the central processing unit for execution.
- Take care of storage and device allocation.
- Provide for long term storage of user information in the form of files.
- Permit system resources to be shared among users when appropriate, and be protected from unauthorised or mischievous intervention as necessary.

Though systems programs such as editor and translators and the various utility programs (such as sort and file transfer program) are not usually considered part of the operating system, the operating system is responsible for providing access to these system resources.

6.4 Types of Operating Systems

Modern computer operating systems may be classified into three groups, which are distinguished by the nature of interaction that takes place between the computer user and his or her program during its processing. The three groups are called batch, time-shared and real time operating systems.

6.4.1 Batch Processing Operating System

In a batch processing operating system environment, users submit jobs to a central place where these jobs are collected into a batch, and subsequently placed on an input queue at the computer where they will be run. In this case, the user has no interaction with the job during its processing, and the computer's response time is the turnaround time – the time from submission of the job until execution is complete, and–the results are ready for return to the person who submitted the job.

6.4.2 Time Sharing Operating System

Another mode for delivering computing services is provided by time sharing operating systems. In this environment a computer provides computing services to several or many users concurrently on-line. Here, the various users are sharing the central processor, the memory, and other resources of the computer system in a manner facilitated, controlled, and monitored by the operating system. The user, in this environment, has

nearly full interaction with the program during its execution, and the computer's response time may be expected to be no more than a few seconds.

6.4.3 Real Time Operating System

The third class of operating systems, the real time operating systems, are designed to service those applications where response time is of the essence to prevent error, misrepresentation or even disaster. Examples of real time operating systems are those which handle airlines reservations, machine tool control, and monitoring of a nuclear power station. The systems, in this case, are designed to be interrupted by external signal that require the immediate attention of the computer system.

In fact, many computers operating systems are hybrids, providing for more than one of these types of computing service simultaneously. It is especially common to have a background batch system running in conjunction with one of the other two on the same computer.
A number of other definitions are important towards gaining an understanding of operating systems:

6.4.4 Multiprogramming Operating System

A multiprogramming operating system is a system that allows more than one active user program (or part of user program) to be stored in main memory simultaneously.

Thus, it is evident that a time-sharing system is a multiprogramming system, but note that a multiprogramming system is not necessarily a time-sharing system. A batch or real time operating system could, and indeed usually does, have more than one active user program simultaneously in main storage. Another important, and all too similar, term is 'multiprocessing'.

A multiprocessing system is a computer hardware configuration that includes more than one independent processing unit. The term multiprocessing is generally used to refer to large computer hardware complexes found in major scientific or commercial applications.

A networked computing system is a collection of physically interconnected computers. The operating system of each of the interconnected computers must contain, in addition to its own stand-alone functionality, provisions for handing communication and transfer of program and data among the other computers with which it is connected.

A distributed computing system consists of several computers that are connected and managed so that they automatically share the job processing load among the constituent computers or separate the job load as appropriate to particularly configured processors. Such a system requires an operating system which, in addition to the typical stand-alone functionality, provides coordination of the operations and information flow among the component computers.

The networked and distributed computing environments and their respective operating systems are designed with more complex functional capabilities. In a network operating system the users are aware of the existence of multiple computers and can log in to remote machines and copy files from one machine to another. Each machine runs its own local operating system and has its own user (or users).

6.4.5 Distributed Operating System

A distributed operating system, in contrast, is one that appears to its users as a traditional uniprocessor system, even though it is composed of multiple processors. In a true distributed system, users should not be aware of where their programs are being run or where their files are located; that should all be handled automatically and efficiently by the operating system.

6.4.6 Network Operating Systems

Network operating systems are not fundamentally different from single processor operating systems. They obviously need a network interface controller and some low-level software to drive it, as well as programs to achieve remote login and remote files access, but these additions do not change the essential structure of the operating systems.

True distributed operating systems require more than just adding a little code to a uniprocessor operating system, because distributed and 94ptimize94ed systems differ in critical ways. Distributed systems, for example, often allow programs to run on several processors at the same time, thus requiring more complex processor scheduling algorithms in order to 94ptimize the amount of parallelism achieved.

6.5 Operating System Components

An operating system provides the environment within which programs are executed. To construct such an environment, the system is partitioned into small modules with a well-defined interface. The design of a new operating system is a major task. It is very important that the goals of the system will define before the design begins. The type of system desired

is the foundation for choices between various algorithms and strategies that well be necessary.

A system as large and complex as an operating system can only be created by partitioning it into smaller pieces. Each of these pieces should be a well-defined portion of the system with carefully defined inputs, outputs, and functions. Obviously, not all systems have the same structure. However, many modern operating systems share the system components outlined below.

6.5.1 Process Management

A process is the unit of work in a system. Such a system consists of a collection of processes, some of which are operating system processes, those that execute system code, and the rest being user processes, those that execute user code. All of those processes can potentially execute concurrently.

The operating system is responsible for the following activities in connection with processes managed:

- The creation and deletion of both user and system processes
- The suspension and resumption of processes.
- The provision of mechanisms for process synchronization
- The provision of mechanisms for deadlock handling.

6.5.2 Memory Management

Memory is central to the operation of a modern computer system. Memory is a large array of words or bytes, each with its own address. Interaction is achieved through a sequence of reads or writes of specific memory address that the CPU fetches from and stores in memory.

For a program to be executed, it must be mapped to absolute addresses and loaded in to memory. As the program executes, it accesses program instructions and data from memory by generating this absolute is declared available, and the next program may be loaded and executed.

The operating system is responsible for the following activities in connection with memory management:

- Keeping track of which parts of memory are currently being used and by whom.
- Deciding which processes are to be loaded into memory when memory space becomes available.
- Allocating and deallocating memory space as needed.

6.5.3 Memory Hierarchy

Memory hierarchy is the structured arrangement of storage systems in a computer based on speed, cost, and capacity trade-offs. It is designed to bridge the performance gap between the CPU and main memory/storage devices by placing faster, smaller, and more expensive memory close to the CPU, and slower, larger, cheaper memory further away.

Levels of Memory Hierarchy (Top to Bottom)
(a) CPU Registers
- Located inside the CPU.
- Fastest memory in the system.
- Very small capacity.
- Stores immediate data for processing (e.g., operands, instructions).

(b) Cache Memory
- Positioned between CPU and RAM.
- Built using SRAM (Static RAM).
- Extremely fast compared to RAM.

Levels of cache:
- L1 Cache: Smallest, fastest, inside CPU core.
- L2 Cache: Larger, slightly slower.
- L3 Cache: Shared across cores, larger but slower than L1/L2.

Function: Stores frequently used instructions/data to reduce access time.
(c) Main Memory (RAM)
- Built using DRAM (Dynamic RAM).
- Medium speed and medium cost.
- Volatile (data lost when power is off).
- Stores currently running programs and active data.

(d) Secondary Storage
- Includes:
  - Hard Disk Drives (HDD)
  - Solid State Drives (SSD)
- Non-volatile storage
- Large capacity but slower than RAM.
- Stores OS, applications, and user files.

(e) Tertiary Storage (Optional / Archival)
- Examples: magnetic tapes, cloud backups, optical disks.
- Very large capacity, very slow access.
- Used for backup and long-term storage.

Hierarchical Structure Summary
From fastest to slowest:
Registers → Cache (L1, L2, L3) → RAM → SSD/HDD → Optical/Tape Storage
From smallest to largest capacity:

Registers → Cache → RAM → SSD/HDD → Archival Storage
From most expensive per bit to cheapest:
Registers → Cache → RAM → SSD → HDD → Tape

6.5.4 I/O System

One of the purposes of an operating system is to hide the peculiarities of specific hardware devices from the user. For example, in Unix, the peculiarities of I/O devices are hidden from the bulk of the operating system itself by the I/O system. The I/O system consists of:

- A buffer caching system
- A general device driver code
- Drivers for specific hardware devices

Only the device driver knows the peculiarities of a specific device.

6.5.5 File Management

File management is one of the most visible services of an operating system. Computers can store information in several different physical forms. The magnetic tape, disk, and drum are the most common forms. Each of these devices has its own characteristics and physical organisation.

For the convenience of using the computer system, the operating system provides a uniform logical view of information storage. The operating system abstracts from the physical properties of its storage devices to define a logical storage unit, the file. Files are mapped by the operating system onto physical devices.

A file is a collection of related information defined by its creator. Commonly, files represent programs (both source and object forms) and data. Data files may be numeric, alphabetic or alphanumeric. Files may be free-form, such as text files, or may be rigidly formatted. In general, a file is a sequence of bits, bytes, lines or records whose meaning is defined by its creator and user. It is a very general concept.

The operating system is responsible for the following activities in connection with file management:

- The creation and deletion of files
- The creation and deletion of a directory
- The support of primitives for manipulating files and directories
- The mapping of files onto disk storage.
- Backup of files on stable (non-volatile) storage.

6.5.6 Protection System

The various processes in an operating system must be protected from each other's activities. For that purpose, various mechanisms are used to ensure that files, memory segments, the CPU, and other resources can be accessed only by processes that have received proper authorisation from the operating system.

For example, memory-addressing hardware ensures that a process can execute only within its own address space. The timer ensures that no process can gain control of the CPU without relinquishing it. Finally, no process is allowed to do its own I/O to protect the integrity of the various peripheral devices.

Protection refers to a mechanism for controlling the access of programs, processes, or users to the resources defined by a computer control, together with some means of enforcement. Protection can improve reliability by detecting latent errors at the interfaces between component subsystems. Early detection of interface errors can often prevent contamination of a healthy subsystem by a subsystem that is malfunctioning. An unprotected resource cannot defend against use (or misuse) by an 98nauthorized or incompetent user.

6.5.7 Networking

A distributed system is a collection of processors that do not share memory or a clock. Instead, each processor has its own local memory, and the processors communicate with one another via communication lines such as high-speed buses or telephone lines. Distributed systems vary in size and function. They may involve microprocessors, workstations, minicomputers, and large general-purpose computer systems.

The processors in the system are connected via a communication network, which can be configured in various ways. The network may be fully or partially connected. The communication network design must consider routing and connection strategies, as well as connection and security issues.

A distributed system provides users with access to the various resources it maintains. Access to a shared resource enables faster computation, improved data availability, and greater reliability.

6.5.8 Command Interpreter System

One of the most important components of an operating system is its command interpreter. The command interpreter is the primary interface between the user and the rest of the system.

Many commands are given to the operating system by control statements. When a new job is started in a batch system or when a user logs in to a time-shared system, a program which reads and interprets control statements is automatically executed. This program is variously called (1) the control card interpreter, (2) the command line interpreter, (3) the shell (in UNIX), and so on.

Its function is quite simple: get the next command statement and execute it.

