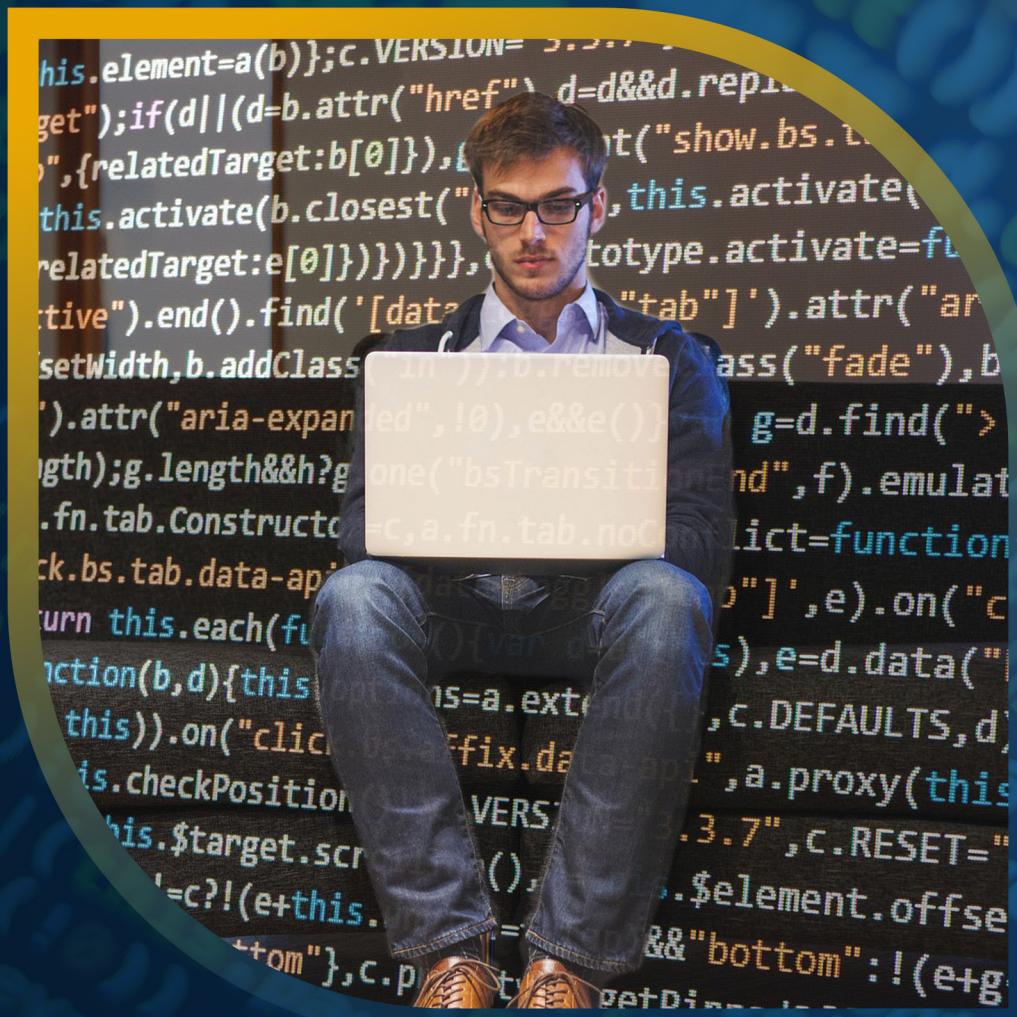
KL UNIVERSITY (DEEMED TO BE UNIVERSITY)

CDOE
CENTER FOR DISTANCE AND ONLINE EDUCATION



COMPUTER ORGANISATION AND ARCHITECTURE

BCA

How to Use Self-Learning Material?

The pedagogy used to design this course is to enable the student to assimilate the concepts with ease. The course is divided into modules. Each module is categorically divided into units or chapters. Each unit has the following elements:

Table of Contents: Each unit has a well-defined table of contents. *For example: "1.1.1. (a)" should be read as "Module 1. Unit 1. Topic 1. (Sub-topic a)" and 1.2.3. (iii) should be read as "Module 1. Unit 2. Topic 3. (Sub-topic iii).*

Aim: It refers to the overall goal that can be achieved by going through the unit.

