COMPUTER MEMORY

CHAPTER 2

After completing this lesson, you will be able to:

- Define bit, byte, memory word and memory units.
- Differentiate between main memory and secondary memory.
- Explain the difference between chip memory and magnetic memory.
- Differentiate between volatile and non-volatile memory.
- Describe internal processor memory, RAM and ROM
- Differentiate between sequential access and direct access memory.
- Describe magnetic tapes, magnetic disks and optical disks.
- Describe flash memory and memory cards.

UNIT INTRODUCTION

Computer memory is one of the important and compulsory components of every computer system. This unit describes memory and memory devices used to store data and programs on a temporary or permanent basis for use in digital computers. The two main types of computer memories i.e. primary and secondary memories are discussed thoroughly.

2.1 INTRODUCTION TO COMPUTER MEMORY

Q.1 Give a brief introduction to computer memory.

Answer

Memory

In computing, memory refers to the physical devices used to store programs (sequence of instructions) or data on a temporary or permanent basis for use in a computer or other digital/computing device. Memory in a digital computer contains the main part of operating system and all the application programs and related data that is being used.

Memory that communicates directly with the CPU (as shown in Fig.2.1) is called main memory or primary memory.

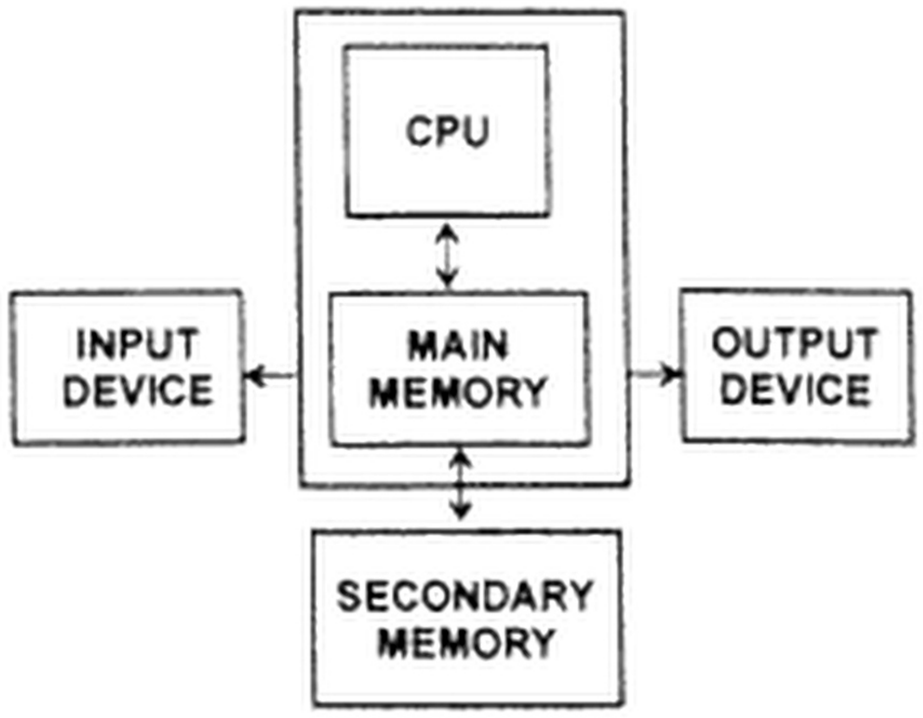

Fig. 2.1 Block diagram of a computer with memory unit

Q.2 Write down the use of secondary memory.

Answer

Secondary memory

Devices that provide backup storage are called secondary memory or mass storage devices. All the information is stored in secondary memory and it is transferred to main memory on a demand basis.

2.1.1 MEMORY CHARACTERISTICS

Q.3 Explain the important characteristics of memory devices.

Answer

Important Characteristics of Memory Device

The important characteristics of any memory device are:

- Access Mode
- Access Time
- Transfer Rate
- Capacity
- Cost

1. Access mode

Memory has two major access modes:

- Sequential Access Mode
- Random Access Mode

i. Sequential Access Mode

In Sequential access mode, memory can be accessed only in serial order. It is also called serial access mode.

Example

If we have to access 4th memory location then first we would have to move to first three locations and skip them and only then we can access the 4th location.

ii. Random Access Mode

In Random access mode, memory location can be accessed at random. It is also called direct access mode.