The command statements themselves deal with process management, I/O handling, secondary storage management, main memory management, file system access, protection, and networking. The relationship between an operating system and other components is shown in Fig. 2

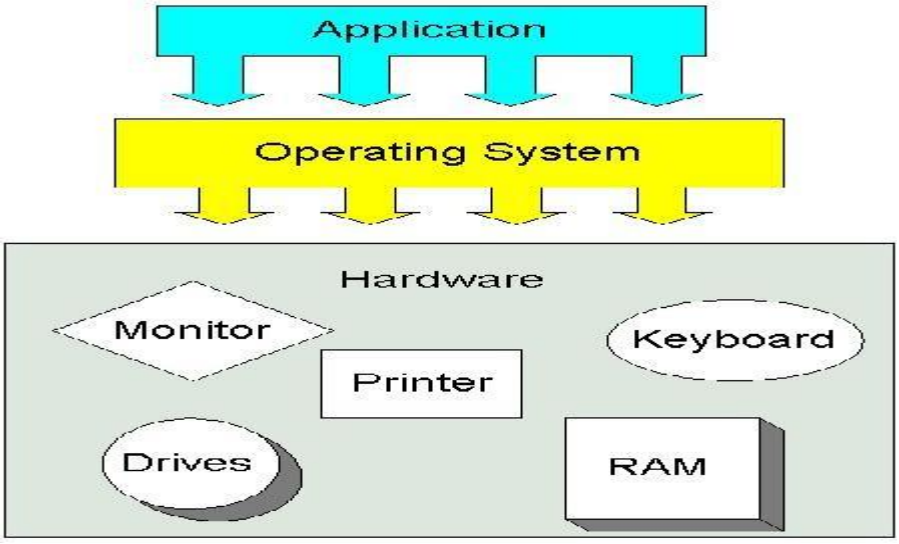


Fig. 2*:* Relationship between the operating system and other components of the computer system

6.6 Application Software

Application software is a set of programs designed to solve problems of a specific nature. It could be supplied by the computer manufacturer or, in some cases, by users, who produce their own application program called a user program. Hence, application software could be subdivided into two classes: 99rganized99d software and user-defined software.

Under generalized software, we have examples such as Word Processing Programs, e.g., WordPerfect, WordStar, Microsoft Word. Also included are Desktop Publishing, e.g., Ventura, PageMaker, CorelDRAW, and Spreadsheet programs, e.g., LOTUS 123, Excel, Super-Q. Under the user-defined software, we could have user-defined packages for a particular company or 100rganized100d100, for accounting, payroll, or other 100rganized100d purposes.

- The Word Processor: A word processor is used to create, edit, save and print reports. It affords the opportunity to make amendments before printing is done. During editing, a character, word, sentence or several lines can be removed or inserted as the case may be. Another possible facility is spell checking. A document can be printed as many times as possible. Word processors are mainly used to produce letters, mailing lists, labels, greeting cards, business cards, reports, manuals and newsletters. Examples include: WordPerfect, WordStar, Display Writer, Professional Writer, LOTUS Manuscript, MS Word, LOCO Script, and MM Advantage II.
- The Spreadsheet**:** This is an application mainly designed for numerical figures and reports. Spreadsheets contain columns and rows, in which numbers can be entered. It is possible to change numbers before printing is done. Other features of spreadsheets are the ability to use formulas to calculate, the ability to use sum and average functions, the ability to perform automatic recalculation, and the capacity to display reports in graphical modes. The spreadsheet is used for budgets, tables, cost analysis, financial reports, tax and statistical analysis. Examples are: LOTUS 123, Supercalc, MS Multiplan, MS-Excel, VP Planner, etc.
- Integrated Packages: They are programs or packages that perform a variety of different processing operations using data that is compatible with whatever operation is being carried out. They perform several operations, such as word processing, database management, and spreadsheet work. Examples are: Office Writer, Logistic Symphony, Framework, Enable, Ability, Smart Ware II, and Microsoft Works V2.
- Graphic Packages: These are packages that enable you to bring out images, diagrams and pictures. Examples are PM, PM Plus, Graphic Writer, and Photoshop.
- Database Packages: These are software for designing, setting up and subsequently managing a database. (A database is an 100rganized collection of data that allows for modification, taking care of different users' views). Examples include dBASE II, III, IV, FoxBASE, Base Data Perfect, Paradox III, Revelation Advanced, and MS Access.
- Statistical Packages: These are packages that can be used to solve

statistical problems, e.g. Stat Graphical and SPSS (Statistical Packages for Social Scientists).

- Desktop Publishing: These are packages that can be used to produce books and documents in standard form. Examples are PageMaker, Ventura, Publishers, Paint Brush, Xerox Form Base, News Master II, and Dbase Publisher.
- Game Packages: These are packages that contain a lot of games for children and adults. Examples are Chess, Scrabble, Monopoly, Tune Trivia, Star Trek 2, California Game, Soccer Game, War Game, Spy Catcher and Dracula in London.
- Communication Packages: Examples are Carbon Plus, Data Talk V3.3, Cross Talk, SAGE Chit Chat and Data Soft.

There are so many packages available, virtually for every field of study, but these are just a few to mention. Advantages of these packages include being quicker and cheaper to implement, saving time, having a minimum design time, being tested and proven correct, usually accompanied by full documentation, and being very portable.

User Programs

This is a suite of programs written by programmers for computer users. They are required for the operation of their individual business or tasks. An example is a payroll package developed for the salary operation of a particular company.

6.7 Utility Software

This is a set of commonly used programs in data processing departments, also called service or general-purpose programs. They perform the following operations.

- File Conversion: This covers data transfer from one medium to another, making an exact copy or simultaneously editing and validating. For example, copying from a hard disk to a diskette.
- File Copy: It makes an exact copy of a file from one medium to another or from one area of a medium to another area of the same medium.
- Housekeeping Operations: These include programs to clear areas of storage, write file labels and update common data. They are not involved in solving the problem at hand. They are operations that must be performed before and after actual processing.
- System Diagnosis and Monitoring: Task managers, system monitors and disk space analysers help track CPU usage, memory consumption and hardware health.
- Data storage and Management: Backup software creates copies of data while compression tools like ZIP/RAR reduce the file size for easier storage or transfer. File managers allow users to reorganise, rename and manage files.

Key Benefits of Utility Software

- Improved Performance: By cleaning out unnecessary data and organising files, utility software increases the speed and responsiveness of the computer.
- Enhanced Security: Regular, automated scans prevent malicious software from compromising data.
- Data Security: Backup utilities ensure that data can be recovered in the event of hardware failure or file corruption.
- Extends System Lifespan: Proper maintenance reduces strain on hardware, helping the computer last longer.

6.8 Language Translators

A programming language is a set of notations in which we express our instructions to the computer. At the initial stage of computer development, programs were written in machine language, using the binary system, i.e. 0 and 1. Such programs were hard to write, read, debug and maintain. In an attempt to solve these problems, other computer languages were developed. However, computers can run programs written only in machine language. There is therefore a need to translate programs written in these other languages into machine language. The software that translates other languages into machine language is called a language translator. The initial program written in a language different from machine language is called the source program, and its equivalent in machine language is called the object program.

Three classes of language translators are assemblers, interpreters, and compilers.

6.8.1 Assemblers

An assembler is a computer program that accepts a source program in assembly language and reads and translates the entire program into an equivalent program in machine language called the object program or object code. Each machine has its own assembly language, meaning that the assembly language of one machine cannot run on another machine.

6.8.2 Interpreters

An interpreter is a program that accepts a program from a source language, reads, translates and executes it, line by line, into machine language.

6.8.3 Compilers

A compiler is a computer program that accepts a source program in one high-level language, reads and translates the entire user's program into an equivalent program in machine language, called the object program or object code.

The stages in compilation include:

- Lexical analysis
- Syntax analysis
- Semantic analysis
- Code generation

For each high-level language, there are different compilers. We can therefore talk of COBOL Compilers, FORTRAN Compilers, BASIC Compilers, etc. A compiler also detects syntax errors, that is, errors that arise from the use of the language. Compilers are portable, i.e., a COBOL Compiler on one machine can run on another machine with minimal changes.



6.9 Self-Assessment Assessments

1. Which type of software manages computer hardware and provides a platform for running application programs?
A. Utility software
B. Application software
C. Operating system
D. Language translator
2. Which of the following is an example of application software?
A. Microsoft Word
B. Device driver
C. Operating system kernel
D. BIOS
3. Which language translator converts an entire high-level language program into machine code before execution?
A. Interpreter
B. Assembler
C. Compiler
D. Loader
4. Which of the following is a primary function of utility software?
A. Designing computer hardware
B. Performing system maintenance and optimisation
C. Executing arithmetic operations in the CPU
D. Controlling data transmission through the motherboard



6.10 Summary

In this unit, you learned that software consists of the programs that enable computer hardware to perform useful tasks. You examined the major categories of software, including system software, application software, utility software, and language translators, together with their functions and practical applications. You also explored the operating system, its types, components, and role in managing computer resources. Understanding these software categories provides a solid foundation for using computer systems effectively and appreciating how hardware and software work together.



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6.12 Possible Answers to Self-Assessment Exercises

1. C. Operating system
2. A. Microsoft Word
3. C. Compiler
4. B. Performing system maintenance and optimisation

MODULE 4 INFORMATION PROCESSING AND DATA REPRESENTATION

Unit 1 Information Processing
Unit 2 Data Representation

Unit 1 Information Processing

Unit Structure

1.1 Introduction
1.2 Learning outcomes
1.3 Concept of Information Processing and its Classification
1.3.1 Data, Information and Knowledge
1.4 The Manual Method
1.5 The Mechanical Method
1.6 The Computer Method
1.7 Role of Information Processing in Society
1.7.1 Education
1.7.2 Business and commerce
1.7.3 Health Sector
1.7.4 Banking and Finance
1.8 Self-Assessment Exercises
1.9 Summary
1.10 References/Further Reading/Web Sources
1.11 Possible Answers to Self-Assessment Exercises



1.1 Introduction

Information surrounds us every day, from examination results and bank transactions to hospital records and online shopping. But how does raw data become meaningful information that people and organisations can use to make decisions? The answer lies in information processing. In this unit, you will explore how data is collected, processed, stored, and transformed into useful information. You will also distinguish between data, information, and knowledge, examine the different methods of data processing, and discover how information processing supports key sectors such as education, business, healthcare, and banking. By the end of the unit, you will have a clearer understanding of why information processing is essential to modern life and decision-making.



1.2 Learning outcomes

By the end of this unit, you will be able to:

- explain the concept of information processing and distinguish between data, information, and knowledge
- differentiate between the manual, mechanical, and computer/electronic methods of data processing, including their characteristics and applications
- examine the role of information processing in key sectors such as education, business, healthcare, and banking.



1.3 Concepts of Information Processing and Its Classification

Information processing refers to the systematic collection, manipulation, storage, retrieval, and dissemination of data in order to produce meaningful information for decision-making and action. It converts raw data into decision facts.

In computing, information processing involves a sequence of activities often called the information processing cycle, which are:

- Data Collection (input): it involves gathering raw facts and figures (e.g., student scores, sales records, etc.). Examples of input units/devices here include keyboard, mouse, scanner, sensor, camera, etc.
- Processing: Transforming data through calculations, sorting, classification, summarization, or analysis. CPU is an example of a processing unit/device
- Output: Presenting processed results in usable forms (reports, charts, screens, printouts). Examples are: monitor/screen, printer, speaker etc.
- Storage: saving data and information for future use (files, databases, cloud storage). Examples are: Hard disk, SSD, flash drive, cloud storage.
- Feedback/Control: using output to refine future input or processing steps.

1.3.1 Data, Information and Knowledge

Data: Raw and unprocessed fact (e.g. 75, 60)

Information: Processed data with meaning (e.g., a student with matric no 1234 scores 60 in COS 101)

Knowledge/Decision Making: The interpreted information used for decision making (e.g. The Class average is low; extra efforts are needed)

Methods of Data Processing

The following are the three major methods that have been widely used for data processing over the years

- the Manual method,
- the Mechanical method and
- the Computer/Electronic method.