Instructional Objectives: These are behavioural objectives that describe intended learning and define what the unit intends to deliver.

Learning Outcomes: These are demonstrations of the learner's skills and experience sequences in learning, and refer to what you will be able to accomplish after going through the unit.

Self-Assessment Questions: These include a set of multiple-choice questions to be answered at the end of each topic.

Did You Know?: You will learn some interesting facts about a topic that will help you improve your knowledge. A unit can also contain Quiz, Case Study, Critical Learning Exercises, etc., as metacognitive scaffolds for learning.

Summary: This includes brief statements or restatements of the main points of unit and summing up of the knowledge chunks in the unit.

Activity: It actively involves you through various assignments related to direct application of the knowledge gained from the unit. Activities can be both online and offline.

Bibliography: This is a list of books and articles written by a particular author on a particular subject referring to the unit's content.

e-References: This is a list of online resources, including academic e-Books and journal articles that provide reliable and accurate information on any topic.

Video Links: It has links to online videos that help you understand concepts from a variety of online resources.

Author Profile

Dr. Mothukuri Radha

Dr. Mothukuri Radha has been a Distinguished Faculty in Computer Science and Engineering teaching at the Graduate Level in various Engineering and Technology Institutes in Andhra Pradesh for the last 14 years. She is currently an Assistant Professor and Programme Coordinator in the Department of Computer Science and Engineering for the BCA Programme at the Center for Distance and Online Education at the Koneru Lakshmaiah Education Foundation (Deemed to be University) in Vaddeswaram, Andhra Pradesh, India. She completed her Bachelor of Engineering at Gulbarga University. She holds a Master's Degree from JNTU Kakinada, Andhra Pradesh, and a Ph.D. from Acharya Nagarjuna University, Guntur, in Text Mining.

She has published nearly 22 articles in various national, international and Scopus-indexed journals and has attended 37 national and international conferences and workshops. She has published an online book entitled "Cloud Computing Security". She has received numerous commendation certi icates at the Koneru Lakshmaiah Education Foundation. She has completed numerous global certi ications to her credit. She has considerable experience in virtual teaching and adapts quickly to the technological changes in the teaching-learning process. Her areas of interest are Machine Learning, Cloud Computing, and Network Security.

Computer Organisation and Architecture

Course Description

The aim of the course is to introduce students to the basic and functional concepts of computer, including the input unit, output unit, memory unit, arithmetic logic unit and control unit. This course introduces the definition of memory, the importance of memory in digital computers and the different types of memory. It also covers topics such as logic gates, various types of logic gates and the structure of logic gates and the construction of truth tables. The course covers Boolean algebra, Boolean expressions, the properties and relations of Boolean algebra that play a significant role in the digital computer system. The course intends to know the concepts of different mapping techniques, the conversions of combinational and sequential circuits.

Through this course students will be able to learn topics such as block diagram of central processing unit, classification of memory, representation of number system, conversion of number system from one number system to another number system. They will also be able to explain the concept of De-Morgan’s theorem and the construction of truth tables for De-Morgan's theorem.

At the end of the course students will be able to describe the Karnaugh Map (K-Map), conversion steps to solve the K-Map, Methods of K maps – 2 variable K Maps, 3 variable K maps, 4 variable K maps and 5 variable K maps. They will be able to explain the concepts of minimisation techniques and conversions from Sum of Products Form (SOP) to Product of Sums Form (POS). They will also be able to understand the concepts of combinational circuits which consists of Half Adder, Full Adder, Half Subtractor, Full Subtractor, Multiplexer, De Multiplexer, Encoders and Decoders. They will be able to demonstrate about the sequential circuits with Flip-Flops, types of Flip-Flops and conversions of sequential circuits, and the conversions from combinational circuits to sequential circuits and vice versa.

One of the main objectives of this course is to teach students basic concepts such as number system, Boolean algebra, logic gates, construction of truth tables for logic gates, De-Morgan theory, Karnaugh maps, differential variable K maps, minimisation techniques: SOP and POS and the conversions SOP to POS and vice versa. And clearly demonstrate the way in which logic gates and digital circuits are designed and analysed nowadays.