Example

If we have to access 4th location then we can directly go to 4th location and access it.

2. Access time

It is the time taken to retrieve data from memory. Access time in sequential access memory devices is more than the random access memory devices.

3. Data transfer rate

It is the time taken to transfer data from one memory device to the other.

Example

Time taken to transfer data for hard disk to the main memory (RAM).

4. Capacity

The memory capacity is the amount of space that a memory device has to store data or the amount of memory required for a program to run.

5. Cost

It is the price that computer users have to pay as per capacity of the memory device.

2.1.2 MEMORY TERMINOLOGY

Q.4 Explain some important memory terms, which are related to memory.

Answer

Important Memory Terms

The following are some important memory terms related to memory:

- Bit
- Byte
- Memory Word

1. Bit

The smallest unit of memory in digital computer is a bit, which stands for binary digit 0 or 1.

State of Memory

The memory of a computer consists of millions of memory (or electronic) cells. Each cell contains one bit of information states of memory cell. The memory cell has two states, ON and OFF. The ON state represents a binary 1 and OFF state binary 0.

2. Byte

Byte is the basic unit of computer memory and it is the minimum piece of data to be processed by a computer. A group of 8 bits is known as one byte. One byte of memory is required to store one character in the computer, for example 'A', 'a', 'b', '*', etc. A byte is generally used to express the memory size of a computer. Computer memory is measured in terms of bytes. The higher units are Kilobyte (KB), Megabyte (MB), Gigabyte (GB) and Terabyte (TB). In future, memories will also be available in Petabyte (PB) and Exabyte (EB).

Relationship between the Memory Units

The relationship between the memory units is shown in Table 2.1.

MEMORY UNIT	EQUIVALENT TO	
1 Byte	8 Bits	
1 Kilobyte (KB)	2^{10} Bytes	= 1024 Bytes
1 Megabyte (MB)	2^{20} Bytes	= 1024 KB
1 Gigabyte (GB)	2^{30} Bytes	= 1024 MB
1 Terabyte (TB)	2^{40} Bytes	= 1024 GB
1 Petabyte (PB)	2^{50} Bytes	= 1024 TB
1 Exabyte	2^{60} Bytes	= 1024 PB

Table 2.1 Memory Units and their Equivalents

3. Memory Word

In computing, the smallest chunk or size of data that a computer can process is called memory word. It is a fixed-sized piece of data handled as a unit by the processor.

Word Size

The number of bits in a word is called the word size. Word size in modern computers typically ranges from 16 to 64 bits, depending on the size of the computer. A computer that has a bigger word size can transfer more bits into the microprocessor at a time for processing and this improves the processing speed of the computer.

Main indication of the word size

The main indication of the word size is how much memory the processor can address. A 32-bit processor is limited to 2^{32} memory addresses. This is a group of bits (cells) in a memory that represents information or data of some type.

2.1.3 MEMORY BUILT-UP AND RETENTION POWER

Q.5 Name some types of computer memory.

Answer

Types of Computer Memories

All types of computer memories, as for as their built-up or manufacturing is concerned, are divided into Chip memory, Magnetic memory and Optical memory. And as far as their retention power is concerned these memories are divided into Volatile memory and Non-Volatile memory.

Q.6 Write a note on chip memory.

Answer

Chip Memory

Chip is a small piece of semi-conducting material (usually silicon). A small circuit called IC (Integrated Circuit) is embedded on it. A typical chip contains millions of electronic components (transistors).

Chip memories are very fast as compared to other memories as there are no mechanical moving parts in them but on the other hand chips rely on electric currents.

Examples of Chip Memory

Examples of chip memory are main memory (RAM, ROM and Cache), Flash memory drives, memory cards and registers.

Special-purpose Chips

Many special-purpose chips, known as application-specific integrated circuits, are also being made today for automobiles, home appliances, telephones, and other devices.

Types of Chip Memory

Different types of chip memory devices are shown in Fig 2 2.

Fig.2.2. Chip Memory devices

Q.7 Write a note on magnetic memory.

Answer

Magnetic Memory

One of the most widely used types of digital data storage is magnetic memory/storage. This refers to any type of data storage using a magnetized medium.