1.4 The Manual Method

The manual method of data processing involves the use of chalk, a wall, a pen, a pencil, and the like. These devices, machines, or tools facilitate human efforts to record, classify, manipulate, sort, and present data or information. The manual data processing operations entail considerable manual effort. Thus, the manual method is unfriendly, tiresome, boring, frustrating and time-consuming. Furthermore, manual data processing is often subject to human error. When errors occur, the reliability, accuracy, neatness, tidiness, and validity of the data are in doubt. The manual method does not allow for the processing of large volumes of data on a regular and timely basis. Examples are: Manual Bookkeeping. Handwritten records, etc.

1.5 The Mechanical Method

The mechanical method of data processing involves the use of machines such as typewriters, adding machines, and the like. These machines facilitate human efforts to record, classify, manipulate, sort, and present data or information. The mechanical operations are routine. There is virtually no creative thinking. Mechanical operations are noisy, hazardous, error-prone, and untidy. The mechanical method does not allow for the continuous, timely processing of large volumes of data. Examples are: Typewriters, calculators, filing machines, etc.

1.6 The Computer/Electronic Method

The computer method of carrying out data processing has the following major features:

- Data can be steadily and continuously processed
- The operations are practically not noisy
- There is a store where data and instructions can be stored temporarily and permanently.
- Errors can be easily and neatly corrected.
- Output reports are usually very neat, decent and can be produced in various forms, such as adding graphs, diagrams and pictures, etc.

- Accuracy and reliability are highly enhanced
- Examples are: databases, information systems, AI systems.

1.7 Role of Information Processing in Society

Information processing plays a central role in modern society across almost all sectors:

1.7.1 Education

Education plays a central role in how a society handles information from creation to utilisation. Within the framework of Information Processing, education functions as a structured system that enables individuals and institutions to acquire, interpret, store, and apply knowledge for societal development.

In modern societies, often referred to as information societies, education is the primary mechanism for managing knowledge resources**.** It is helpful in Student record management, examination processing, and result computation. Also, it helps with e-learning platforms, digital libraries, and online assessments, as well as supports research, data analysis, and knowledge sharing.

1.7.2 Business and Commerce

In modern business environments, information is a critical asset. The ability to collect, process, analyse, and utilise information effectively determines the success of commercial activities. Within the Information Processing framework, businesses rely on structured systems to convert raw data into useful insights for decision-making**.** In business and commerce, information processing supports payroll processing, inventory control, accounting, and sales analysis. It also assists in decision support systems for management planning and forecasting.

1.7.3 Health Sector

Information processing is useful in healthcare because it means capturing patient data, turning it into useful information, and using that information to improve care, safety, efficiency, and outcomes. The health sector relies heavily on accurate and timely information to deliver effective patient care and manage healthcare systems. Within the framework of Information Processing, healthcare institutions transform raw medical data into actionable knowledge for diagnosis, treatment, and decision-making, such as patient record management, diagnosis support systems, medical imaging, laboratory result processing, hospital administration, public health surveillance and research data analysis.

1.7.4 Banking and Finance

The banking and finance sector depends heavily on accurate, secure, and efficient handling of data. Through Information Processing, financial institutions transform large volumes of transactional data into useful information for decision-making, risk management, and customer service. It is useful for Transaction processing (ATM, online banking, mobile banking), account management, fraud detection, credit scoring, as well as in financial reporting and market analysis.



1.8 Self-Assessment Exercises

1. Which of the following best describes information processing?

A. The manufacture of computer hardware
B. The systematic conversion of data into meaningful information
C. The storage of files on a computer only
D. The use of the internet for communication

2. Which method of data processing is most suitable for handling large volumes of data accurately and efficiently?

A. Manual method
B. Mechanical method
C. Computer/Electronic method
D. Paper-based method

4. Information processing supports the banking and finance sector by performing all of the following except:

A. Transaction processing
B. Fraud detection
C. Credit scoring
D. Agricultural land preparation



1.9 Summary

In this unit, you learned that information processing is the systematic transformation of raw data into meaningful information through activities such as input, processing, output, storage, and feedback. You also distinguished between data, information, and knowledge, examined the manual, mechanical, and computer/electronic methods of data

processing, and explored the significant role information processing plays in education, business, healthcare, and banking.



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1.11 Possible Answers to Self-Assessment Exercises

1. B. The systematic conversion of data into meaningful information
2. C. Computer/Electronic method
3. D. Agricultural land preparation

Unit 2 Data Representation

Unit Structure

2.1 Introduction
2.2 Learning Outcomes
2.3 Data Representation
2.4 Binary Representation
2.4.1 Binary Number System
2.4.2 Binary to Decimal Conversion
2.5 Decimal number system
2.6 Octal number system
2.7 Hexadecimal number system
2.7.1 Decimal to Hexadecimal to decimal conversion
2.7.2 Hexadecimal to Binary conversion
2.8 Character codes
2.8.1 ASCII code
2.8.2 EBCDIC code
2.9 Self-Assessment Exercises
2.10 Summary
2.11 References/Further Reading/Web Sources
2.12 Possible Answers to Self-Assessment Exercises



2.1 Introduction

Welcome to this unit! Take a moment to think through the devices you use every day, whether they are smartphones, laptops, tablets, or ATMs. Although they display text, images, videos, and sounds in forms that people can easily understand, they all process information using only two digits: **0** and **1**. How is this possible? In this unit, you will discover how computers represent different types of data using binary digits and other number systems. You will learn how to convert numbers between binary, decimal, octal, and hexadecimal systems and explore how character coding schemes such as BCD, ASCII, and EBCDIC enable computers to represent letters, numbers, and symbols. As you work through the unit, you will gain a deeper appreciation of the language computers use to store, process, and communicate information.



2.2 Learning outcomes

By the end of this unit, you will be able to:

- explain the concept of data representation and describe how computers use binary numbers and character codes to represent different types of data
- convert numbers accurately between decimal, binary, octal, and hexadecimal number systems using appropriate conversion techniques
- differentiate between common character coding schemes, including BCD, ASCII, and EBCDIC, and explain their applications in computer systems.



2.3 Data Representation

Data representation refers to the methods used to encode and store data in a computer system so that it can be processed efficiently. Since computers operate on electronic signals, all forms of data must be converted into a format the machine can understand, typically based on the Binary Number System.

In a digital system, numerical information is usually represented in binary form. The binary form uses digits 0 and 1, called bits.

Bit is an acronym for binary digit. A bit is the smallest piece of information that can be stored and manipulated in a computer. When bits are organised into larger units, they are called a byte. Data representation is the process of converting real-world data (numbers, letters, images, sounds) into a binary format (0s and 1s) that a computer can understand, store, and process.

2.4 Binary representation

Binary representation is the method of expressing numbers, characters, images, sounds, and instructions using only two digits: 0 and 1. These two digits are called bits (binary digits).

Every piece of data inside a computer, from the number 42 to a photograph to a video game, is ultimately stored and processed as a sequence of 0s and 1s.

2.4.1 Binary Number System (Base-2)

How It Works
The decimal system (base-10) uses 10 digits (0–9). Each position represents a power of 10.

The binary system (base-2) uses 2 digits (0 and 1). Each position represents a power of 2.

Position (from right)	Place Value (Power of 2)	Value
1st (rightmost)	2^0	1
2nd	2^1	2
3rd	2^2	4
4th	2^3	8
5th	2^4	16
6th	2^5	32
7th	2^6	64
8th	2^7	128

2.4.2 Binary to Decimal Conversion

Multiply each binary digit by its place value and sum.
Example 1: Convert 1011_2 to decimal

Binary Digit	Position	Place Value (2^n)	Contribution
1	3	$2^3 = 8$	8
0	2	$2^2 = 4$	0
1	1	$2^1 = 2$	2

Binary Digit	Position	Place Value (2^n)	Contribution
1	0	$2^0 = 1$	1

Sum: $8 + 0 + 2 + 1 = 11_{10}$

Example 3: Convert 11001_2 to decimal

$1 \times 16 = 16$

$1 \times 8 = 8$

$0 \times 4 = 0$

$0 \times 2 = 0$

$1 \times 1 = 1$

Total = 25_{10}

Example 3**:** Convert 11111111_2 (8 bits all 1s) to decimal

$128 + 64 + 32 + 16 + 8 + 4 + 2 + 1 = 255_{10}$

Or

- Convert 10111_2 to base 10

Solution: 1 0 1 1 1

4 3 2 1 0 Digit Position

L R

$10111_2 = 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$

$= 16 + 0 + 4 + 2 + 1 = 23_{10}$

Example 4:

1 1 0 1. 0 0 1 1

3 2 1 0 .-1 -2 -3 -4



$1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 . 0 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3} + 1 \times 2^{-4}$

$= 8 + 4 + 0 + 1 . 0 + 0 + 0.125 + 0.0625$

$1101.0011_2 = 13.1875_{10}$

2.5 Decimal Number System (Repeated Division by 2)

A decimal number has base 10, and a binary number has base 2. In decimal-to-binary conversion, the base of the number also changes, i.e., from base 10 to base 2. All the decimal numbers have their equivalent binary numbers. These binary numbers are mainly used in computer applications, where they are used for programming or coding purposes. This is because computers understand the language of binary digits, o and 1.

2.5.1 Decimal to Binary Conversion

Example 1: Convert 13_{10} to binary

Division	Quotient	Remainder
13 ÷ 2	6	1
6 ÷ 2	3	0
3 ÷ 2	1	1
1 ÷ 2	0	1

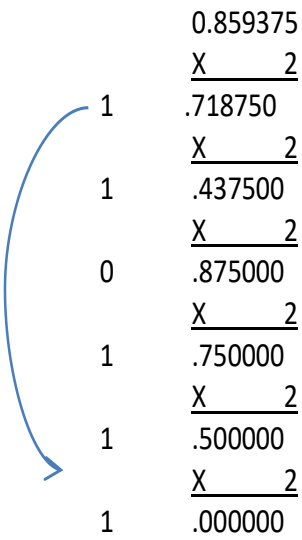
$13_{10} = 01101_2$

Example 2: convert 58_{10} to binary

2	58
2	29 r 0
2	14 r 1
2	7 r 0
2	3 r 1
2	1 r 1
2	0 r 1

$58_{10} = 111010_2$

Example 3: Convert 0.85937510 to the corresponding binary fraction.



$0.85937510 = 0.110111_2$

2.6 Octal Numbering System

The octal numbering system is a system of numbers in base eight. It takes some eight numbers between 0-7, it has ease of conversion and can be used as shorthand for binary numbers.

