CONTENTS

CHAPTER 1:

INTRODUCTION TO SYSTEMS

Solved Exercise

Tick (✓) the correct answer

1. What is the primary function of a system?

a) To work independently
b) To achieve a common goal
c) To create new systems
d) To provide entertainment

2. What is one of the fundamental concepts of any system?

a) Its size
b) Its objective
c) Its age
d) Its price

3. What is an example of a simple system?

a) A human body
b) A computer network
c) A thermostat regulating temperature
d) The Internet

4. What type of environment remains unchanged unless the system provides an output?

a) Dynamic
b) Static
c) Deterministic
d) Non-deterministic

5. What are the basic components of a system?

a) Users, hardware, software
b) Objectives, components, environment, communication
c) Inputs, outputs, processes
d) Sensors, actuators, controllers

6. What concept does the theory of systems aim to understand?

a) Hardware design
b) System interactions and development overtime
c) Software applications
d) Network security

7. What role does the Operating System (OS) play in a computer?

a) It performs calculations and executes instructions
b) It temporarily stores data and instructions for the CPU
c) It receives input from interface components and decides what to do with it
d) It provides long-term storage of data and software

8. Which of the following describes the Von Neumann architecture's main characteristic?

a) Separate memory for data and instructions
b) Parallel execution of instructions
c) Single memory store for both program instructions and data
d) Multiple CPUs for different tasks

9. What is a disadvantage of the Von Neumann architecture?

a) Complex design due to separate memory spaces
b) Difficult to modify programs stored in memory
c) Bottleneck due to single memory space for instructions and data
d) Lack of flexibility in executing instructions

10. Which of the following transport data inside a computer among different components?

a) control Unit b) System Bus c) Memory d) Processor

Answer Key:

1	2	3	4	5	6	7	8	9	10
b	b	c	b	b	b	c	c	c	b

Short Answer Questions and Answers

1. Define system. What are its basic components?

Ans: **System:**

A system is described by its objectives components, communication among components and environment in which it works. The components of a system communicate with each other to achieve the system's objective in an environment. Systems can be simple, like a thermostat, or complex, like the human body or a computer network.

Components:

Components are the building blocks of any system. The basic components of a system include:

1. Inputs
2. Processing.
3. Outputs
4. Feedback
5. Control
6. Boundaries
7. Storage
8. Interface
9. Environment

2. Differentiate between natural and artificial systems.

Ans: Natural Systems:

Natural systems are those that exist in nature and operate independently of human involvement. They are governed by natural laws and processes.

Artificial Systems:

Artificial systems are created and developed by people so that they may fulfill certain functions or address certain issues. They support productivity, solve complex problems, and improve people's welfare.

3. Describe the main components of a computer system.

Ans: A computer composed of many essential components that operate in conjunction. These components include:

Interface Components:

Interface components include input devices such as the keyboard and mouse and output devices, such as monitors and printers.

Processing Components:
The processing components of a computer consist of the CPU.
Random Access Memory (RAM).
The operating system.
Application software.
Communication Components:
Communication components include

- Motherboard
- A system bus

4. List and describe the types of computing systems.
Ans: Computing systems come in various types; some of these include the followings:
1. Computer 2. Software Systems 3. Computer Networks 4. Internet
5. What are the main components of the Von Neumann architecture?
Ans: The key parts that constitute the architecture of the von Neumann computer are

- Memory
- Central Processing Unit (CPU)
- Input Devices
- Output Devices

6. What is the Von Neumann computer architecture? List its key components.
Ans: The Von Neumann architecture is a computer model that explains a system in which the hardware of the computer has four primary components: the memory, the Central Processing Unit (CPU), input mechanisms, and output mechanisms. The Neumann model named in honor of the mathematician and physicist who contributed to its development during the 1940s.
7. What are the four main steps in the Von Neumann architecture's instruction cycle?
Ans: The Von Neumann architecture encompasses four main steps for a CPU to carryout instructions, namely fetching, decoding, execution, and storage.
8. What is the Von Neumann bottleneck?
Ans: The Von Neumann bottleneck occurs when a single memory area limits the CPU's ability to retrieve instructions and data quickly.
9. What is a key advantage of the Von Neumann architecture?
Ans:
1. Programs can be easily changed by changing memory contents.
2. By combining instructions and data into a single memory area, architecture is simplified.