Common Example

Hard disk is the common example of magnetic memory as shown in Fig 2.3.

Fig.2.3: Magnetic disk with read/write head

Examples of magnetic memory devices

Magnetic tapes and disks are examples of magnetic memory devices.

Structure of Magnetic memory

A thin layer of magnetic material is coated on the surface of magnetic tape and magnetic disks. Binary information is stored in the form of tiny magnetized and non-magnetized spots on the surface of magnetic tape or disk. A magnetized spot represents a binary 1 and a non-magnetized spot a binary 0.

Working of Magnetic Memory

A read-write head moves very close to the magnetic surface. The head is able to detect and modify the magnetization of the material. Magnetic storage is widely used because it is relatively cheap in comparison with other storage technologies. The storage capacity is also very large, making it attractive for storing very large amounts of data.

Major Limitation of Magnetic Storage

The major limitation of magnetic storage is that accessing the data can be quite slow.

Q.8 Explain optical memory.

Answer

Optical Memory

In optical-storage technology, a laser beam encodes digital data onto an optical disk in the form of tiny pits and lands arranged in concentric tracks on the disk's surface as shown in Fig. 2.4.

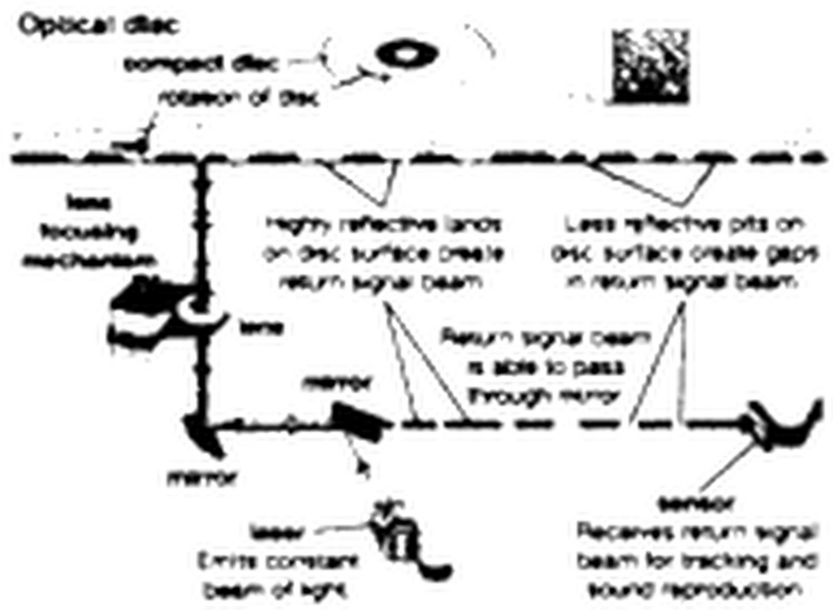

Fig 2.4: Optical Memory technology

Low-Power Laser Scanner

A low-power laser scanner is used to "read" data or information from these pits and lands, and converts it to digital form.

Characteristics of Optical Storage

Optical storage provides cheaper and greater memory capacity than magnetic storage.

Example

An entire set of encyclopaedias, can be stored on a standard 12-centimetre (4.72-inch) optical disk.

Q.9 Describe types of memory based on retention power.

Answer

Types of Memory Based on Retention Power

Memory, on the basis of retention power, can be divided into two types:

- Volatile Memory
- Non-Volatile Memory

1. Volatile memory

Volatile memory is computer memory that requires power (electricity) to maintain the stored information. Volatile memory retains the information as long as power supply is on, but when power supply is off or interrupted the stored memory is lost. It is also known as temporary memory.

Examples

Examples of such memory are RAM (Random access memory), Cache memory and Registers.

2. Non-Volatile memory

Non-volatile memory is a permanent memory that can retain the stored information even when not powered. Non-volatile memory is typically used as secondary storage for long-term or future use.

Examples

Examples of non-volatile memory include ROM (Read-only memory), flash memory, magnetic storage devices (e.g. hard disks and magnetic tape), optical disks, and blue-ray disk.

2.1.4 TYPES OF COMPUTER MEMORY

Q.10 What are the types of computer memory?

Answer

Computer memory can be classified into two main types as shown in Fig. 2.5.