Conversion table for Octal System

Decimal	Binary representation in Octal
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

The digit position in octal form is

8	8	8	.	8	8	8	
2	1	0		-1	-2	-3	Digit Position

Example 1: Convert 423_8 to decimal

4	2	3_8
2	1	0

$= 4 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$

$= (4 \times 64) + 2 \times 8 + 3 \times 1$

$= 256 + 16 + 3$

$423_8 = 275_{10}$

Example 2: Convert 24.6_8 to binary

NB: steps involved

(i) convert to decimal

(ii) then convert to binary

$2 \times 8^1 + 4 \times 8^0 . 6 \times 8^{-1}$

$16 + 4 . 6/8 = 20.75_{10}$

(ii) Convert 20.75_{10} to binary

2	20
2	10 r 0
2	5 r 0
2	2 r 1
2	1 r 0
2	0 r 1

- Ans: $24.6_8 = 10100.11_2$

0.75_{10} to 2

0.	7	5
	X 2	
1.	5	0
	X 2	
1.	0	0

Convert 216_{10} to octal

8	216
8	27 r 0
8	3 r 3
8	0 r 3

$216_{10} = 330_8$

2.7 Hexadecimal Numbering System

Hexadecimal Notation

- Internally, computers store and process 0 and 1 (bits)
- But, it is hard for humans to deal with writing, reading and remembering bits
- Hexadecimal notations help humans to communicate
- Represents each 4 bits by a single symbol
  - Example: A3 denotes 1010 0011

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

6

2.7.1 Decimal – Hexadecimal-Decimal Conversion

Example1: Convert 132_{10} to hexadecimal

Convert 132_{10} to hexadecimal

16	132
16	8 r 4
16	0 r 8

$132_{10} = 84_{16}$ or 84_h

Example 2: Convert 84_h to decimal

$8 \times 16^1 + 4 \times 16^0$

$= 128 + 4$

$= 132_{10}$

Example 3: Convert $2AF_h$ to decimal

$(2 \times 16^2) + A \times 16^1) + (F \times 16^0)$

$= 2 \times 256 + 10 \times 16 + 15 \times 1$

$= 512 + 160 + 15$

$2AF_h = 687_{10}$

2.7.2 Hexadecimal to Binary

$9A2_h$ to binary

$9 = 1001_2$

$A = 1010_2$

$2 = 0010_2$

$9A2_h = 100110100010_2$

Example2: Convert $B2F_h$ to Octal

$B2F_h$

$B = 1011_2$

$2 = 0010_2$

$F = 1111_2$

$B2F_h = 101\ 100\ 101\ 111_2 = 5457_8$

2.8 Character Codes

Character code is a type of code in which a group of binary digits represents each character. Character includes digit (0-9), letter (A-Z) and marks such as (semicolon, colon, comma, quotation mark, blanks, etc.)

There are types of codes; character codes that are commonly used include

- Binary coded decimal (BCD)
- ASCII code
- EBCDIC Code

BCD represents decimal numbers by coding each decimal separately into four bits.

Example: The binary representation of the decimal number 236 is 11101100 while

The 4-bit BCD of 236 = 2 3 6

- 0010 0011 0110

The 4-bit BCD representation requires more bit positions BCD code keeps track of each decimal digit.

BCD Representation

- We can use 4 bits to represent decimal digits 0,1,2,3,4,5,6,7,8,9
  - This is called “Binary-coded decimal” (BCD) representation
  - Example: 317=0011 0001 0111
- Problems
  - We waste last 6 bit-patterns of 4 bits
  - Difficult to do calculation (+-*/)

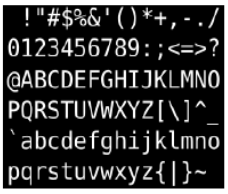
	BCD
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

2.8.1 ASCII Code

American Standard Code for Information Interchange is a standard code developed in the early 1960s. It is used in small computers, terminals, peripherals and communication devices. ASCII code uses seven bits to represent each character. Seven bits give us $2^7 = 128$. ASCII can represent 128 characters. It is sufficient to represent uppercase and lowercase letters, digits, punctuation marks, and a small number of special characters. ASCII code with 7 bits uses three zone bits and four numeric bits to represent characters. ASCII code with 8 bits adds one bit for parity checking.

Text Data

- Each character is assigned a unique bit pattern
- ASCII code
  - **A**merican **S**tandard **C**ode for **I**nformation **I**nterchange
  - Uses **7 bits** to represent most symbols used in English text



01001000	01100101	01101100	01101100	01101111	00101110
H	**e**	**l**	**l**	**o**	**.**

(Fig. 1.13)

29

Zone bit bits								**Numeric**	
000	001 2	010 1	011	100	101	110	111	8	4
NUL	DLE 0	Space 0	0	@	P	\	p	0	0
SOH	DCI 0	! 1	1	A	Q	a	q	0	0
STX	DC2 1	" 0	2	B	R	b	r	0	0
ETX	DC3 1	# 1	3	C	S	c	s	0	0
EOT	DC4 0	$ 0	4	D	T	d	t	0	1
ENQ	NAK 0	% 1	5	E	U	e	u	0	1
ACK	SYN 1	8 0	6	F	V	f	v	0	1
BEL	ETB 1	/ 1	7	G	W	g	w	0	1
BS	CAN 0	(0	8	H	X	h	x	1	0
HT	EM 0	) 1	9	I	Y	h	y	1	0
LF	SUB 1	* 0	:	J	Z	j	z	1	0

• VT	ESC	+	;	K	[	k	{	1	0
	1	1							
• FF	fs	)	<	L	\	l	/	1	1
	0	0							
• CR	GS	-	=	M	]	m	}	1	1
	0	1							
• SO	RS	.	>	N	^	n	~	1	1
	1	0							
• SI	US	/	;	O	-	o	DEL	1	1
	1	1							

For Example

A =	zone bit	Numeric	
	100	0001	= 65
• a =	110	0001	= 97

2.8.2 EBCDIC

The name stands for Extended Binary Coded Decimal Interchange Code. IBM developed this code for use on its computers. In EBCDIC 8 bits represent each character. Eight bits give us $2^8 = 256$. In EBCDIC 256 characters can be represented. This is twice the ASCII. IBM minicomputers and mainframe computers, as well as some mainframe computers similar to IBM's, use the EBCDIC code. The eight bits can be divided into two zones - Zone bit and numeric bit, which both have four bits each.

The EBCDIC representation can be summarized as follows:

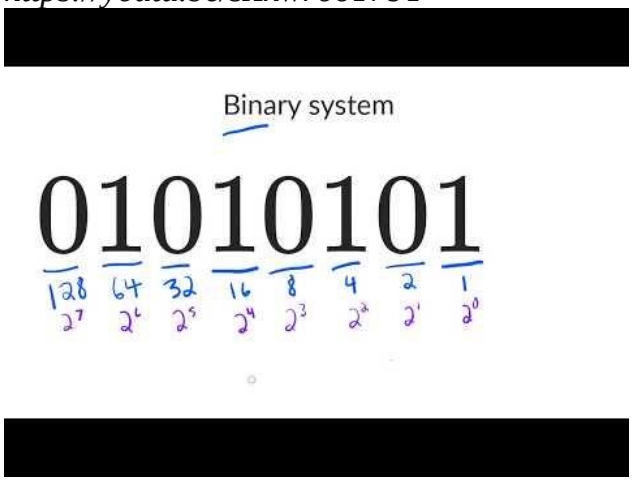
Characters	**Zone bits**	**Numeric Bits**
• 0 - 9	1111	0000 - 1001
• A - I	1100	0001- 1001
• J - R	1101	0001 - 1001
• S - Z	1100	0001 - 1000

Example: 37 in EBCDIC

Zone bit	**Numeric bit**
• 3	1111 0011
• 7	1111 0111
•	= 1111001111110111

37 require a total of sixteen bits.

Click on the link to watch a short video on this topic or scan the QR code with your phone;
https://youtu.be/sXxwr66Y79Y



2.9 Self-Assessment Exercises

1. How many distinct values can be represented with 8 bits?
- A) 128
- B) 255
- C) 256
- D) 512

2. What is the decimal equivalent of the binary number 10110?
- A) 20
- B) 22
- C) 24
- D) 26

3. The ASCII code for the character 'A' is 65 decimal. What is its binary representation?
- A) 1000001
- B) 1000010
- C) 1100001
- D) 01000001

4. Which number system is most commonly used as a shorthand for binary?
- A) Decimal
- B) Octal
- C) Hexadecimal
- D) Base-64

5. What is the hexadecimal equivalent of binary 11110000?
- A) 0F
- B) F0
- C) FF
- D) 00



2.10 Summary

This unit introduced the concept of data representation and explained how computers represent information using binary digits. You learned how to convert numbers between binary, decimal, octal, and hexadecimal number systems and explored common character coding schemes such as BCD, ASCII, and EBCDIC. Together, these concepts provide the foundation for understanding how computers store, process, and communicate digital information.



2.11 References/Further Reading/Web Sources

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Forouzan, B. A., & Mosharraf, F. (2017). *Foundations of Computer Science* (3rd ed.). McGraw-Hill Education.

Akinyokun, O.C. (1999). *Principles and Practice of Computing Technology*. Ibadan: International Publishers Limited.

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2.12 Possible Answers to Self-Assessment Exercise

1. C
2. B
3. D
4. C.
5. B

MODULE 5 THE INTERNET AND MODERN COMPUTING ENVIRONMENT

Unit 1 Définition of the Internet
Unit 2 Internet Applications

Unit 1 Internet

Unit Structure

1.1 Introduction
1.2 Learning outcomes
1.3 Basic Internet Concepts
1.4 Internet Address
1.4.1 IP Address (Internet Protocol Address)
1.4.2 Public IP Address
1.4.3 Private IP Address
1.4.4 Dynamic IP Address
1.4.5 Versions of IP Addresses
1.4.6 URL (Uniform Resource Locator)
1.4.7 Domain Name
1.5 Internet Service Providers (ISP)
1.5.1 Examples of ISPs
1.5.2 Types of Internet Connections Provided by ISPs
1.6 Internet Terminology
1.7 Self-Assessment Exercises
1.8 Summary
1.9 References/Further Reading/Web Sources
1.10 Possible Solutions to Self-Assessment Exercises



1.1 Introduction

The Internet is one of the most transformative technologies of the modern world. From accessing educational resources and conducting business transactions to communicating with people across continents, the Internet has become an essential part of everyday life. Its ability to connect people, devices, and information has changed the way we learn, work, communicate, and access services. As you study this unit, you will discover how the Internet functions, how devices are identified and located via Internet addresses, and the important role of Internet Service Providers (ISPs) in connecting users to the global network. You will also become familiar with common Internet terms that you encounter while browsing websites, sending emails, downloading files, and using online services. By the end of the unit, you will have a clearer understanding of

the technologies and concepts that make Internet communication possible and support confident participation in today's digital world.

1.2 Learning outcomes

By the end of this unit, you will be able to:

- explain the concepts of the Internet, Internet addresses, and Internet Service Providers (ISPs)
- differentiate between various types of Internet addresses, Internet protocols, and common Internet services and terminology
- apply knowledge of Internet concepts and terminology to identify Internet resources and describe how users connect and communicate online.

1.3 Internet

The Internet is a worldwide system of computer networks connected by standard communication protocols (especially TCP/IP), enabling devices to exchange data and share resources such as websites, email, files, and online services.



Fig. 1: Internet

1.4 Internet Address

An Internet address is a unique identifier used to locate and access a resource on the Internet. It tells your computer where to find a particular website, server, or service on the global network.

In simple terms, an Internet address is the location of something on the Internet.

An Internet address is a unique identifier used to locate and access a computer, website, or resource on the Internet, such as an IP address or a web address (URL). It is a unique number assigned to every device connected to a computer network. It acts as a digital address for identifying devices and routing data, consisting of a network ID and a host ID. These addresses enable communication across the internet, allowing devices to send and receive information.

1.4.1 IP Address (Internet Protocol Address)

An IP address is a numerical label assigned to each device connected to a network.

- It identifies each device and its location on the network

Types of Internet Addresses

1.4.2 Public IP Address

A public IP address is a globally unique, internet-facing identifier assigned by an internet service provider (ISP) to a router, allowing a network to communicate across the internet. It makes a home or business network accessible and serves as the digital, routable address for sending/receiving web traffic.

