Programming for Problem Solving (PPS- BCS 101)

Unit 1

Introduction to components of computer system

What Is Computer?

The word computer comes from the word "compute" which means, "to calculate". A computer is an electronic device that can perform arithmetic operations at high speed and it can process data, pictures, sound, and graphics. It can solve highly complicated problems quickly and accurately.

A computer is also called a data processor because it can store, process, and retrieve data whenever desired

Computer receives input, stores, or processes the input as per user instructions and provides output in desired format.

A computer has two primary components

- **Hardware**-The term hardware refers to mechanical device that makes up computer. Computer hardware consists of interconnected electronic devices that we can use to control computer's operation, input and output. Examples of hardware are CPU, keyboard, mouse, hard disk, etc.
- **Software**: A set of instructions that drives computer to do stipulated tasks is called a program. Software instructions are programmed in a computer language, translated into machine language, and executed by computer.

Software can be categorized into two types

1.System software

2.Application software

System Software-System software operates directly on hardware devices of computer. It provides a platform to run an application. It provides and supports user functionality. Examples of system software include operating systems such as Windows, Linux, Unix, etc.

Application Software-An application software is designed for benefit of users to perform one or more tasks. Examples of application software include Microsoft Word, Excel, PowerPoint, Oracle, etc.
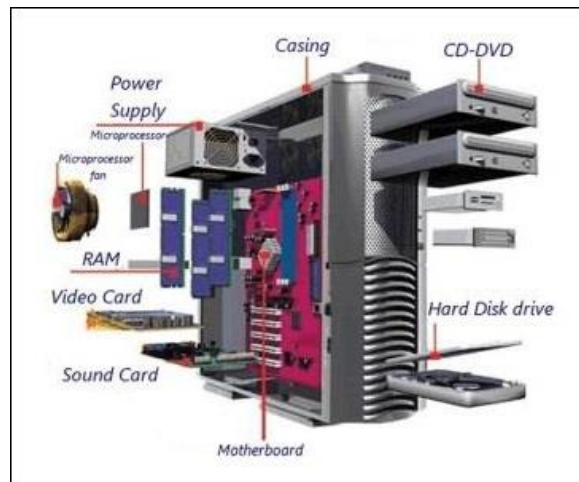
What is Digital Computer? Draw and Explain block diagram of digital computer. (2017-18, 2018-19, 2019-20, 2021-22) [7Marks]

Digital computers are the computer system which uses binary number system, which has two digits: 0,1 and performs many tasks.

OR

The digital computer is a digital system that performs various computational tasks. The word digital implies that the information in the computer is represented by variables that take a limited number of discrete values. These values are processed internally by components that can maintain a limited number of discrete states. The decimal digits 0, 1, 2, ..., 9, for example, provide 10 discrete values.

Block diagram of Digital computer

Fig: Block Diagram of the computer.
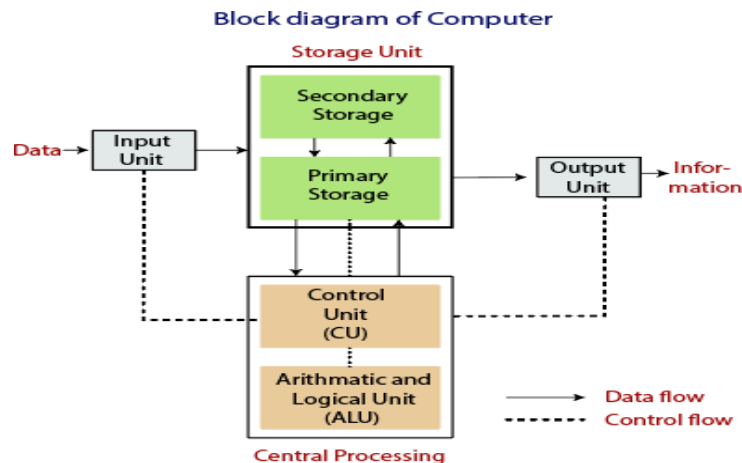
Block diagram of a computer gives you the pictorial representation of a computer that how it works inside. Or you can say that, in computers block diagram, you will see how computer works from feeding the data to getting the result.