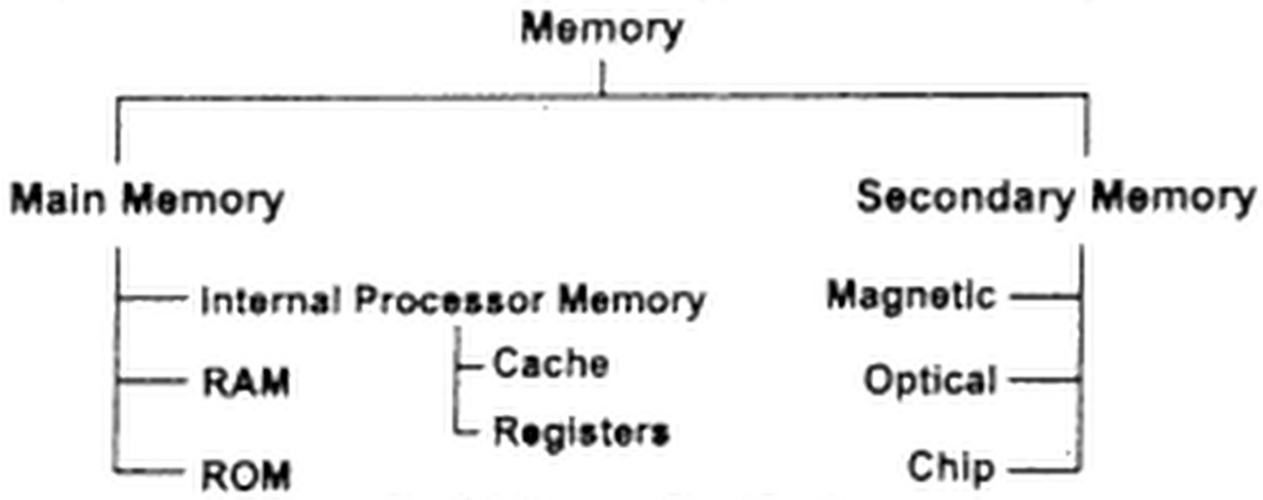

Fig. 2.5 Memory Classification

2.2 MAIN MEMORY

Q.11 Explain main memory of computer.

Answer

Main Memory

Main memory, also called primary or internal memory is the part of the computer system that holds data and instructions for processing. It is mainly used to store data that is used by the system at startup and to run various types of programs such as the operating system and other programs.

Structure of Main Memory

Typically, Main memory is contained on microchips that are either attached or connected to the computer's motherboard.

Range of Memory

Computer memory can range from a couple of megabytes (MBs) to several gigabytes (GBs). When users load software from a storage medium, it is first loaded in the main memory and then executed or processed

Types of Main Memory

Main memory is divided into the following three types:

- Internal Processor Memory
- RAM
- ROM

2.2.1 Internal Processor Memory

Q.12 Describe internal processor memory and its types.

Answer

Internal Processor Memory

Internal processor memories are directly accessible to the CPU. Cache memory and processor

registers are the examples of such memories. These are extremely fast memories.

Cache Memory

Cache memory is small amount of high-speed semiconductor memory, which exists inside the microprocessor or on the motherboard of the computer. This memory stores some active portion of main memory. It lies between the main memory and the processor. When the processor requires any information, first it will look up in the cache memory, and if it is not available in the cache then it will fetch it from the main memory.

Types of Cache Memories

There are three types of cache memories, Level 1(L1), Level 2(L2) and Level 3(L3) as shown is Fig.2.6.

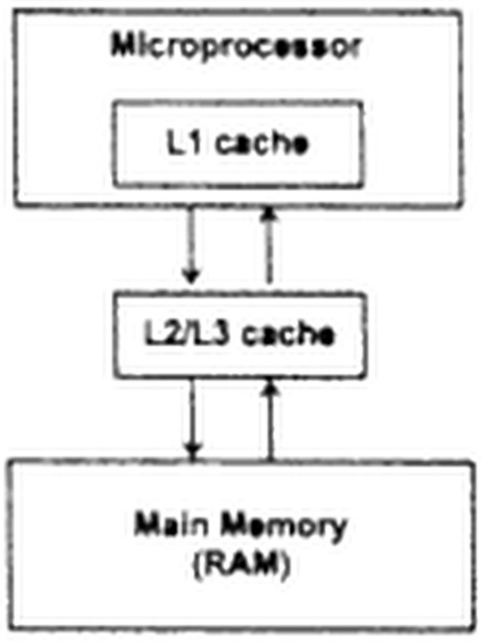

Fig.2.6 L1, L2 and L3 cache memory

L1 cache memory is built inside the microprocessor chip. It has the fastest access time. L2 and L3 cache memories are separate chips on the motherboard. These can be accessed more quickly than the main memory.