1.4.3 Private IP Address

A private IP address is a non-internet-routable address assigned to devices within a local network (LAN), such as homes or offices, allowing them to communicate with each other without direct internet access. These addresses are assigned by a router and are typically used to enable multiple devices to share one public IP address via Network Address Translation (NAT)

1.4.4 Dynamic IP Address

A dynamic IP address is a temporary network address automatically assigned to a device by an ISP or router using DHCP (Dynamic Host Configuration Protocol), which changes periodically or upon reconnection. It is the standard for most home users and consumer devices because it allows ISPs to manage limited IP address pools efficiently iv. Static IP Address: A static IP address is a permanent, unchanging numerical label assigned to a device or server, unlike dynamic IPs that change over time. It is essential for consistent remote access, hosting websites, mail servers, or VoIP services, providing stability and easier tracking for network administrators.

1.4.5 Versions of IP Addresses

There are two main, active versions of IP addresses: IPv4 (32-bit, decimal format) and IPv6 (128-bit, hexadecimal format). IPv4 is widely used but has a limited address space, while IPv6 was developed to replace it by providing a vastly larger address space. They often coexist through techniques like dual-stacking.

(IPv4) Internet Protocol version 4:
- 192.168.1.1

(IPv6) Internet Protocol version 6:
- 2001:0db8:85a3:0000:0000:8a2e:0370:7334

1.4.6 URL (Uniform Resource Locator) Web Address

A URL is what people commonly call a website address. It specifies the exact location of a resource (such as a web page, image, or file) on the Internet.

- Example:
  - https://www.google.com
  - https://www.university.edu.ng/admissions

A URL usually contains:
- The protocol (e.g., http, https, ftp)
- The domain name (e.g., www.google.com)
- Sometimes a path to a specific page or file

1.4.7 Domain Name

A domain name is a human-friendly name that represents an IP address.

- Example:
  - www.google.com instead of 142.250.190.14

Domain names make Internet addresses easy to remember**.** The Domain Name System (DNS) translates domain names into IP addresses that computers understand.

Examples:
- IP address: 8.8.8.8
- Web address (URL): https://www.wikipedia.org
- Domain name: www.yahoo.com

1.5 Internet Service Providers (ISP)

An Internet Service Provider (ISP) is a company or organisation such as Comcast. AT&T or Verizon that provide individuals and businesses access to the internet and related services, including web hosting and email. It connects individuals, homes, schools, and businesses to the

global Internet network. An Internet Service Provider (ISP) is a company that supplies Internet access and related services to users.

An ISP:

- Provides Internet connectivity (via fiber, cable, mobile data, satellite, etc.)
- Assigns IP addresses to users' devices
- Allows users to browse websites, send emails, and use online services
- Often provides additional services such as:
    - Email accounts
    - Web hosting
    - Domain name registration
    - Technical support

1.5.1 Examples of ISPs

- International examples: Google Fiber, AT&T, Vodafone, MTN, Airtel
- In Nigeria (examples): MTN, Airtel, Glo, 9mobile, Spectranet, Smile

1.5.2 Types of Internet Connections Provided by ISPs

- Dial-up (older and slow)
- DSL
- Cable Internet
- Fiber-optic Internet
- Mobile broadband (3G, 4G, 5G)
- Satellite Internet

1.6 Internet Terminology

When working with the Internet, certain terms and terminologies are used to describe processes and concepts. A vast list of such terminology is available. Table 1 below describes a few of the more commonly used terms and terminology.

Table 1: Common Internet Terms and Their Meanings

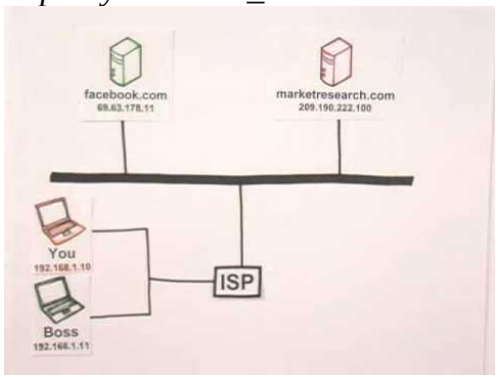
Terminology	Definition
Access Privileges	The privilege to access and make changes to folders.
Address	The unique code assigned to the location of a file in storage, a device in a system or network, or any other data source on a network.
Attachments	Multimedia files that are 'attached' to an email can be text, graphics, sound, video, spreadsheet, database or even an entire application.
Baud	The number of signalling elements that can be transmitted per second on a circuit. Older term being replaced by bps-bits per second
Bit	The smallest amount of information that can be transmitted. A combination of bits can indicate an alphabetic character, a numeric digit, or perform signalling, switching or other functions.
Browser	Application software that gives you a graphical interactive interface for searching, finding, viewing and managing information over a network.
World Wide Web (WWW)	A collection of web pages and websites that can be accessed on the Internet using a web browser.
Website	A collection of related web pages stored on a web server and identified by a domain name (e.g., www.university.edu.ng).
Web Page	A single document on the World Wide Web, usually written in HTML and viewed in a web browser.
Web Browser	A software application used to access and view websites. Examples: Google Chrome, Mozilla Firefox, Microsoft Edge, Safari.
URL (Uniform Resource Locator)	The address of a resource on the Internet. Example: https://www.google.com
Email (Electronic Mail)	A system for sending and receiving messages over the Internet. Example: user@example.com

Search Engine	A tool used to find information on the Internet. Examples: Google, Bing, DuckDuckGo.
Hyperlink (Link)	A clickable text or image that takes you from one web page to another or to a different part of the same page.
Hyperlink (Link)	A clickable text or image that takes you from one web page to another or to a different part of the same page.
Homepage	The main or first page of a website
Bandwidth	The amount of data that can be transmitted over an Internet connection in a given time.
Download	To copy data or files from the Internet to your computer or device.
Upload	To send data or files from your computer or device to the Internet.
Client	A computer or device that requests services or resources from a server (e.g., your phone or PC accessing a website).
Wi-Fi	A wireless technology used to connect devices to the Internet or a local network.
Web Server	A computer that stores websites and delivers web pages to users over the Internet.
Modem	A device that connects a computer or router to the Internet through an ISP.
Router	A device that distributes Internet connection to multiple devices in a network.
Cloud	A system of online servers used to store and process data over the Internet. Examples: Google Drive, OneDrive, Dropbox.

Social Media	Online platforms used for social interaction and content sharing. Examples: Facebook, X (Twitter), Instagram, WhatsApp, TikTok.
Streaming	Watching or listening to audio/video directly from the Internet without fully downloading it first. Examples: YouTube, Netflix, Spotify.
E-commerce	Buying and selling goods and services over the Internet. Examples: Amazon, Jumia, Konga.
Client	A computer that uses the services of another computer (a server or host). If you have a PC on your desk and you retrieve information from the World Wide Web, your PC is a client of the Web server to which it is connected.
Cybercafe	A café or bar allowing customers to explore the World Wide Web whilst having a drink or snack, usually charged per half-hour of usage.
Cyberspace	Originally used in "Neuromancer," William Gibson's novel of direct brain-computer networking, referring to the collective realms of computer-aided communication.
Database	A multi-user collection of information. Often supports random access selectivity and multiple "views" or levels of abstraction of the underlying data.
HTML (Hyper Text Markup Language)	A "tag" language in which web pages are Formatted and web information is distributed.
HTTP (Hypertext Transfer Protocol)	The method by which documents are transferred from the host computer or server to browsers and individual users.
Hyperlink	In World Wide Web pages, hyperlinks are highlighted text or images which, when selected (usually by clicking the mouse button), follow a link to another page. Hyperlinks can also be used to automatically download other files as well as sounds and video clips.

MoDem (MODulator-DEModulator)	End-of-user computer interface that enables digital data to be transmitted over analog transmission facilities like phone lines.
Multimedia	Computer systems that integrate audio, video and data.
Network	A system of interrelated elements that are interconnected in a dedicated or switched linkage to provide local or remote communication (of voice, video, data, etc.) and to facilitate the exchange of information between users with common interests.
Newsgroup	A distributed bulletin board system about a particular topic. Usenet news is a system that distributes thousands of newsgroups to all parts of the Internet.

Click on the link to watch a short video on this topic or scan the QR code with your phone;
https://youtu.be/7_LPdttKXPc





1.7 Self-Assessment Exercise

1. Which of the following best describes the Internet?

A. A collection of standalone computers that cannot communicate
B. A worldwide network of interconnected computers that share information using standard protocols
C. A single computer that stores all websites
D. A software application used to browse websites

2. Which Internet address is designed to be easy for people to remember instead of using numerical IP addresses?

A. MAC Address
B. Domain Name
C. URL Path
D. Port Number

3. What is the primary function of an Internet Service Provider (ISP)?

A. To manufacture computer hardware
B. To provide Internet connectivity and related online services
C. To develop operating systems
D. To create web browsers

4. Which of the following is an example of a web browser?

A. Google Drive
B. YouTube
C. Google Chrome
D. Gmail



1.8 Summary

The Internet is a global network that enables communication and information sharing among connected devices. It relies on Internet addresses such as IP addresses, URLs, and domain names to identify and locate resources. Internet Service Providers (ISPs) connect users to the Internet, while common Internet tools and terminology, such as web browsers, search engines, and websites, help users access and interact with online information and services efficiently.



1.9 References/Further Reading/Web Sources

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French, C. S. (2000). *Computer Science* (5th ed.) Gosport, Hants:



1.10 Possible Answers to Self-Assessment Exercise

1. B. A worldwide network of interconnected computers that share information using standard protocols
2. B. Domain Name
3. B. To provide Internet connectivity and related online services
4. C. Google Chrome

Unit 2 Internet Applications

Unit Structure

2.1 Introduction
2.2 Learning outcomes
2.3 E-mail
2.3.1 Key Components of an Email Message
2.3.2 Functional Features of Email Clients
2.3.3 Major Aspects of Effective Email
2.4 Social Media
2.4.1 Features of Social Media
2.4.2 Major Types of Social Media Platforms
2.5 Self-Assessment Exercises
2.6 Summary
2.7 References/Further Reading/Web Sources
2.8 Possible Solutions to Self-Assessment Exercises



2.1 Introduction

Welcome to this unit on Email and Social Media, two of the most popular and influential applications of the Internet. Whether you are communicating with colleagues, submitting assignments, promoting a business, or connecting with friends across the world, these digital communication tools have become an essential part of everyday life. As you work through this unit, you will explore how email enables formal, reliable communication by exchanging digital messages and files. You will also discover how social media platforms have transformed the way people interact, share information, build communities, and collaborate in real time. By understanding their features, uses, and best practices, you will be better equipped to communicate effectively, responsibly, and professionally in today's digital environment.



2.2 Learning outcomes

By the end of this unit, you will be able to:

- **describe** the concepts of email and social media as important Internet communication tools
- **explain** the components, features, and best practices for effective email communication, as well as the characteristics of social media platforms
- **differentiate** between traditional media and social media, including the major types of social media platforms

- **apply** appropriate email etiquette and identify suitable social media platforms for different communication and information-sharing purposes.

2.3 Email

Electronic Mail (Email) is one of the most widely used internet applications for sending and receiving messages electronically over the internet. It allows users to exchange text, files, images, and other digital content instantly across the world. Email operates using communication protocols such as the Simple Mail Transfer Protocol and the Internet Message Access Protocol.

It is a method of exchanging digital messages between people using electronic devices connected to a network, typically the Internet. It is one of the oldest and most widely used applications of the Internet, dating back to the 1960s.

Email is like traditional postal mail (snail mail), but much faster and fully digital.