10. What are the three main requirements for a computing system to function?

Ans: 1. Hardware 2. Software 3. Electricity

Long Questions

1. Define and describe the concept of a system. Explain the fundamental components, objectives, environment, and methods of communication within a system.

Ans: A system is described by its objectives components, communication among components and environment in which it works. The components of a system communicate with each other to achieve the system's objective in an environment. Systems can be simple, like a thermostat, or complex, like the human body or a computer network.

Objective

Every system has a purpose or goal that it wishes to fulfil. Analyzing a system's operation requires understanding its aim. This insight improves the efficiency and efficacy of the present system. A transport system aims to transfer people and products securely and effectively between locations. A computer system's principal goal is to process data and provide useful information to users.

Types of System Objectives

Systems can have different objectives depending on their nature and purpose. Common objectives include:

Information processing: Collecting, storing, processing, and distributing.

- A computer system processes user data to produce meaningful outputs.
- The human brain processes information received by the human senses to perceive the environment.

Supporting other systems: Providing a platform or infrastructure for other systems to work, for example:

- A cell phone provides a platform to run different applications.
- The sun provides energy to all species on Earth to live.

Achieving specific goals: Completing tasks or processes, for example

- A thermostat system maintains a set temperature in an environment.
- A car engine system aims to convert fuel into mechanical energy efficiently.

Components

Components are the building blocks of any system. Each component plays a specific role and contributes to the overall functionality of the system. Understanding the role of each component of the system is essential to understand how the entire system works. This helps in identifying problems, improving performance, and refining system design. Smooth and proper working of these components together ensures the system meets its objectives,

Environment

The environment of a system includes everything external to the system that interacts with it. It consists of all external factors that affect the system's operation. Understanding the environment of a system is important as it influences the system's performance and behavior by providing inputs and receiving outputs. Intelligent systems adjust to changes in their environment to continue their functionality. There are several properties of a system's environment that affect system design and its functionality. Two of these properties are described as follows:

Static vs. Dynamic:

Static: The environment remains unchanged unless the system provides an output. There are no changes occurring in the environment while the system is working internally.

Dynamic: The environment can change independently of the system's output. The system must account for changes that occur over time in the environment.

Deterministic vs. Non-deterministic:

Deterministic: A deterministic system is characterized by its fully known and certain impact of its output on the environment.

Non-deterministic: The impact of the system's output on the environment is characterized by inherent uncertainty, randomness, or probability.

Communication

Communication and interaction among system components is key to the functioning of a system. It ensures that components work together in an organized and smooth manner to achieve the system's objectives. For example, in a computing system the CPU communicates with memory to fetch and store data, and in a biological system brain sends signals to muscles to initiate movement.

2. Differentiate between natural and artificial systems. Discuss their characteristics, functions, and purposes with relevant examples.

Ans: Natural Systems:

Natural systems are those that exist in nature and operate independently of human involvement. Natural systems are of various forms and sizes, from very tiny objects like atoms and cells in our body to very huge like forests, oceans and the cosmos. Following are examples of some natural systems that exists in nature.

1. Physical Systems

Physical systems are composed of physical components using by the laws of physics. They include things ranging from atoms to planets, stars, galaxies, and cosmos.

2. Chemical Systems

Chemical systems involve substances and their interactions, transformations, and reactions. They follow the laws of chemistry forming new substances. For example, water (H,0) is formed when hydrogen atoms bond with oxygen atoms.

3. Biological Systems

Biological systems consist of living organisms and their interactions They involve biological processes such as growth, reproduction, and metabolism. Molecules interact in complex ways to form living cells, which then form tissues, organs, and organisms.

4. Psychological Systems

Psychological systems involve the mind and behavior. They include thoughts, emotions, and mental processes. Psychological systems emerge from biological systems when the brain's physical and chemical processes give rise to thoughts, emotions, and behaviors.

Artificial Systems

Artificial systems are created and developed by people so that they may fulfill certain functions or address certain issues. These systems can be as small as a wheel or as large as the United Nations.

There are different types of artificial systems, some of which are described below:

1 Knowledge Systems

A knowledge system is unique because it is developed to capture, process, facilitate, store, retrieve and manage information. Such systems facilitate in managing and utilizing the resources of knowledge effectively for the purpose of decision-making, learning and problem-solving.

Mathematics: Mathematics is a field of knowledge, which is studied to focus problems connected to numbers, their amounts, forms, structures, and patterns.