The course is divided into four modules.

MODULE I: BASICS OF COMPUTERS AND NUMBER SYSTEM

Central Processing Unit - Block Diagram of CPU - Input Unit, Output Unit, Arithmetic and Logic Unit, Control Unit, **Memory** - Classification Of Memory – ROM And RAM, Types of RAM SRAM and DRAM, ROM: PROM, EPROM, EEPROM, **Number System** - Definition of Number System and Types of Number System, Decimal Number System, Binary Number System, Octal Number System, Hexadecimal Number System, **Conversion of Number System** - Decimal into Binary, Binary into Decimal, Decimal into Octal, Binary into Octal, Decimal into Hexadecimal, Binary into Hexadecimal.

MODULE 2: BOOLEAN ALGEBRA AND LOGIC GATES

Boolean Algebra - Boolean Algebra, Application of Boolean Algebra, Boolean Functions, Rules of Boolean Algebra, Properties of Boolean Algebra and **De-Morgan's Theorem, Operations of Boolean Algebra** - Boolean Addition, Boolean Subtraction. **Logic Gates, Truth Table, and Logic Design** – AND Gate, NAND Gate, OR Gate, NOR Gate, EX-OR Gate, EX-NOR Gates.

MODULE 3: KARNAUGH MAP (K-MAP) AND SIMPLIFICATION OF BOOLEAN FUNCTIONS

Karnaugh Map - K-Map, Conversion Steps for Solving K-Map, Steps used to solve the expressions, Methods of K-Map - 2 Variable K Maps, 3 Variable K Maps, 4 Variable K Maps, 5 Variable K Maps. **Minimisation Techniques** - Minterm and Maxterm, Sum of Product (SOP), Product of Sum (POS) and Conversion of SOP to POS and Conversion of POS to SOP.

MODULE 4: COMBINATIONAL CIRCUITS & SEQUENTIAL CIRCUITS

Combinational Circuits - Half Adder, Full Adder, Half Subtractor, Full Subtractor, Multiplexer and De Multiplexer. Conversion, **Sequential Circuits** – Flip Flops, Types of Flip Flop – SR Flip Flop, J K Flip Flop, and D flip flop, T Flip flop, Master-Slave JK Flip Flop, Conversion.

Table of Contents

Computer Organisation and Architecture

MODULE - I

BASICS OF COMPUTERS AND NUMBER SYSTEM

MODULE 1

Basics of Computers and Number System

Module Description

The term computer system is derived from the word compute, which means ‘to calculate’. The computer system is an electronic machine that can conduct a variety of computations. It is made up of the following components: input unit, output unit, central processing unit, memory unit and control unit. Input and output units are also called the peripheral devices. Input and output units are also called peripherals. A memory unit is an essential part of a computer system. The memory unit contains programs and data. Memory is divided into two categories: main memory and secondary memory.

Number system is a method of representing and manipulating numbers. The computer only understands binary code, which consists of 0s and 1s. Decimal number system is a widely used system with numbers. Other types of number systems include octal and hexadecimal systems. We will discuss different number system conversion in the fourth coming units. At the end of this module, the learner will be able to understand the fundamentals of computers, their role in human existence and the functional units of computers. Students will be able to describe the concepts of memory and the basics of number systems.

Unit 1.1 Basics of Computers
Unit 1.2 Number System

Unit Table of Contents

Aim

Students will be introduced to the fundamental ideas of computers as well as the functional units of a digital computer.

Instructional Objectives

This unit is designed to:

- Define a computer and show the importance of computer
- Demonstrate the definitions and uses of hardware and software
- Discuss various components of a computer
- Explain the importance of architecture and organisation of a computer

Learning Outcomes

At the end of this chapter, you will be able to:

- Analyse how a computer works
- Distinguish between Software and Hardware
- Define the peripheral devices of a computer
- Describe the functional units of a computer

1.1.1 Introduction to Computers

A computer is a well-known programmed machine that performs arithmetic and logical functions in a sequential and automatic manner. The computer works on the basis of user input and, after processing, produces the desired output. There are two main types of computer components: hardware and software. The machine is referred to as hardware and includes examples of monitor, keyboard and mouse devices. Software is a set of programs that use hardware to perform a wide range of tasks. Examples of software are Windows operating system, Linux, MS Office, etc.