Fig.1: Email ICON

2.3.1 Key Components of an Email Message

- Header: Contains metadata for the message, including:
  - From: The sender's email address.
  - To: The primary recipient(s).
  - Subject Line: A concise, descriptive summary of the topic.
  - Date/Time: Automatically recorded, allowing for tracking.

  - Cc (Carbon Copy): Recipients who receive a copy but are not the primary target.
  - Bcc (Blind Carbon Copy): Recipients hidden from others to protect privacy.
- Body: The actual content of the message, including text, HTML formatting, images, and links.
- Sign-off/Signature: A closing phrase (e.g., "Best regards") followed by the sender's name, title, and contact details.
- Attachments: Digital files (documents, images, audio/video) sent alongside the message.

2.3.2 Functional Features of Email Clients

- Address Book: Allows users to save and instantly retrieve contact details, including groups.
- Organisation Tools: Folders, labels, and filters for sorting messages (e.g., Inbox, Sent, Drafts, Spam/Trash).
- Search Functionality: Enables searching for specific emails based on keywords, sender, or date.
- Auto-Reply/Out-of-Office: Sends automatic responses when the user is unavailable.
- Automatic Forwarding/Redirection: Automatically sends incoming messages to another address.
- **Delivery Notification:** Warns the sender if a message cannot be delivered ("bounce" messages).

2.3.3 Major Aspects of Effective Email

- Conciseness: Emails should be short, clear, and to the point to ensure they are read and processed quickly.
- Structured Format: Often left-justified (block format) with blank lines between short paragraphs for readability.
- Tone and Etiquette: Proper, polite greetings and closings are crucial, particularly in professional contexts.
- Call-to-Action (CTA): A clear, specific instruction at the end of the email regarding the next steps, often used in business or marketing, such as "Please confirm the meeting time".
- Record-Keeping: Emails create a durable, searchable written record of communication, unlike verbal conversations.
- Versatility: Can be sent to individuals, groups, or as bulk marketing campaigns (newsletters, promotions).

2.4 Social Medias

Social media refers to digital platforms, applications, and websites that enable users to create, share, and exchange content (text, images, videos, audio) while interacting with other users in virtual communities and networks.

Social media platforms are web-based and mobile applications that enable users to create, share, and interact with content and with other users in real time. They are a major component of modern internet applications and are widely used for communication, education, business, and entertainment. It operates over internet infrastructure using protocols such as Internet Protocol.

Unlike traditional media (newspapers, television, radio), social media is:

- Interactive – Users can comment, like, share, and reply
- User-generated – Content comes from users, not professional publishers
- Two-way – Communication flows in all directions, not just broadcaster to audience

Differences between traditional and social media means of operation

Traditional Media	**Social media**
One-to-many (broadcast model)	Many-to-many (network model)
Professional content creators	User-generated content
Passive consumption	Active participation
Fixed publishing schedule	Real-time, continuous
Limited feedback (letters, calls)	Immediate interaction (likes, comments, shares)

2.4.1 Features of Social media

A platform is generally considered social media if it has these five characteristics:

Characteristic	**Description**
User accounts	Users create profiles to represent themselves
Content creation	Users can post text, photos, videos, or links
Interaction	Users can like, comment, share, or reply to others' content

Characteristic	Description
Networks	Users can connect with friends, followers, or other users
Timeline/Feed	Content is displayed in a chronological or algorithmic feed

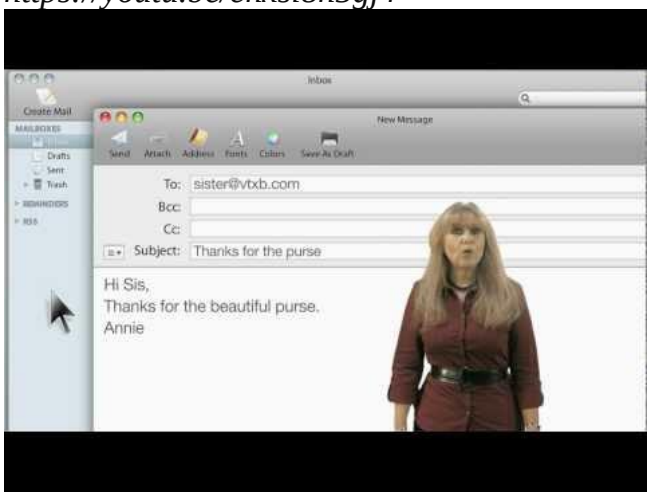
2.4.2 Major Types of Social Media Platforms

Below are the various types of social media platforms, their primary focus and examples of the social media platforms concern.

Type	Primary Focus	Examples
Social Networking	Connecting with friends, family, and colleagues	Facebook, LinkedIn, Google+ (defunct)
Microblogging	Short, frequent updates (text, links, images)	X (Twitter), Threads, Tumblr
Media Sharing	Sharing photos and videos	YouTube, Instagram, TikTok, Snapchat, Flickr
Messaging Apps	Private one-to-one or group communication	WhatsApp, Messenger, WeChat, Telegram, Signal
Discussion Forums	Topic-based conversations and Q&A	Reddit, Quora, Discord
Professional Networking	Career and business connections	LinkedIn
Review Platforms	User reviews of businesses, products, services	Yelp, TripAdvisor, Google Maps (reviews)
Live Streaming	Real-time video broadcasting	Twitch, YouTube Live, Instagram Live, TikTok Live

Type	Primary Focus	Examples
Blogging Platforms	Long-form written content	Medium, wordpress.com, Substack
Social Bookmarking	Sharing and discovering links	Pinterest, Flipboard
Interest-Based Communities	Niche hobbies and interests	Goodreads (books), Strava (fitness), Ravelry (knitting)

Click on the link to watch a short video on this topic or scan the QR code with your phone;
https://youtu.be/cnxsl8h5gj4





2.5 Self-Assessment Exercises

1. Which of the following is the primary purpose of email?

A. To edit documents offline
B. To exchange digital messages and files over the Internet
C. To install software applications
D. To create computer programs

2. Which part of an email contains the main message sent by the sender?

A. Header
B. Attachment
C. Body
D. Subject Line

3. Which of the following is a key characteristic that distinguishes social media from traditional media?

A. Content is produced only by professionals.
B. Communication flows only from publishers to audiences.
C. Users can create, share, and interact with content in real time.
D. It cannot be accessed using mobile devices.

4. Which of the following is an example of a professional networking social media platform?

A. TikTok
B. WhatsApp
C. LinkedIn
D. YouTube



2.6 Summary

Email and social media are essential Internet applications that support communication and information sharing. Email provides a fast and reliable means of exchanging digital messages and files, while social media enables users to create, share, and interact with content through online communities. Understanding their features, appropriate uses, and best practices helps individuals communicate effectively and participate responsibly in the digital world.

2.7 References/Further Reading/Web Sources

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2.8 Possible Answers to Self-Assessment Exercise

1. B. To exchange digital messages and files over the Internet
2. C. Body
3. C. Users can create, share, and interact with content in real time.
4. C. LinkedIn

MODULE 6 COMPUTING DISCIPLINE, CAREERS AND FUTURE TRENDS

Unit 1 Job Specialisations in Computing
Unit 2 Future of Computing

Unit 1 Major Computing Disciplines

Unit Structure

1.1 Introduction
1.2 Learning outcomes
1.3 Computer Science
1.3.1 Major Types and Paradigms
1.3.2 Popular Languages and Their Uses
1.4 Information Technology
1.4.1 Core Components of IT
1.4.2 Impact and Importance
1.5 Software Engineering
1.5.1 Core Components of Software Engineering
1.5.2 Major Skills & Principles of Software Engineering
1.5.3 Career Pathways & Education in Software Engineering
1.6 Computer Engineering
1.6.1 Major Aspects of Computer Engineering
1.6.2 Computer Engineers
1.7 Information Systems
1.7.1 Components of Information Systems
1.7.2 Career in Information Systems
1.8 Cybersecurity
1.8.1 Major Components and Types of Cybersecurity
1.8.2 Common types of cyber threats
1.8.3 Cybersecurity practices
1.8.4 Areas within cybersecurity
1.9 Data Science
1.9.1 Techniques in Data Science
1.9.2 Application of Data Science
1.9.3 Career in Data Science
1.10 Importance of Job Specialisation in Computing
1.11 Self-Assessment Exercises
1.12 Summary
1.13 References/Further Reading/Web Sources
1.14 Possible Solutions to Self-Assessment Exercises



1.1 Introduction

As technology continues to transform every aspect of modern life, the computing profession has expanded into several specialised fields, each contributing unique knowledge and expertise to solving different technological challenges. From developing software and managing information systems to securing digital assets and analysing data, computing professionals play vital roles in driving innovation across industries. In this unit, you will explore the major branches of computing, including Computer Science, Information Technology, Software Engineering, Computer Engineering, Information Systems, Cybersecurity, and Data Science. You will also discover the career opportunities associated with each discipline and appreciate the importance of job specialisation in meeting the growing demands of today's digital economy. By understanding the focus and responsibilities of these fields, you will be better prepared to identify their contributions to society and make informed decisions about future areas of study or career paths.



1.2 Learning outcomes

By the end of this unit, you will be able to:

- identify the major fields of computing
- explain the roles of the different computing disciplines
- apply knowledge of the computing disciplines to real-life situations
- differentiate between the various computing disciplines based on their functions.



1.3 Computer Science

Computer Science is the study of computers and computational systems. It involves the design, development, and analysis of algorithms, software, and hardware for processing information.

It is both a theoretical discipline (focused on algorithms, computation, and data structures) and a practical discipline (focused on building software and systems).
Computer Science integrates concepts from:

- Mathematics (logic, discrete structures)

- Engineering (system design)
- Natural sciences (problem-solving methods)

It is concerned with:

- Problem-solving using computers
- Designing efficient algorithms
- Developing reliable software systems

The core areas of Computer science are:

A. Algorithms and Data Structures: Algorithms and data structures involve step-by-step procedures for solving problems and also involve the organisation of data.

B. Programming Languages: A programming language is a formal system of rules and instructions used by humans to communicate with computers and develop software. These languages allow developers to express algorithms in a human-readable format, which is then translated into a machine-executable binary.

1.3.1 Major Types and Paradigms

Programming languages are categorised based on their level of abstraction and how they structure code:

- High-Level vs. Low-Level: High-level languages (e.g., Python, Java) use English-like syntax and abstract away hardware details, making them easier to read and write. Low-level languages (e.g., Assembly, Machine Code) provide direct hardware control but are complex and machine-dependent.
- Compiled vs. Interpreted: Compiled languages (e.g., C, Rust) are converted entirely into machine code before execution for high speed. Interpreted languages (e.g., JavaScript, Python) execute code line-by-line during runtime, offering greater flexibility.
- Programming Paradigms: Object-Oriented Programming (OOP) (e.g., Java, C++) organises code around reusable "objects". Functional programming (e.g., Haskell, Elixir) focuses on mathematical functions and immutable data. Procedural languages (such as C, BASIC) follow a linear sequence of commands.

1.3.2 Popular Languages and Their Uses

- Python: The leading language for artificial intelligence, data science, and automation due to its simplicity.
- JavaScript: Essential for web development, powering interactive front-end and server-side logic (via Node.js).
- Java: Widely used in enterprise software, Android apps, and large-scale banking systems.

- C / C++: Preferred for system programming, operating systems, and high-performance game engines.
- SQL: A domain-specific language used exclusively for database management and data manipulation.
- Swift & Kotlin: Modern languages designed for native mobile app development on iOS and Android, respectively.
- Rust & Go: Emerging languages focused on performance and safety; Rust is noted for memory security, while Go excels in cloud infrastructure.