Logic: Logic is a theoretical model consisting of concepts and strategies on identifying and assessing rationale. That is why it is a basis of all logical thinking processes and practice of critical analysis.

Databases: A database system is a software for managing data, particularly to enable easy retrieval, management, and updating of data. Some of the examples are relational database management system like MySQL.

Information Management Systems: These are specific applications developed with the purpose of capturing, archiving, organizing, and disseminating data.

2. Engineering Systems

Products developed by engineers are complex frameworks or devices that apply engineering concepts to perform certain tasks or solve technical challenges. These are some examples of how engineers of various types develop systems according to their own special knowledge.

Civil Engineering Systems: Concentration on developments such as constructing houses, roads, bridges and even maintaining these structures. For

instance, a structure used to provide a passage over water, valleys or roads is termed a bridge.

Mecharical Engineering Systems: Engage in planning and creating devices that make utilization of forces from outside to accomplish work. For instance, a robotic arm applied in assembly line for packaging of products in factories.

Chemical Engineering Systems: Focuses on converting raw materials into useful products through chemical processes, considering internal molecular interactions. For example, water treatment plant that purifies water using chemical processes like coagulation and filtration.

Electrical Engineering Systems: Involves the study and application of electricity, electronics, and electromagnetism to develop electrical systems. For example, a home automation system that controls lighting, heating, and security using a smartphone app.

Software Engineering Systems: It is the process of designing, developing, and maintaining software to perform certain tasks eradicating errors. For instance, an online tool assisting a library in tracking books, users as well as stocks in their possession.

3. Examine the relationship between systems and different branches of science, including natural science, design science, and computer science. How do these branches utilize system theory to understand and improve their respective fields? Provide specific examples to support your analysis.

Ans: System and Science

Knowledge is our understanding of various systems in the universe around and within us. Science is a systematic way to validate this understanding. Science can be divided into two main types: natural science and design-science. Both natural and design sciences study systems, but they approach them differently. In natural science, scientists' study existing natural systems to understand their workings. While in design science, scientists create new systems (artifacts) to solve problems or achieve specific goals. Each type of science addresses different systems and questions, and therefore follows different scientific methods.

1. Natural Science

Natural science is meant to uncover the objectivity and functionality of natural systems in the natural world. Its nature is descriptive, meaning that the scientists seek to understand and describe natural phenomena. To achieve this, natural scientists follow the empirical cycle of natural science,

2. Design Science

Design Science is focused on designing and creating artifacts (tools, systems; methods) to achieve specific goals. The nature of design science is prescriptive,

meaning that it aims to prescribe and create artificial systems. To achieve this design science researchers, follow the regulative cycle.

Examples

Natural Science: Studying the ecosystem of a forest to understand how different species interact (descriptive).

Design Science: Developing a new software system to manage forest data and improve conservation efforts (prescriptive).

3. Computer Science

Computer science is the study of how computers work, including at what they can do and their limitations. To understand computer science, we use methods of both design science and natural science.

Natural Science of Computer Science

Natural science of computer science focuses on finding the basic rules that control how computer systems work. This involves the study of various algorithms and their characteristics.

Study of Algorithms: Researchers analyze existing algorithms to understand their efficiency and limitations. For example, studying different sorting algorithms and their characteristics which arrange given data in an order, like Quick sort or Merge Sort. To understand their speed and how they perform with different kinds of data.

Design Science of Computer Science

Design science of computers focuses on creating and improving computer tools and systems to make them work better.

- **Development of New Software Tools**: Researchers create new tools or applications to solve specific problems. For example: Designing a new programming language that makes it easier for developers to write secure computer programs.
- **Improvement of Computer Systems:** Researchers work on enhancing existing systems to perform better. For example, creating a more efficient database management system that can handle larger amount of data faster and with fewer errors.

4. Explore the different types of computing systems such as computers, software systems, computer networks, and the internet.

Ans: Types of Computing Systems

Computing systems come in various types, some of these include the followings:

Computer, 2. Software Systems,3. Computer Networks, and the 4. Internet. Computers as a system has been discussed in previous sections, while the remaining two computing systems are described in this section.

1. Computers

- Personal Computers (PCs): Desktops, laptops, and mobile devices used for personal and professional purposes.
- Mainframes: Large, high-performance computers used by organizations for bulk data processing, such as banking and financial transactions.
- Supercomputers: Extremely powerful computers used for scientific simulations, weather forecasting, and other high-performance computing applications.