Processor Registers

Registers are small memory units. There are a large number of registers inside the processor. Their function is to temporarily store binary information and pass it on to the other parts of the processor or main memory during the execution of program instructions.

Commonly Used Registers

Some commonly used registers inside the microprocessors are:

- Accumulator
- Instruction Register
- Data Register
- Program Counter Register
- Memory Address Register

2.2.2 RAM (Random Access Memory)

Q.13 Define RAM and explain its types.

Answer

RAM

RAM stands for Random Access Memory. When the term RAM is used with semiconductor memories, it is usually taken to mean READ/WRITE memory. It is used in computers for the storage of active programs and data. The contents of RAM change continually as the computer executes a program. RAM plays very important role in the processing speed of the computer. Large RAM size provides larger amount of information to a computer for processing and hence increases the processing speed.

Major Disadvantage of RAM

The major disadvantage of RAM is that it is volatile and will lose all stored information if power is turned off.

Types of RAM

The following are the types of RAM:

- Dynamic RAM (D-RAM)
- Static RAM (S-RAM)

1. Dynamic RAM (D-RAM)

Dynamic RAM (D-RAM) is the most common type of RAM in the computer. Each dynamic RAM chip contains millions of memory cells. A memory cell is an electronic switch, having two states, ON and OFF, representing binary 1 and 0. These memory cells are made up of a transistor and a capacitor. Each memory cell can store one bit of information. A small amount of power is put into the cell to store one bit of information. This energy leaks out quickly. Therefore, computer must recharge all the cells in the memory chip many times per second otherwise the information will be lost. It is used in computers as temporary memory

2. Static RAM (S-RAM)

Static RAM (S-RAM) works in a different way. Each memory cell of static RAM is like an electronic switch having two states, ON and OFF. ON state represents a binary 1 and OFF state a binary 0. It does not need to be recharged but it requires more transistors than dynamic RAM. It is faster than dynamic RAM and more expensive. Static RAM is used as cache memory in computers.

DO YOU KNOW?
Robert H. Dennard invented first dynamic random-access memory (DRAM) in 1968.

2.2.3 ROM (Read Only Memory)

Q.14 Explain ROM and its types.

Answer

ROM

ROM stands for Read Only Memory.

Programming the ROM

The process of entering data in ROM is called programming the ROM. Some ROMs cannot have their data changed once they have been programmed; others can be erased and reprogrammed as often as required by the manufacturers.

Uses of ROMs

ROMs are used to store programs that are frequently required and are not to change during the operation of the computer.

Non-Volatile ROM

All ROMs are non-volatile because programs stored in them are not lost when the computer is turned off.

Types of ROM

There are three types of ROM, which are as follows:

- PROM
- EPROM
- EEPROM

1. PROM

PROM stands for Programmable Read Only Memory. A PROM is a semiconductor chip that is obtained from the manufacturer in an un-programmed state and the user programs it according to his requirements. It can be programmed only once. PROM is used in electronic machine that require some information to be stored in it permanently.

2. EPROM

EPROM stands for Erasable Programmable Read Only Memory. This type of ROM can have its contents erased by ultraviolet light using special circuitry outside the computer and then reprogrammed. This procedure can be carried out many times. However, the constant erasing and rewriting will eventually make the chip useless. EPROMs are generally used for programs designed for repeated use such as the BIOS but that can be upgraded with a later version of the program.

3. EEPROM

EEPROM stands for Electrically Erasable PROM. EEPROM is also being used for ROM applications. The EEPROM can be altered while being used in a logic board by using special power circuits and write, pulse generators. The EEPROM can work like a read/write semiconductor memory while retaining the non-volatile nature of ROMs and PROMs. This type of ROM works in a similar way to flash memory. It is used to store a computer system's BIOS and can be updated without removing it from the circuit board

2.3 SECONDARY MEMORY

Q.15 What is secondary memory? Name some types of secondary memory.