1.4 Information Technology

Information Technology (IT) is the discipline concerned with the selection, deployment, configuration, management, security, and support of computing technologies to meet organisational needs. IT is about making technology work reliably, securely, and efficiently for users and businesses.

Information technology (IT) is the use of computers, storage, networking, and physical devices to manage, process, store, secure, and exchange all forms of electronic data. It encompasses both hardware and software to facilitate daily business operations, communications, and data-driven decision-making, acting as the foundation of modern digital infrastructure.

1.4.1 Core Components of IT

- Hardware: Servers, computers, data centres, and physical devices.
- Software: Applications, operating systems, and functional programs.
- Networking: Systems facilitating communication, such as routers and switches, and the internet.
- Data Management**:** Systems for storing, securing, and retrieving information (e.g., databases, cloud storage).

1.4.2 Impact and Importance

IT is essential for modern business and daily life, enabling e-commerce, remote work, advanced healthcare through Electronic Health Records (HER), and instant global communication. It is a rapidly evolving field driven by artificial intelligence (AI), machine learning, and automation.

1.5 Software Engineering

Software engineering is the systematic application of engineering principles, methods, and tools to the design, development, testing, and

maintenance of software systems. It goes beyond coding, focusing on creating reliable, scalable, and efficient solutions to complex problems while collaborating with teams to deliver, maintain, and document software.

1.5.1 Core Components of Software Engineering

- Design & Architecture: Creating high-level, scalable, and secure system architectures.
- Development: Writing code for front-end (user interface) and back-end (business logic) systems.
- Testing & Maintenance:

Ensuring software quality, repairing bugs, and updating systems to meet user needs.

- Methodologies**:** Utilising structured approaches like Agile, Scrum, or DevOps to manage development.

1.5.2 Major Skills & Principles of Software Engineering

- Programming Languages: Proficiency in languages like Java, Python, C++, or JavaScript.
- Problem-Solving: Applying analytical thinking to solve technical challenges, not just writing syntax.
- Collaboration: Working with designers, project managers, and other developers, often requiring version control tools like Git.
- Core Concepts: Understanding algorithms, data structures, and software architecture patterns.

1.5.3 Career Pathways & Education in Software Engineering

- Roles: Software Developer, Systems Software Engineer, Front-end/Back-end Engineer, and Solutions Architect.
- Education: A bachelor's degree in computer science, software engineering, or IT is common, though practical experience and certifications are highly valued.
- Industries: Software engineers work in technology, finance, healthcare, and manufacturing, among others.

1.6 Computer Engineering

Computer engineering is a dynamic field combining electrical engineering and computer science to design, develop, and integrate hardware and software systems. Professionals create technology such as processors, circuit boards, robotics, and embedded systems. They bridge the gap between low-level hardware and high-level software for applications like AI, telecommunications, and aerospace.

1.6.1 Major Aspects of Computer Engineering

- Hardware Design: Focuses on developing computer components like processors, memory chips, and circuit boards.
- Software Development: Involves creating low-level software, such as firmware, embedded systems, and operating systems, to run hardware
- System Integration: Combines hardware and software for specialised products like smart appliances, automobiles, and medical devices.
- Areas of Study: Students study electronics, computer architecture, VLSI, data structures, and algorithms.

1.6.2 Computer Engineers

- Design & Test: Create schematics for new computer equipment and test prototypes to ensure functionality.
- Embed Systems: Write software for real-time microcontrollers used in automation, robots, and UAVs.
- Network Development: Build and maintain network systems and data communication systems.

1.7 Information Systems

An information system (IS) is an integrated set of components people, hardware, software, networks, and data designed to collect, process, store, and distribute information to support decision-making, coordination, and control in organisations. Unlike IT, which focuses on technology, IS focuses on using technology to achieve business goals and create value.

1.7.1 Components of Information Systems

Information systems rely on a sociotechnical approach, blending technology with human activity:

- Hardware: Physical devices like computers, servers, smartphones, and tablets.
- Software: Programs and applications that process data, including operating systems and business applications.
- Data: Raw facts and data points that are organised and stored in databases.
- Networks: Systems connecting hardware, such as the internet and internal networks.
- People: The users, technicians, and managers who operate and utilise the system.

1.7.2 Careers in Information Systems

Information systems professionals bridge the gap between technical teams and business operations. Common roles include:

- Systems Analyst: Analysing and designing improvements to information systems.
- Database Administrator: Managing the databases and ensuring data integrity.
- Information Security Analyst: Protecting organisational data and systems.
- Business Intelligence Analyst: Interpreting data to identify business opportunities.
- IT Project Manager: Leading the implementation of new technology systems.

1.8 Cybersecurity

Cybersecurity is the practice of protecting systems, networks, and data from digital attacks. It is a broad field that touches everything from personal devices to global infrastructure. Cybersecurity is critical because nearly everything today, banking, healthcare, communication, and government, depends on digital systems. A single breach can lead to financial loss, privacy violations, or even national security risks. As threats such as ransomware and AI-powered attacks evolve, organisations are investing heavily in proactive defences, with security spending projected to reach USD 377 billion by 2028.

At its core, cybersecurity focuses on three main goals (often called the CIA triad):

- Confidentiality: keeping data private
- Integrity: ensuring data isn’t altered or tampered with
- Availability: making sure systems and data are accessible when needed

1.8.1 Major Components and Types of Cybersecurity

- Network Security: Protecting network infrastructure from unauthorised access or misuse.
- Application Security: Securing software and devices from threats, ideally addressed during development.
- Cloud Security: Protecting data, applications, and infrastructure in cloud environments.
- Information Security: Ensuring the integrity and privacy of data in storage and transit.
- IoT Security: Securing internet-connected devices.

1.8.2 Common types of cyber threats

- Malware – viruses, ransomware, spyware
- Phishing – fake emails/messages tricking users into giving info
- DDoS attacks – overwhelming systems to shut them down
- Man-in-the-middle attacks – intercepting communications
- Password attacks – brute force or credential theft

1.8.3 Cybersecurity Practice

- Use strong, unique passwords (and a password manager) ,
- Enable two-factor authentication (2FA)
- Keep software updated
- Avoid suspicious links and downloads
- Use antivirus/firewall protection
- Back up important data regularly

1.8.4 Areas within Cybersecurity

- Network security – protecting internal systems
- Application security – securing software and apps
- Cloud security – protecting cloud-based systems
- Ethical hacking (penetration testing) – testing systems for weaknesses
- Digital forensics – investigating cyber incidents

1.9 Data Science

Data Science evolved from statistics and computer science, gaining prominence in the early 21st century as digital data volumes expanded. The term gained traction in academia and industry through the widespread adoption of big data technologies and cloud computing. Universities worldwide now offer dedicated programs emphasising both theoretical foundations and applied analytics.

Data Science is an interdisciplinary field that uses scientific methods, algorithms, and systems to extract knowledge and insights from data for decision-making. It combines concepts from:

- Statistics: for analysing data
- Computer Science: for programming and automation
- Domain Knowledge: to interpret results meaningfully

The discipline's workflow typically includes data collection, cleaning, and preprocessing; exploratory data analysis; model development using machine learning; and result communication through visualisation and reports. Methods span regression, classification, clustering, deep learning,

and natural language processing, supported by scalable computing infrastructure and reproducible pipelines.

Data science turns raw data → useful information → actionable decisions
Data Science Process (Lifecycle)

1. Data Collection: gathering data (databases, APIs, sensors, surveys)
2. Data Cleaning: removing errors, duplicates, and missing values
3. Data Exploration (EDA): Understanding patterns using charts and summaries
4. Modeling: applying algorithms (such as regression, classification)
5. Evaluation: testing model accuracy and performance
6. Deployment: using the model in real-world applications

1.9.1 Techniques in Data Science

- Machine Learning: systems that learn from data
- Data Mining: discovering hidden patterns
- Predictive Analytics: forecasting future outcomes
- Big Data Analytics: handling massive datasets

1.9.2 Applications of Data Science

Data science is applicable in the following areas:

- Healthcare: disease prediction, medical diagnosis
- Finance: fraud detection, risk analysis
- Business: customer behaviour analysis, sales forecasting
- Education: student performance prediction
- Social Media: recommendation systems
-

1.9.3 Careers in Data Science

- Data Scientist
- Data Analyst
- Machine Learning Engineer
- Data Engineer
- Business Intelligence Analyst

1.10 Importance of Job Specialisation in Computing

Job specialisation is important for the following reasons

1. Increased Efficiency and Productivity
   Specialists develop deep expertise in a narrow area, allowing them to perform tasks faster and more accurately.
   For example, a database administrator can optimise queries far better than a generalist.

2. Improved Quality of Work
   Specialisation leads to mastery. Professionals with specialised skills produce high-quality, reliable, and secure systems, especially in critical areas such as software development and cybersecurity.
3. Handling Complexity in Modern Systems

Computing systems are highly complex and involve multiple layers such as:

- Software development
- Networking
- Security
- Data management

No single individual can effectively manage all these areas. Specialisation ensures each component is handled by an expert.

4. Faster Problem Solving
   Specialists can quickly diagnose and resolve issues within their domain.
   For example, a network engineer can troubleshoot connectivity problems more efficiently than a general IT worker.
5. Encourages Innovation and Advancement

Focused expertise allows professionals to:

- Conduct research
- Develop new technologies
- Improve existing systems

Many breakthroughs in areas like Artificial Intelligence and Cybersecurity come from specialised professionals.



1.11 Self-Assessment Exercises

1. Which discipline focuses on the theoretical foundations of computing?
A. Information Technology
B. Software Engineering
C. Computer Science
D. Cybersecurity

2. Which field is primarily concerned with protecting systems and data?
A. Data Science
B. Cybersecurity
C. Information Technology
D. Software Engineering

3. Data Science mainly deals with:
A. Hardware design
B. Data analysis and prediction
C. Network installation
D. Software testing

4. Software Engineering is best described as:
A. Managing networks
B. Designing and developing software systems
C. Studying algorithms only
D. Repairing computers

5. Information Technology focuses on:
A. Theoretical computation
B. Practical use and management of computer systems
C. Data mining only
D. Robotics



1.12 Summary

Computing is a broad field comprising several specialised disciplines, including Computer Science, Information Technology, Software Engineering, Computer Engineering, Information Systems, Cybersecurity, and Data Science. Although each discipline has distinct roles and areas of focus, they work together to design, develop, manage, secure, and improve modern computing systems. Job specialisation enables professionals to develop expertise, improve efficiency, solve

complex problems, and drive technological innovation across diverse sectors of society.



1.13 References/Further Reading/Web Sources

Glenn Brookshear, J., and Dennis Brylow (2023). Computer Science: An Overview, 13th Edition, Amazon.

Yale N. Patt and Sanjay J. Palet (2019) Introduction to Computing Systems: From Bits and Gates to C & Beyond. 3rd Edition. McGraw-Hill Education.