1.1.1.(a) Digital Computers

A digital computer is a computer that can perform a variety of computations. The term “digital” refers to the fact that a computer’s data is represented by variables with a limited number of discrete numbers. Internally, these values are processed by components that have only a finite discrete state. Decimal numbers 0, 1, 2, ..., 10. The binary system consists of only the two digits 0 and 1, which are used by digital computers. A bit is a single binary digit. In a computer system, information is represented by a group of bits. Hardware and software are the two major components of a computer system. The hardware is made up of electronic and electromechanical components that make up device’s external form. Instructions and data that the computer manipulates to complete various data processing tasks are referred to as computer software. A program is a set of instructions for a computer.

Inside, these qualities are handled by parts that can hold a limited number of discrete states. The decimal numbers 0, 1, 2, ..., 10. The parallel number framework, which has two digits: 0 and 1, is utilised by computerised PCs. A piece is a solitary twofold digit. In computerised PCs, data is addressed by a - gathering of pieces. Hardware components and software are the two parts of a PC framework. PC’s devices include electronic components and electromechanical gadgets that make up the actual structure of the gadget.

Why is Computer Organisation and Architecture important?

Every programmer, particularly system programmers, should have a thorough understanding of computer architecture and organisation. It also enables people to comprehend why a software performs poorly, despite the fact that it may be using an effective method. We may claim that computer architecture and organisation is an important subject for all electrical, electronics, and computer science undergraduate students.

Computer Architecture

The structure and behaviour of a computer, as observed by the user, is the subject of computer architecture.

Computer Organisation

Computer organisation is the process by which hardware components work and how they are integrated into a computer system. The computer organisation is related to the internal vision of the computer and the roles that internal components play during program execution.
In other words, computer organisation is responsible for the interconnection of various computer components, such as the processor, memory, and peripherals, as well as the responsibilities that these components perform during program execution.

Computer Design

Computer design is related to computer hardware design. It is the designer's job to design the system's hardware after setting up the computer architecture and other parameters. Computer design is concerned with deciding what hardware to use and how to connect it. The term "computer implementation" refers to this part of computer hardware.

1.1.1.(b) Functional Units of Computer System

A computer is made up of several components or units that are connected to each other as shown in the diagram below. The Von Neumann architecture refers to a block diagram of a computer.

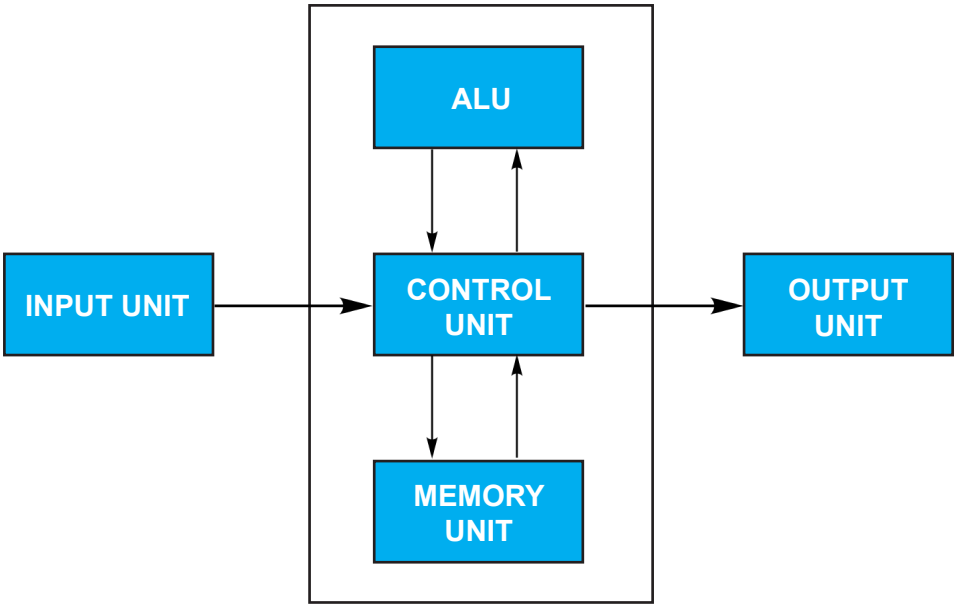


Fig. 1.1: Block Diagram of Computer (Von Neumann architecture)

Input Unit

It is a peripheral device that assists the user in accessing information to the computer (a peripheral device is a computer connected and controlled input/output device; without these peripherals the computer would not detect the outside world). There are many types of input devices available. Input units include mouse, keyboard, joystick, scanner, and modem light pens, etc.