Working of Digital Computer (Input-Processing-Output: IPO)

The data is entered through input devices such as the keyboard, mouse, etc. This set of instruction is processed by the CPU after getting the input by the user, and then the computer system produces the output. The computer can show the output with the help of output devices to the user, such as monitor, printer, etc.

Example

Expression: 2+2*3/2

Input: 2,3,2,2, +,*,/ through Keyboard

Processing: Expression evaluation [ALU]

2+2*3/2

1st: 2+2*3/2 [* and / has same precedence > + and evaluate left to right]
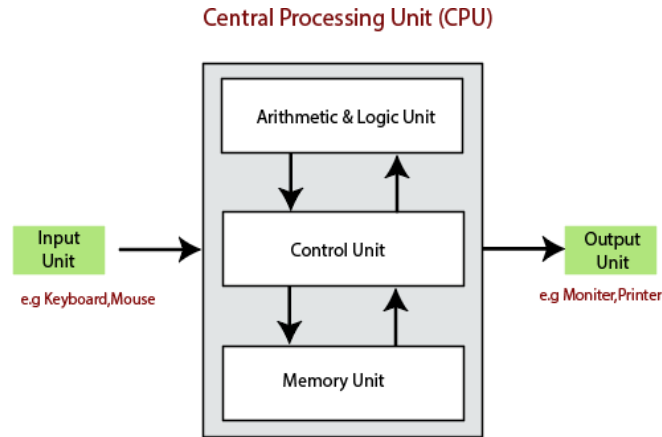
2nd: 2+6/2

3rd: 2+ 3

Result: 5

Output: 5 [Monitor]

Central Processing Unit (CPU)

The computer system is nothing without the Central processing Unit. So, it is also known as the brain of computer. The CPU is an electronic hardware device which can perform different types of operations such as arithmetic and logical operation.

Central Processing Unit (CPU)

The CPU contains two parts: the arithmetic logic unit and control unit. We have discussed briefly the arithmetic unit, logical unit, and control unit which are given below:

Control Unit

- The control unit (CU) controls all the activities or operations which are performed inside the computer system. It receives instructions or information directly from the main memory of the computer.
- When the control unit receives an instruction set or information, it converts the instruction set to control signals then; these signals are sent to the central processor for further processing. The control unit understands which operation to execute, accurately, and in which order.

Arithmetic and Logical Unit

- The arithmetic and logical unit is the combinational digital electronic circuit that can perform arithmetic operations on integer binary numbers. It presents the arithmetic and logical operation. The outputs of ALU will change asynchronously in response to the input. The basic arithmetic and bitwise logic functions are supported by ALU.

Storage Unit

- The information or set of guidelines are stored in the storage unit of the computer system. The storage unit provides the space to store the data or instruction of processed data. The information or data is saved or hold in computer memory or storage device. The data storage is the core function and fundamental of the computer components.
- There are mainly two types of storage Unit-

i) Primary Storage

ii) Secondary Storage

i) **Primary memory** is the main memory of computer system. The instructions that must be currently executed is copied to the primary memory because CPU can directly access the data from primary memory. Accessing data from primary memory is faster as it is an internal memory and processor accesses data from primary memory using data bus.

ii) **Secondary storage** is also called as permanent storage unit as when the data store in this memory are stored permanently user can recall the data whenever they need. The data remains in this memory even when there is a power failure or shutdown, they are much cheaper than primary memory. The Example of Secondary Storage are Hard disk and Zip drives.

Input Devices

The user provides the set of instruction or information to the computer system with the help of input devices such as the keyboard, mouse, scanner, etc.

Output Devices

The output devices produce or generate the desired result according to our input, such as a printer, monitor, etc. These devices convert the data into a human-readable form from binary code.
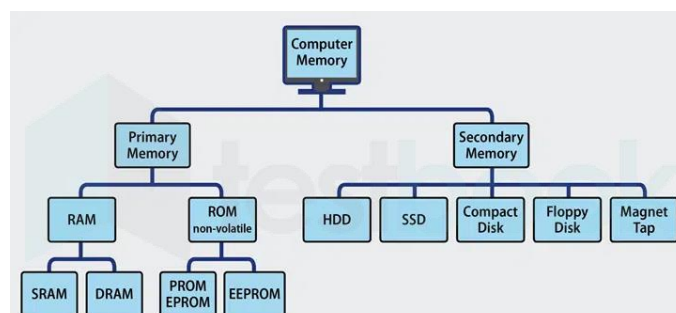
Computer Memory:

Memory is storage part of computer. It stores data, information, programs during processing in computer.