2. Software Systems

- System Software (OS): Manage computer hardware resources and provide a platform for running applications, such as Windows, macOS, and Linux.
- Application Software: Programs that perform specific tasks, such as word processing, web browsing, and gaming.
- Utility Software: Programs that manage and maintain computer systems, such as disk formatting, backup, and antivirus software.

3. Computer Networks

- **Local Area Network (LAN):** Connects computers in a specific area, such as a single building or school. For example, an office network that connects everyone. Employee PCs and printers.
- **Wide Area Network (WAN):** connects computers across larger geographic regions, such as cities, nations, and even continents. For example, consider the Internet which links computers worldwide.

4. The Internet

The Internet is a vast and complex system designed to connect multiple networks worldwide, including private, public, academic, business, and government networks. Its primary objective is to facilitate communication and at an exchange between computers and users globally.

- Global Network: A worldwide network of interconnected computers and servers that communicate with each other using standardized protocols.
- Internet Service Providers (ISPs): Organizations that provide access to the internet, such as cable companies, telephone companies, and satellite providers.
- Internet Protocols: Standardized protocols that govern communication over the internet, such as TCP/IP, HTTP, and FTP.
- Online Services: Services provided over the internet, such as email, social media, online banking, and e-commerce websites.

5. Describe the main characteristics of a computer as a system, including its objectives, components, and interactions among these components.

Ans: Computer Network as Systems

A computer network connects multiple computers and devices, enabling the efficient exchange of resources and information.

Objectives:

Resource Sharing: Allow multiple users to share resources like files, printers, and internet access within an office or other settings.

Communication: Enable efficient communication between devices and users.

Data Management: Facilitate easy data management and collaboration.

Components:

Networking Hardware:

Routers: Routers are devices that transmit data packets between their networks.

Switches: Switches connect devices in a network and facilitate communication.

Network Cables: A physical medium for data transfer.

Network Software:

Protocols: Rules and conventions for data exchange such as TCP/IP. Network Operating Systems: Software that manages network resources, such as Windows Server.

Environment

A computer network operates in various environments, such as office buildings, data centers, or across the globe via the Internet. The environment influences network design, security, and performance.

Types of Computer Network

Local Area Network (LAN): Connects computers in a specific area, such as a single building or school. For example, an office network that connects everyone. Employee PCs and printers.

Wide Area Network (WAN): connects computers across larger geographic regions, such as cities, nations, and even continents. For example, consider the Internet which links computers worldwide.

Internet as a System:

The Internet is a vast and complex system designed to connect multiple networks worldwide, including private, public, academic, business, and government networks. Its primary objective is to facilitate communication and at an exchange between computers and users globally.

6. Explain the Von Neumann architecture of a computer. Include a discussion on the main components, their functions, and the step-by-step process of how the architecture operates.

Ans: The Architecture of von Neumann Computers The Von Neumann architecture is a computer paradigm that delineates a system in which the

hardware of the computer has four primary components: the memory, the Central Processing Unit (CPU), input mechanisms, and output mechanisms. This model is called the John von Neumann model, the Neumann model named in honor of the mathematician and physicist who contributed to its development during the 1940s.

- **Components:**
- Memory: Contains both input data and the instructions (program) require for CPU processing. For instance, consider the RAM of your computer: where the program starts it is loaded into RAM to enable faster execution compared when it runs from the hard disk.
- **Central Processing Unit (CPU):** Performs addition and subtraction, and executes commands provided by the memory. The system has two main components: the Arithmetic Logic Unit (ALU) and the Control Unit (CU). The Arithmetic Logic Unit (ALU) performs mathematical computations and logical operations.
- **A Control Unit (CU):** It is a peripheral that governs the activities of the CPU by instructing the ALU and memory to execute tasks according to the program instructions. It ensures the proper and timely execution of duties by all the other components.
- **Input Devices:** Enable users to input data and instructions into the computer system. Examples include keyboard, mouse, and microphone. Entering text on the keyboard transmits data to the CPU for subsequent processing.
- **Output Devices:** Present or communicate the outcomes of the tasks executed by the computer. i Consider, for instance, a monitor and printer. Upon completion of data processing, the CPU transmits the outcome to the monitor for visual display.
- **A system bus:** It is a communication mechanism that facilitates the movement of data between components inside a computational system. It comprises:

Data Bus: Transports data.
Address Bus: Maintains data destination information.
Control Bus: Transports control of electrical signals.