Central Processing Unit (CPU)

CPU is the main unit of computer consists of the internal storage, processing and control circuitry. ALU (Arithmetic Logic Unit), Control Unit, Memory Unit are all part of this. The ALU and control unit are housed on a microprocessor chip. All these parts are attached to the motherboard. The CPU is connected to all peripherals via cables called bus. The CPU is also known as the system unit. This is the computer brain.

The data is processed by the CPU. It controls the flow of information through a computer system. It instructs the data entry into the system, stores the data in memory, retrieves the required data, and directs information output. It consists of the following units:

(a) Arithmetic Logic Unit (ALU)

It is fully responsible for performing various arithmetic operations such as addition, subtraction, multiplication, division, increment and decrement. It also performs logical operations such as AND, OR NOT, etc. Shift operations such as shift left, shift right, circular shift left, and circular shift right can be performed on occasion.

(b) Control Unit

The activities or actions of all computer units are coordinated and controlled by this unit. It is a part of the CPU. The key functions of the control unit are as follows:

- It has the ability to retrieve the instructions from the memory unit.
- It is capable of comprehending the commands given to it.
- It ensures that data is sent to the right location at the right time.
- After the previous instruction has been executed, it gets the next instructions.

(c) Memory Unit

Memory Unit is used to store useful data or information. It has the ability to receive, capture and deliver data in accordance with instructions. There are two types of memory, primary memory and secondary memory.

(d) Output Unit

It is a peripheral device which display or prints results of computer operation. Monitor, printer and plotters are the examples of output units.

Konrad Zuse, a German civil engineer born in 1910, was the inventor of the first computer in the world in 1936 and named it the Z1.

The Z1 was a motor-based mechanical computer designed by Konrad Zuse from 1936 to 1937, which he built in his parents' home from 1936 to 1938. It is the first in a series of computers designed by Zuse. The Z1 contained almost all components of a modern computer, including the control unit, memory, micro sequences, floating point logic, and input-output devices. It was freely programmable via punched tape and punched tape reader. The Z2 and Z3 are follow-ups based on the Z1.

Self-Assessment Questions

1. Which of the following defines computer architecture?

   A. Set of classifications and techniques that indicate the working, association, and execution of PC frameworks
   B. set of standards and techniques that determine the working, association, and execution of PC frameworks
   C. Set of functions and techniques that determine the working, association, and execution of PC frameworks
   D. None of the above

2. Which of the below is a method by which the components of a computer are connected with each other?

   A. Parts of a computer
   B. Architecture of computer
   C. Computer hardware
   D. None of the above

3. A program is a sequence of _____.

   A. Data
   B. Instructions
   C. Operations
   D. All the above

4. Which of the below is not considered as a peripheral device?

A. CPU
B. Keyboard
C. Monitor
D. All the above

5. Which of the below operations is/are achieved by the ALU?

A. Data manipulation
B. Exponential
C. Square root
D. All the above

6. In which form the computer stores its data in memory?

A. Hexadecimal form
B. Octal form
C. Binary form
D. Decimal form

7. Where is the document temporarily stored during working on a document on PC?

A. ROM
B. CPU
C. RAM
D. Flash memory

1.1.2 Memory: Classification of Memory

Memory

The memory unit consists of collective storage cells as well as the circuitry required to transport data in and out of storage. Collections of bits stored in memory are referred to as words.

Word: It is a collection of bits that move in and out of storage as a single unit in memory. A memory word defined as a collection of 0s and 1s that can be used to represent a number, an instruction code, one or more alphanumeric characters, or any other binary-coded data.