Answer

Secondary Memory

Secondary memory is also known as backing storage, auxiliary storage or mass storage. It stores large amount of information permanently.

Types of Secondary Storage

Some types of secondary storage devices are:

- Hard Disk drive
- CD
- DVD
- Blu-Ray Disk
- Flash memory
- Memory cards

2.3.1 SECONDARY STORAGE DEVICES

Q.16 Write a note on secondary storage devices.

Answer

Secondary Storage Devices

Secondary storage devices are used to store information even when the computer is turned off. All the secondary storage devices are non-volatile memory

2.3.2 SEQUENTIAL ACCESS AND DIRECT ACCESS MEMORY DEVICES

Q.17 Explain the types of memory based on the access mode.

Answer

Memory devices are classified into sequential access memory and direct access memory devices, based on the access mode.

1. Sequential Access Memory

It is a type of memory in which data is accessed sequentially one after the other. A particular stored data is found by sequencing through all locations until the desired data is reached. This produces access times, which are much longer than those of direct access memories.

Examples

Examples of sequential access memory devices include magnetic tapes and audio/video tapes.

2. Direct Access Memory

In this type of memory the data is accessed directly or randomly. Semiconductor memories, disk

memories and optical memories are direct access memories. Direct access memory is also known as random access memory.

Examples

Hard disk, compact disk and flash memory are examples of direct access memory.

2.3.3 TYPES OF SECONDARY STORAGE DEVICES

Q.18 Into how many types, secondary storage devices are classified?

Answer

Types of Secondary Storage Device

Secondary storage devices are classified into the following types:

- Magnetic Tape
- Magnetic Disks
- Optical Disks
- Chip Memory

Q.19 Write a note on magnetic tape.

Answer

Magnetic Tape

Magnetic tape is a plastic strip with a magnetic coated material. Bits are recorded as magnetic spots on the tape along several tracks. Usually 7 or 9 bits are recorded simultaneously to form a character. Read/write heads are mounted one in each track so that data can be recorded and read as a sequence of characters. Magnetic tape is either in the form of cassette or big reels as shown in Fig.2.7.

Fig.2.7 Magnetic Tape Cassette and Reel

Magnetic tape is slow in operation as it has sequential access to data but it is a cheap storage device. Magnetic tape drive is used to write data to and read data from a magnetic tape. Tapes are used for storing large amount of data. Modern tapes can store data up to 5 TB. It is used with minicomputers and mainframes for backups and archives.

Q.20 Define magnetic disks and describe commonly used magnetic disks.

Answer

Magnetic Disks

A magnetic disk is a flat disk coated with a magnetic material on which data/information is stored in digital form.

Bits

Data/information is stored in digital form in the shape of tiny magnetized spots called bits.

Commonly used magnetic disk

Hard disk is the common type of magnetic disk in use today. Some other types of magnetic disks were also used in the past like Floppy disks and Zip disks. These disks are obsolete and not in use nowadays. These disks have been replaced by optical disks and USB flash drives, which are more reliable and have more storage capacity. The only magnetic disk used nowadays is the Hard disk.

i. Hard Disk

Hard disk contains one or many platters (disks) coated with magnetic material on both sides. The platters are attached to a spindle holding them in parallel with equal gap. All the platters rotate together at high speed.

Tracks

Bits are stored on the magnetic surface in spots along concentric circles called tracks. Hard disks contain thousands of tracks.

Sectors

Track is divided into sections called sectors. Each platter has two read/write heads for writing data to and reading data from both surfaces of the platter.

Hard Disk Manufacturing Environment

Hard disks are manufactured in very clean environment. They must be kept dust free. Dust particles can create scratches on the surface of the platters and damage the data stored in it. The storage capacity of modern hard disks is in Tera bytes. A hard disk is shown in Fig.2.8.

Fig 2.8 Hard Disk

ii. Portable Hard Drive

A portable hard drive is a compact magnetic disk drive that plugs into a USB port on a computer. It is used as portable secondary or backup storage device.

Storage Capacity

Its common storage capacity may range from 500GB to 4TB.