It stores data either temporarily or permanent basis. Memory has important roles in saving and retrieve data.

Types of memory:

Mainly computer has two types of memory

1. Primary Memory/ Volatile Memory
2. Secondary Memory/ Non-Volatile Memory

RAM (Random Access Memory):

Random Access Memory (RAM) is a type of computer memory that is used to temporarily store data that the computer is currently using or processing. RAM is volatile memory, which means that the data stored in it is lost when the power is turned off. RAM is typically used to store the operating system, application programs, and data that the computer is currently using.

Types of Random Access Memory (RAM)
- Static RAM (SRAM): SRAM stands for Static Random Access Memory. It is a type of semiconductor which is widely used in computing devices and microprocessors. Retain stored information if the power supply is on. SRAM of higher cost and consumes more power. They have higher speed than DRAM.
- Dynamic RAM (DRAM): It stored information in a very short time (a few millisecond) even though the power supply is ON. The DRAM is cheaper and moderate speed and, they consume less power. It is made of Capacitors and has smaller data life span than Static RAM.

Question: Difference between SRAM & DRAM [2Marks]

DRAM	SRAM
1. Constructed of tiny capacitors that leak electricity.	1.Constructed of circuits similar to D flip-flops.
2.Requires a recharge every few milliseconds to maintain its data.	2.Holds its contents as long as power is available.
3.Inexpensive.	3.Expensive.
4. Slower than SRAM.	4. Faster than DRAM.
5. Can store many bits per chip.	5. Can not store many bits per chip.
6. Uses less power.	6.Uses more power.
7.Generates less heat.	7.Generates more heat.
8. Used for main memory.	8. Used for cache.

Read Only Memory (ROM) is a type of computer memory that is used to permanently store data that does not need to be modified. ROM is non-volatile memory, which means that the data stored in it is retained even when the power is turned off. ROM is typically used to store the computer's BIOS (basic input/output system), which contains the instructions for booting the computer, as well as firmware for other hardware devices.

Types of Read-Only Memory (ROM)

1. PROM (Programmable read-only memory): It can be programmed by the user. Once programmed, the data and instructions in it cannot be changed.
2. EPROM (Erasable Programmable read-only memory): It can be reprogrammed. To erase data from it, expose it to ultraviolet light. To reprogram it, erase all the previous data.
3. EEPROM (Electrically erasable programmable read-only memory): The data can be erased by applying an electric field, with no need for ultraviolet light. We can erase only portions of the chip.

Question: Difference between RAM & ROM [2Marks/ 5Marks]

Difference	Random Access Memory (RAM)	Read Only Memory (ROM)
Data-Retention	RAM is a volatile memory that could store the data if the power is supplied.	ROM is a non-volatile memory that they could retain the data even when the power is turned off.
Read/Write	Read and write operations are supported.	Only read operations are supported.
Use	Used to store the data that has to be currently processed by CPU temporarily.	It is typically used to store firmware or microcode, which is used to initialize and control hardware components of the computer.
Speed	It is a high-speed memory.	It is much slower than the RAM.
CPU Interaction	CPU can easily access data stored in RAM.	CPU cannot easily access data stored in ROM.
Size and Capacity	Large size with higher capacity, concerning ROM.	Small size with less capacity, concerning RAM.
Used as/in	CPU Cache, Primary memory.	Firmware, Micro-controllers.
Accessibility	The data stored is easily accessible.	The data stored is not as easily accessible as in the concerning RAM.
Cost	RAM is costlier than ROM.	ROM is cheaper than RAM.