1.14 Possible Answers to Self-Assessment Exercises

1. Computer science (C)
2. Cybersecurity (B)
3. Data Analysis and Protection (B)
4. Designing and developing software systems (B)
5. Practical use and management of computer systems (B)

Unit 2 Future Trends in Computing

Unit Structure

2.1 Introduction
2.2 Learning outcome(s)
2.3 Artificial Intelligence
2.4 Agentic AI and Multi-Agent Systems
2.4.1 Concepts of AI Agents & MAS
2.5 Quantum Computing
2.5.1 Qubit
2.5.2 Superposition
2.5.3 Entanglement
2.5.4 Advantages of Quantum Computing
2.5.5 Challenges of Quantum Computing
2.6 Next-Generation Connectivity (6G & Beyond)
2.6.1 6G
2.6.2 Ultra-High Speed
2.6.3 Ultra-low Latency
2.6.4 AI-Native Network Architecture
2.6.5 Ubiquitous (Global) Connectivity
2.7 Self-Assessment Exercise(s)
2.8 Summary
2.9 References/Further Reading/Web Sources
2.10 Possible Answers to Self-Assessment Exercises



2.1 Introduction

Congratulations on reaching the final unit of this course! Throughout this course, you have explored the fundamentals of computing, computer systems, information processing, networking, and the Internet. Now, it is time to look ahead and discover the technologies that are shaping the future of computing. In this unit, you will be introduced to some of the most exciting developments in the digital world, including Artificial Intelligence (AI), AI agents and Multi-Agent Systems, Quantum Computing, and next-generation connectivity such as 6G. As these technologies continue to transform industries, businesses, education, healthcare, and everyday life, understanding their basic concepts and potential applications will prepare you to appreciate the future direction of computing and its growing impact on society.



2.2 Learning outcome(s)

By the end of this unit, you will be able to:

- identify the major emerging technologies in computing
- describe the basic concepts of Artificial Intelligence, Quantum Computing, and 6G technology
- explain how these emerging technologies are used in different areas of society
- compare the features and applications of Artificial Intelligence, Quantum Computing, and next-generation connectivity.



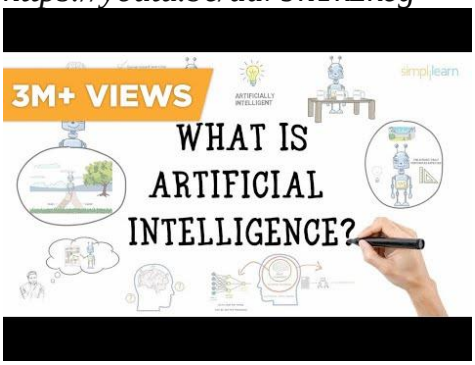
2.3 Artificial Intelligence

Artificial Intelligence (AI) is the branch of computer science focused on creating machines and systems that can perform tasks that normally require human intelligence**.** These tasks include learning, reasoning, problem-solving, perception, understanding language, and decision-making. AI is becoming the foundation of modern computing systems, not just a feature.

- Shift from basic automation → agentic AI (autonomous decision-making systems)
- AI integrated into software, cloud, and business processes
- AI systems increasingly make decisions with minimal human input

Artificial intelligence (AI) is technology that enables computers and machines to simulate human learning, comprehension, problem-solving, decision-making, creativity, and autonomy. Applications and devices equipped with AI can see and identify objects. They can understand and respond to human language. They can learn from new information and experience. They can make detailed recommendations to users and experts. They can act independently, replacing the need for human intelligence or intervention (a classic example being a self-driving car).
Directly underneath AI, we have machine learning, which involves creating models by training an algorithm to make predictions or decisions based on data. It encompasses a broad range of techniques that enable computers to learn from data and make inferences without being explicitly programmed for specific tasks.

Click on the link to watch a short video on this topic or scan the QR code with your phone;
https://youtu.be/ad79nYk2keg



2.4 Agentic AI and Multi-Agent Systems

AI agents are autonomous systems that perceive their environment, reason, and take actions to achieve specific goals, often utilising Large Language Models (LLMs). Multi-Agent Systems (MAS) enhance this by employing multiple specialised, interacting agents that collaborate to solve complex, large-scale tasks and increase efficiency beyond what single agents can achieve. Images of single- and multi-agent systems are shown in Fig. 1 below.

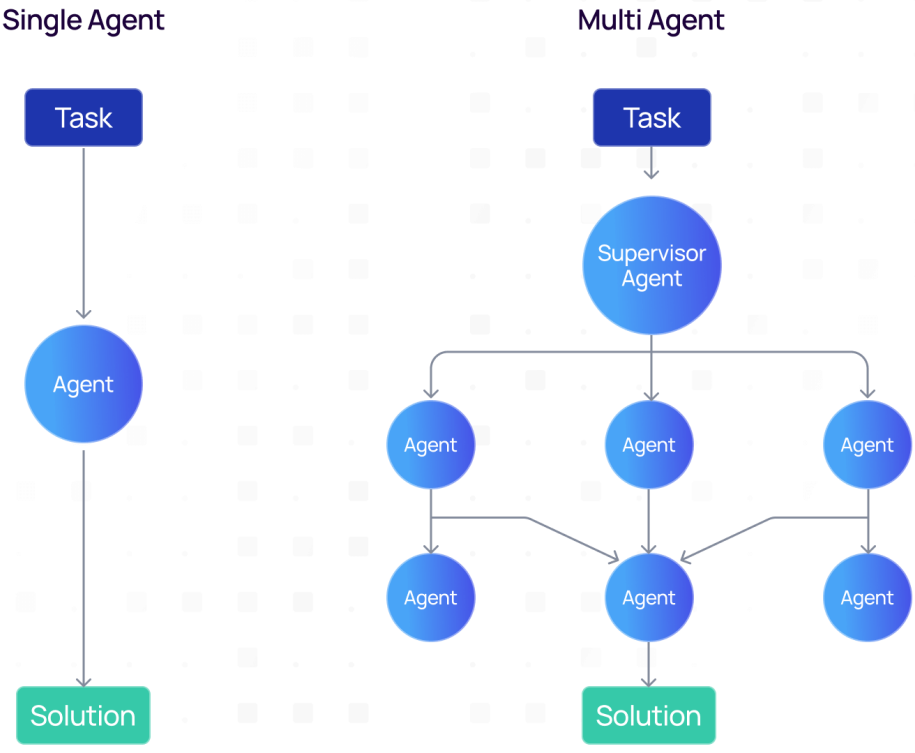


Fig. 1: Single-agent and Multi-Agent systems

2.4.1 Concepts of AI Agents & MAS

- AI Agents: Autonomous software or robots that use AI to make decisions, utilise tools, and act. They are proactive and can learn from their environment.
- Multi-Agent Systems (MAS): Networks of agents that work together to perform complex, multi-stage tasks that a single model cannot efficiently handle.
- Interaction Types: Agents within a MAS can work cooperatively (shared goals), competitively (conflicting goals), or perform parallel, specialised tasks.
- Benefits of MAS:
    - Scalability: Can manage complex projects by involving many agents.
    - Specialisation: Individual agents can focus on specific tasks (e.g., researcher, coder, manager).
    - Resilience: More fault-tolerant and robust for enterprise applications

Single vs. Multi-Agent Systems

- Single-Agent: Ideal for well-defined, simpler tasks. Less complex to set up but limited to one model and context.
- Multi-Agent: Better for complex workflows requiring specialised roles and parallel processing.

2.5 Quantum Computing

Quantum Computing utilises quantum mechanics, specifically superposition and entanglement, to solve complex problems far beyond the capabilities of classical computers. By using quantum bits (qubits) that can represent multiple states simultaneously, these machines offer exponential speed advantages for specialised tasks such as drug discovery, materials science, and cryptography. It is a type of computation that uses the principles of quantum mechanics (physics of subatomic particles) to perform calculations. Unlike classical computers that use bits (0 or 1), quantum computers use qubits that can exist in multiple states simultaneously.

Key Concepts in Quantum Computing

2.5.1 Qubit

- The basic unit of quantum information.
- Can exist in multiple states simultaneously (superposition).

2.5.2 Superposition

- A qubit can be both 0 and 1 at the same time until measured.

2.5.3 Entanglement

- Two or more qubits can be linked such that the state of one affects the other, even at a distance.

2.5.4 Advantages of Quantum Computing

- Can solve certain problems much faster than classical computers.
- Useful in:
  - Cryptography and security analysis
  - Drug discovery and materials science
  - Optimisation problems
  - Complex scientific simulations

2.5.5 Challenges of Quantum Computing

- Very expensive and complex to build
- Sensitive to environmental disturbances
- Still largely in research and experimental stages

2.6 Next-Generation Connectivity (6G & Beyond)

Next-generation connectivity refers to the evolution of wireless and wired network technologies beyond current 5G networks. The next major milestone is 6G (the sixth generation of cellular networks), followed by the speculative 7G and beyond. It aims to deliver ultra-fast, intelligent, and highly reliable communication systems that support advanced digital applications.

2.6.1 6G

6G is the next phase of mobile network technology after 5G, expected to emerge around 2030. It will significantly enhance how devices, systems, and people connect.

Features of 6G

2.6.2 Ultra-High Speed

Ultra-high data rates are extremely fast data transmission speeds over a network. In 6G systems, this is one of the most defining capabilities. Data rates in 6G are expected to reach up to 1 terabit per second (Tbps)
This is:

- ~100× faster than typical 5G speeds
- Capable of transmitting massive amounts of data almost instantly

2.6.3 Ultra-Low Latency

Ultra-low latency refers to the extremely short delay between sending and receiving data across a network. In 6G, latency is expected to drop to the microsecond (µs) range, far lower than previous generations.

- Latency = time delay in communication
- 6G latency ≈ 1–100 microseconds (µs)

Compared to:

- 4G: ~50 milliseconds (ms)
- 5G: ~1 millisecond (ms)

2.6.4 AI-Native Network Architecture

AI-native network architecture refers to a communication system in which Artificial Intelligence is embedded in the network design, rather than added as an external tool. In 6G, AI is fundamental to how the network operates, manages itself, and delivers services**.**

AI is integrated into every layer of the network

The network can:

- Learn from data
- Adapt to changing conditions
- Make autonomous decisions

2.6.5 Ubiquitous (Global) Connectivity

Ubiquitous connectivity means seamless, reliable network access everywhere, regardless of location. In 6G, the goal is to eliminate coverage gaps and ensure that people, devices, and systems are always connected anytime, anywhere**.**



2.7 Self-Assessment Exercises

1. Which emerging technology enables computers to perform tasks that normally require human intelligence?

A. Cloud Computing
B. Artificial Intelligence
C. Database Management
D. Word Processing

2. What is the basic unit of information in quantum computing?

A. Bit
B. Byte
C. Qubit
D. Register

3. Which of the following is an advantage of Multi-Agent Systems (MAS)?

A. They can only perform one task at a time.
B. They rely entirely on human intervention.
C. They allow multiple specialised agents to collaborate on complex tasks.
D. They replace all networking technologies.

4. One of the key features expected of 6G technology is:

A. Reduced Internet connectivity
B. Ultra-low latency and AI-native networking
C. Slower data transmission than 5G
D. Dependence on wired communication only



2.8 Summary

Emerging technologies are transforming the future of computing by making systems more intelligent, faster, and more connected. Artificial Intelligence enables machines to perform tasks that require human intelligence, while Multi-Agent Systems allow multiple intelligent agents to work together to solve complex problems. Quantum Computing introduces a new approach to computation using qubits, offering significant advantages for specialised applications. Next-generation connectivity, particularly 6G, promises ultra-fast, low-latency, and AI-driven communication that will support future digital innovations across various sectors.

2.9 References/Further Reading/Web Sources

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2.10 Possible Answers to Self-Assessment Exercises

1. B. Artificial Intelligence
2. C. Qubit
3. C. They allow multiple specialised agents to collaborate on complex tasks.
4. B. Ultra-low latency and AI-native networking