Byte: It is an eight-bit unit of measurement. The majority of computer memories use words with a bit count multiplied by 8.

Two bytes make up a 16-bit word.

A 32-bit word is made up of four bytes.

Starting with 0 and counting up to 2^k-1, where k is the number of address lines, each word in memory is given an identifying number called an address. The selection of a specific word within the memory is accomplished by applying the k-bit binary address to the address lines. This address is accepted by a decoder inside the memory, which opens the path required to choose the bits of the specific word.

The size of computer memory can range from 1024 words (requiring a 10-bit address) to 232 words (requiring 32-bit address).

The number of words (or bytes) stored in memory is denoted by the Letters K (Kilo=210), M (Mega=2^{20}), or G (Giga=2^{30}).

In computer systems, there are two types of memories: Main memory and Secondary Memory. Main memory, also known as Primary memory, contains programs and data that are currently executing. It can not store large amounts of data because the main memory capacity is too small. Examples are RAM (Random Access Memory) and ROM (Read Only Memory).

Secondary memory is also known as Auxiliary memory, which is used to store large amounts of data. The secondary memory capacity is very large compared to the main memory, so all the unused data and backup information is stored in the secondary memory. Whenever the data is required to process, the processor will fetch the necessary data from the auxiliary memory and stored it in the primary memory for further process. Examples of secondary memory are hard disks, floppy disks, CDs, DVDs, pen drives, magnetic disks and magnetic tapes.

1.1.2.(a) RAM and Its Types

In a computer system, RAM provides vast amounts of temporary storage. A RAM may hold a large number of values. We'll use an address location to identify which memory value we're looking for. A multiple-bit word can be used for each value (e.g., 32 bits).

RAM should be able to do the following:

- Store a large number of words, one for each address.
- Take a look at where the word is saved in a specific location.
- Changing the word saved in a specific location.

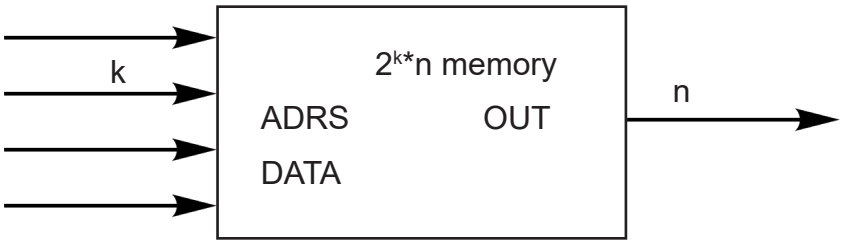


Fig 1.1.1: Architecture of RAM

WR	CS	Memory Operation
X	0	None
0	1	Read the selected word
1	1	Write the selected word

The basic interface to RAM is shown in this block diagram.

- The RAM is enabled or disabled by a chip select, CS.
- The address or location to read from or write to is specified by ADRS.
- WR chooses whether to read from or write to the memory.

WR should be set to 0 to read from memory.

The n-bit value saved at ADRS will be OUT.

We set WR to 1 to write to memory.

The n-bit value to save in memory is called DATA.

This is referred to as a 2k x n memory.

- Each of the 2k addresses can be specified by one of the k address lines.
- An n-bit word is contained in each address.

A 224 x 16 RAM, for example, holds 224 = 16M words, each of which is of sixteen bits long.

- There are 24 address lines in RAM.
- 224 x 16 = 228 bits is the overall storage capacity.

Different Categories of RAM chips: There are basically two types of RAM.

- SRAM- Static RAM
- DRAM- Dynamic RAM

The Flip-flop is the basic memory cell in an SRAM. It is the capacitor in the case of DRAM, and a 0 or 1 is stored as the absence or presence of a change on the capacitor. Change leakage is a concern with DRAMs, thus they must be charged on a regular basis. SRAMs are more expensive, but they are fast. DRAMs have a higher memory density.

Advantages of RAM are:

- They can be revised and changed.
- They are volatile, which means that if the power is turned off, the data or information will be gone.
- They are used to store temporary data.
- They do not require the same amount of programming time as ROMs.
- There is no need for any specific programming equipment.