Difference	Random Access Memory (RAM)	Read Only Memory (ROM)
Chip Size	A RAM chip can store only a few gigabytes (GB) of data.	A ROM chip can store multiple megabytes (MB) of data.
Function	Used for the temporary storage of data currently being processed by the CPU.	Used to store firmware, BIOS, and other data that needs to be retained.

Question: Difference between Primary Memory & Secondary Memory [2Marks]

| Primary memory	Secondary memory
Primary memory is temporary(RAM) pr Permanent (ROM)	Secondary memory is permanent
Primary memory is directly accessible by Processor/CPU	Secondary memory is not directly accessible by CPU
Nature of Parts of Primary memory varies. RAM- volatile in nature. ROM- Non-volatile	It's always Non-volatile in nature
Primary memory devices are more expensive than secondary storage devices	Secondary memory devices are less expensive when compare to primary memory devices
The memory devices used for primary memory are semiconductor memories	The secondary memory devices are magnetic and optical memories
Primary memory is also known as Main memory or Internal memory	Secondary memory is also known as External memory or Auxiliary memory
Examples: RAM, ROM, Cache memory, PROM, EPROM, Registers etc	Examples: Hard Disk, Floppy Disk, Magnetic Tapes e

Cache Memory

Question: Write short note on cache memory [5Marks]

Cache Memory is a special very high-speed memory. The cache is a smaller and faster memory that stores copies of the data from frequently used main memory locations. There are various independent caches in a CPU, which store instructions and data. The most important use of cache memory is that it is used to reduce the average time to access data from the main memory. Generally, cache memory is very small and hence is used as a buffer.

Characteristics of Cache Memory

- Cache memory is an extremely fast memory type that acts as a buffer between RAM and the CPU.
- Cache Memory holds frequently requested data and instructions so that they are immediately available to the CPU when needed.
- Cache memory is costlier than main memory or disk memory but more economical than CPU registers.

- Cache Memory is used to speed up and synchronize with a high-speed CPU.
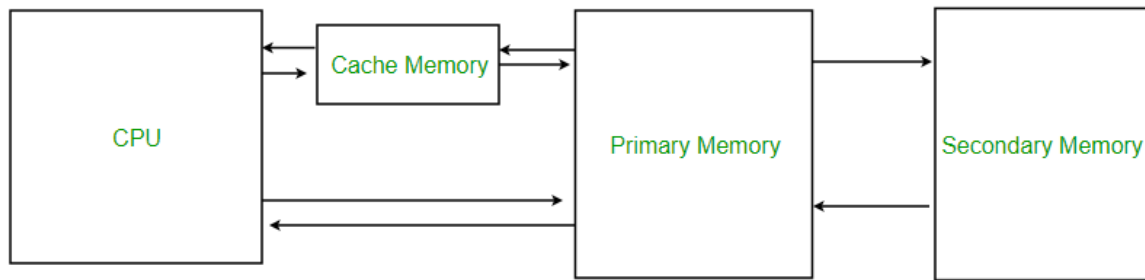
Role of Cache Memory

The role of cache memory is explained below,

- Cache memory plays a crucial role in computer systems.
- It provides faster access.
- It acts buffer between CPU and main memory (RAM).
- Primary role of it is to reduce average time taken to access data, thereby improving overall system performance.

Question: Differentiate between Cache & RAM

RAM	Cache
RAM is larger in size compared to cache. Memory ranges from 1MB to 16GB	The cache is smaller in size. Memory ranges from 2KB to a few MB generally.
It stores data that is currently processed by the processor.	It holds frequently accessed data.
OS interacts with secondary memory to get data to be stored in Primary Memory or RAM	OS interacts with primary memory to get data to be stored in Cache.

Question: Draw and Explain Memory hierarchical structure of a computer system (2018-19) [7 Marks]

Memory Hierarchy is an enhancement to organize the memory such that it can minimize the access time. The Memory Hierarchy was developed based on a program behaviour known as locality of references.