Working : The Von Neumann architecture encompasses three essential stages for a CPU to carry out instructions, namely retrieval, interpretation, execution, and storage. To demonstrate this procedure, we will use the example two-digit addition with 2 basic calculator applications.

- **Fetching:** Description: The central processing unit retrieves an instruction from the computer's memory. This instruction specifies the operation to be executed by the CPU. The Program Counter (PC) stores the memory address of the subsequent instruction.

- **Decoding:** The control unit (CU) decodes the operation code of the instruction and determines the required procedures and data.
- **Execution:** Description: The CPU processes the instruction. When the instruction involves a computation, it is executed by ALU. The Arithmetic and Logic Unit (ALU) carries out mathematical and logical calculations, while the Control Unit (CU) handles data transmission activities.
- **Storing:** The outcome is either stored in a designated memory location or sent to an output device, such as a display.

7. **Provide a detailed explanation of how a computer interacts with its environment. Include examples of user input, network communication, and power supply.**

Ans: A computer is a complex system designed to process data and performs tasks according to a set of instructions. The main objective of a computer is to perform computations, process data, and execute different tasks efficiently. For example, a personal computer's objective is to run software applications such as word processors, web browsers, and games through various computational processes. A computer composed of many essential components that operate in conjunction. These components include:

Interface Components: Interface components refer to the fundamental parts of a computer system, including input devices such as the keyboard and mouse, which allow users to interact with the computer. Computer output devices, such as monitors and printers, are used to generate results from the computer's operations.

Processing Components: Communication components in a computer refer to the physical elements that provide communication between different components of the computer such as the motherboard serves as the primary circuit board that interconnects all components by using cables and circuits. A system bus is a collection of electrically conductive cables that transmit data between the CPU and all other interconnected components.

Interactions among Components: The components of a computer interact with each other to perform tasks. For example, when we open a file using the mouse or keyboard, several components of the computer interact seamlessly to make this action happen.

Environment: The computer system environment includes any external devices that interact with the computer. For example:

Power Supply: Provides electrical power to allow the computer to work.

Network: Connects the computer to other systems and the Internet.

Peripherals: Include printers, scanners, and external discs that expand the computer's capabilities.

Interaction with the Environment: A computer interacts with its environment to perform its functions. For examples:

User Input: A user types on the keyboard, and the computer processes the input to display text on the screen.
Network Communication: The computer sends and receives data over the internet to browse websites or download files.
Power Supply: The computer relies on a stable power supply to function correctly.

8. Describe the process of retrieving and displaying a file using a computer, based on the interactions among different components. Provide a step-by step explanation of how input is processed, data is transferred, and results are displayed on the screen.

Ans: Here's a step-by-step explanation of how a computer retrieves and displays a file:

Step 1: User Input
The user provides input by clicking on a file icon or typing a command to open a file. This input is sent to the:

Step 2: Operating System
The OS receives the input and interprets it as a request to open a file. The OS then sends a request to the control unit.

Step 3: Hard Drive Controller
The hard drive controller receives the request and locates the file on the hard drive. The controller then reads the file's contents and sends them to the main memory.

Step 4: Memory (RAM)
The file's contents are stored in the RAM, where they can be accessed quickly by the central processing unit.

Step 5: Central Processing Unit (CPU)
The CPU processes the file's contents, performing any necessary calculations or formatting. The CPU then sends the processed data to the graphic card.

Step 6: Graphics Card
The graphics card receives the processed data and converts it into a visual format that can be displayed on the monitor.

Step 7: Monitor
The monitor displays the file's contents, allowing the user to view and interact with the file.

Step 8: User Interaction
The user can interact with the file by scrolling, clicking, or typing, sending new input to the OS and starting the process again.

Data Transfer
Throughout this process, data is transferred between components using various buses and interfaces.

Results Displayed on the Screen

The final result is the file's contents displayed on the screen, allowing the user to view and interact with the file. As the file is displayed on the screen, the user may interact with the file (e.g., scrolling through a document, zooming into an image). These actions involve repeated cycles of input and output processing, where the OS and application continue to update the display in real-time based on the user's actions.