1.1.2.(b) ROM and its Types

Read-only memory, or ROM for short, is the most common type of memory found in computers. In contrast to RAM, ROM is a type of memory that can only be read. Read-only memory is used for some specific functions within the computer for two basic reasons.

Performance: The values saved in the ROM are always available, whether the power is on or off. The data in it is deleted from the computer, saved for an indefinite period of time, and then replaced. For this reason, it is called volatile storage. For the same reason, the hard disk drive (HDD) is non-volatile, but not normal RAM.

Security: Since the ROM cannot be easily manipulated, it offers some protection against unintentional alterations to the contents. It's just not possible to identify a virus that infects genuine ROMs. (It's technically conceivable with erasable EPROMs, but it's never been done in practise.)

The most typical application of ROM is to store framework level programmes that we need to keep accessible to the PC consistently. The most effective example is the system BIOS programme, which is stored in a ROM called the system BIOS ROM, and is accessible when the power is turned on, permitting the PC to utilise it to boot up the framework. Keep in mind that the system memory on your PC was empty when you first turned it on, so there must be something to use when it starts up.

While it is true that the contents of the ROM are not designed to be modified, the change in the contents of the ROM is very valuable. Under certain conditions, some ROM versions will be modified; These are referred to as "primarily read-only memory". A variety of ROMs are shown below, along with a discussion of related modifications.

ROM:

A standard ROM, such as a processor, is designed with hard-wired logic covered in silicon. It is built to do specific work and cannot be changed. Because it is flexible, traditional ROMs are only used for stable programs (i.e., do not change frequently) and are mass-produced.

PROM - Programmable ROM:

It is a type of ROM that can be programmed with the help of special equipment, and this can only be written once. This is advantage for organisations who manufacture their own ROMs from software they write, as it allows them to create the latest PROMs without the need for expensive equipment when their code changes. This is similar to how a CD-ROM recorder works, allowing you to "burn" programs once on blank disks and read them several times. In fact, programming a PROM is sometimes called burning and is equivalent in terms of ease in burning a CD-R.

EPROM - Erasable Programming ROM:

EPROM stands for “Erasable Programmable Read-Only Memory”. A small glass window is inserted at the top of the ROM through which you can see the memory chip. Ultraviolet light is a specific frequency that is emitted by glass over a period of time, eradicating the EPROM and allowing it to be reconstructed. It’s definitely more valuable than a traditional PROM, despite the fact that it requires the utilisation of eradicating light. By re-using the CD analogy, this invention is practically identical to the reusable CD-RW.

EEPROM - Electrically Erasable Programmable ROM:

EEPROM, the next level of erasability that can be wiped out in software control. It is the most versatile type of ROM and is now widely used to store BIOS programs. When you hear the words “Flash BIOS” or “Flash VOIS”, you are prompted to rewrite the BIOS EEPROM using a special software program. We’re blurring the line between what “read-only” memory really means, but keep in mind that this rewriting only happens once or twice a year compared to true read-write memory (RAM) where rewriting happens several times per second.

Some of the advantages of ROM are:

- Since they are non-volatile, they do not lose their information when the power is turned off.
- ROMs cost less than RAM.
- ROMs are easy to test because their content is always known and verified.
- Because of their basic circuitry, they are more reliable than RAM.
- They do not need to be refreshed as they are stable.
- ROMs are easier to use than RAMs and cannot be modified inadvertently.

Robert Heath Dennard devised one-transistor dynamic random access memory, or “DRAM,” in 1967, which is regarded as one of the most significant developments in computer technology.