Memory Hierarchy Design
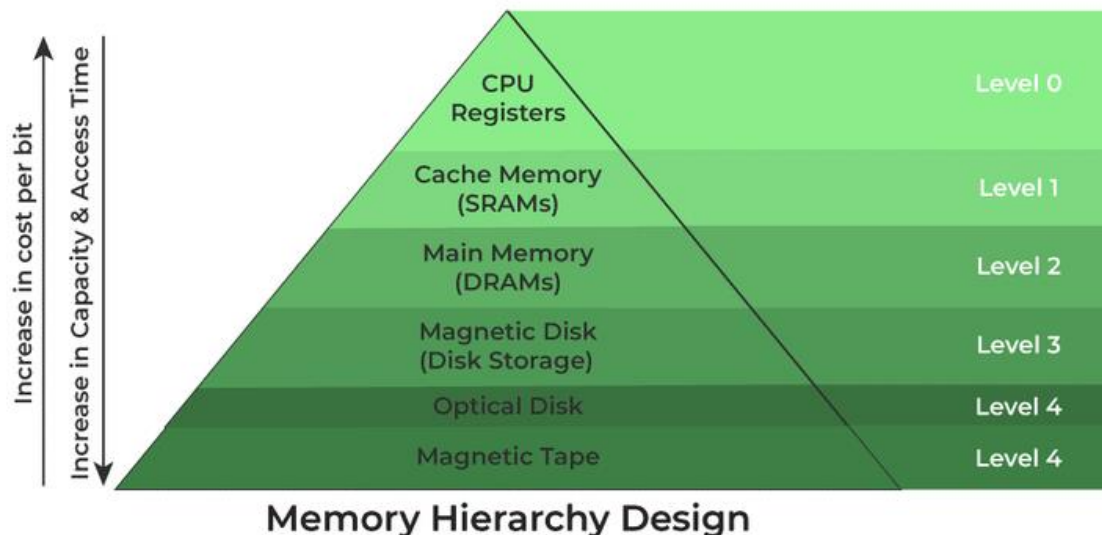
This Memory Hierarchy Design is divided into 2 main types:

- **External Memory or Secondary Memory:** Comprising of Magnetic Disk, Optical Disk, and Magnetic Tape i.e. peripheral storage devices which are accessible by the processor via an I/O Module.
- **Internal Memory or Primary Memory:** Comprising of Main Memory, Cache Memory & CPU registers. This is directly accessible by the processor.

Registers

Registers are small, high-speed memory units located in the CPU. They are used to store the most frequently used data and instructions. Registers have the fastest access time and the smallest storage capacity, typically ranging from 16 to 64 bits.

Cache memory is a small, fast memory unit located close to the CPU. It stores frequently used data and instructions that have been recently accessed from the main memory. Cache memory is designed to minimize the time it takes to access data by providing the CPU with quick access to frequently used data.

Main memory, also known as RAM (Random Access Memory), is the primary memory of a computer system. It has a larger storage capacity than cache memory, but it is slower. Main memory is used to store data and instructions that are currently in use by the CPU.

Secondary storage, such as hard disk drives (HDD) and solid-state drives (SSD), is a non-volatile memory unit that has a larger storage capacity than main memory. It is used to store data and instructions that are not currently in use by the CPU. Secondary storage has the slowest access time and is typically the least expensive type of memory in the memory hierarchy.

Magnetic Disks, are simply circular plates that are fabricated with either a metal or a plastic or a magnetized material. The Magnetic disks work at a high speed inside the computer and these are frequently used.

Magnetic Tape, is simply a magnetic recording device that is covered with a plastic film. It is generally used for the backup of data. In the case of a magnetic tape, the access time for a computer is a little slower and therefore, it requires some amount of time for accessing the strip.

Characteristics of Memory Hierarchy

- **Capacity:** It is the global volume of information the memory can store. As we move from top to bottom in the Hierarchy, the capacity increases.
- **Access Time:** It is the time interval between the read/write request and the availability of the data. As we move from top to bottom in the Hierarchy, the access time increases.
- **Performance:** Earlier when the computer system was designed without a Memory Hierarchy design, the speed gap increased between the CPU registers and Main Memory due to a large difference in access time. This results in lower performance of the system and thus, enhancement was required. This enhancement was made in the form of Memory Hierarchy Design because of which the performance of the system increases.
- **Cost Per Bit:** As we move from bottom to top in the Hierarchy, the cost per bit increases i.e. Internal Memory is costlier than External Memory.