Self-Assessment Questions

8. Which storage stores or retains data after power off is called?

A. Volatile
B. Non-volatile
C. Sequential
D. Direct

9. Which of the below mentioned memories must be refreshed many times per second?

A. EPROM
B. ROM
C. Static RAM
D. Dynamic RAM

10. Main memory of computer is _____.

A. Internal
B. External
C. (A) and (B) both
D. Auxiliary

11. The contents of memory into blocks of the same size is called as:

A. ROM
B. EPROM
C. EEPROM
D. All of above

12. What is the permanent memory built into your computer called?

A. RAM
B. ROM
C. CPU
D. CD-ROM

Summary

- A computer is an electronic device that executes a series of operations on a single task.
- When it comes to computers, the terms hardware and software programme are nearly interchangeable.
- Computers are used for calculating the arithmetic operations and data transformations such as bill preparation, solving real-time equations, and so on.
- The keyboard and mouse are the most frequent ways to input data into a computer.
- On the monitor, the output will be displayed.
- Keyboard, mouse, joysticks and scanner are the examples for the input devices.
- Monitor, printer and speakers are the examples for output devices.
- The control unit is responsible for the operation of the entire computer system.
- The CPU is the brain of the computer and is responsible for executing user instructions.
- The arithmetic, logical, and shift operations are all handled by the ALU.
- The information is saved in memory.
- Primary memory and secondary memory are the two types of memory.
- Primary memory is represented by RAM and ROM.
- Secondary memory includes hard discs, pen drives, floppy discs, and magnetic discs.

Terminal Questions

1) Define computer and its applications.
2) Distinguish between hardware and software with examples.
3) Define computer organisation, architecture and design.
4) Describe the Von Neumann architecture with a neat sketch.
5) List and describe the types of memory used in a computer.
6) Identify the difference between ROM, EPROM and EEROM.

Answer Keys

Self-Assessment Questions

Question No.	Answers
1	B
2	B
3	C
4	A
5	D
6	C
7	C
8	B
9	D
10	A
11	D
12	B

Activity

Activity type: Offline **Duration: 40 Minutes**

1. Describe and illustrate a presentation on basic computer architecture.
2. Tabulate various types of ROM.

BIBLIOGRAPHY

e-References

- https://homepage.cs.uri.edu/faculty/wolfe/book/Readings/Reading01.htm
- https://whatis.techtarget.com/definition/memory

External References

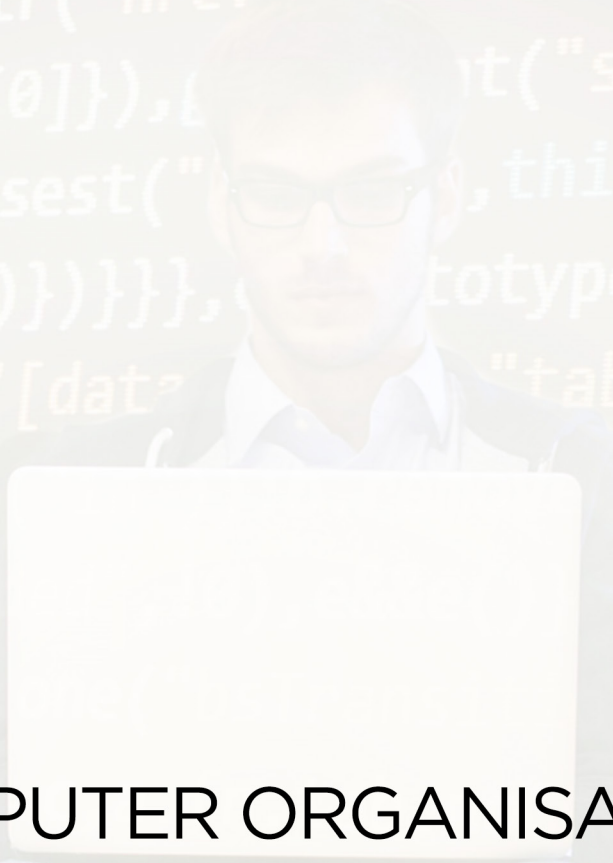
- Suresh Babu, J. V., Nagendra, N. (2017). *Digital Electronics and Computer Architecture*. Falcon Publishers.

Image Credits

- Figure 1.1.1: T. Anuradha, C. V. P. R. Prasad. *Computer Organisation*.

Video Links

Topic	Link
Introduction to Computers	https://www.youtube.com/watch?v=-AP1nNK3bRs
Types of memory	https://www.youtube.com/watch?v=MbQH0O3ruVc



COMPUTER ORGANISATION AND ARCHITECTURE

KL (DEEMED TO BE UNIVERSITY) | CDOE CENTER FOR DISTANCE AND ONLINE EDUCATION

https://www.kluniversity.in/cdoe/

supportcdoe@kluniversity.in