Structure of Portable Hard Drive

Portable hard drive consists of one or more platters, which are air-sealed inside a casing and connected to and powered by USB port of computer.

Use of Portable Hard Drive

Portable hard drive is used for storing data, programs, photos, music, videos and documents.

New models of Portable Hard Drive

New models are using USB 3.0 technology, which provides fast file transfer rate. Some portable hard drives contain built-in wireless functionality to communicate with the computer through Wi-Fi connection. A portable hard drive is shown in Fig.2.9.

Fig. 2.9 Portable Hard Drive

DO YOU KNOW?

In September 1956 IBM launched the 305 RAMAC, the first 'SUPER' computer with a hard disk drive (HDD). The HDD weighed over a ton and stored 5 MB of data.

Q.21 What are optical disks? Explain its types.

Answer

Optical Disks

Optical disk is a plastic-coated disk that can store digital data. Data is stored in optical disk in digital form by laser technology as tiny bumps etched on the surface.

Types of Optical Disks

The following are types of optical disks:

- CDs
- DVDs
- Blu-ray Disk

1. Compact Disks (CDs)

CD is an optical disk used for storing digital data. It was originally developed for storing and playback of sound recording but later on its use expanded to computer data storage.

Structure of CD

A CD is 1.2 millimetres thick with a diameter of 120 millimetres. It is made up of polycarbonate plastic and weighs 15 to 20 grams.

Storage Capacity of CDs

The storage capacity of CDs ranges from 350 MB to 800MB.

Use of CDs

CDs are popular for storing data, application programs, device drivers, Windows operating system, images and videos.

Storing Information in CD

A CD has a single spiral track that spirals from the center to the outside edge. Information is stored on a CD in the form of lands and bumps. A binary 0 is represented by a bump and a 1 by a land.

CD Drive/Player

A CD drive/player is used for reading the data stored on the CD as shown in Fig.2.11.

Fig.2.11 A CD inside a CD Player

Job of CD player

The job of CD player is to focus the laser on the track of bumps. The laser beam passes through the polycarbonate layer, reflects off the aluminium layer and hits the censor that detects changes in light. The bump scatters the light and the land reflects it into the censor. The change in reflectivity is transmitted as 0s and 1s into the memory of the computer.

Q.22 Write a note on DVDs.

Answer

Digital Video/Versatile Disks (DVDs)

DVD is very similar to CD but has larger data storage capacity. Its data storage capacity is about seven times more than CD. It has replaced the video tapes that were used in the past for storing movies.

DVD Writer/Player

A DVD writer or player is used to read the data stored on a DVD. DVD players are compatible with CD, which means they can play CDs also.

Structure of DVDs

DVDs have the same diameter and thickness as CDs and are made of the same material and manufacturing methods. Data is also stored just like a CD on a spiral track in the form of lands and bumps.

Storage Capacity of DVDs

The storage capacity of DVDs ranges from 2GB to 16 GB. The MPEG (Moving Picture Experts Group) format is used for storing movies in a compressed form on the DVDs.

Q.23 What is blu-ray disk? State its advantages.

Answer

Blu-ray Disk (BD)

Blu-ray is a new type of optical storage device. Its main advantage over CD and DVD is that it has storage capacity up to 300GB and it is also faster. The bumps on the surface of Blu-ray that represent digital information are much smaller and very densely packed compared to DVD. This increased the storage capacity of Blu-ray.

Advantages of Blu-ray Disk

Blu-ray disks are better storage devices for storing movies because they require a lot more storage. Another advantage of Blu-ray disk is their durability They have a special coating that helps prevent scratches and marks.

A Blu-ray disk is shown in Fig 2.12.

Fig 2.12 Blu-ray Disk

Q.24 Define flash memory. Describe its forms and advantages.

Answer

Flash Memory/Chip Memory

Flash memory or Chip memory is a type of EEPROM. It is solid-state storage device, which means that there are no moving parts in it. Everything inside the flash or chip memory is in electronic form. It got its name "Flash" from the fact that it can store chunks of data and also erase large chunks of data in a flash because it is a semiconductor IC chip memory.

Forms of Flash Memory

Flash memory comes in two forms:

- Flash Drive
- Flash Memory Cards

1. Flash Drive

Flash drives are also called USB flash drives. They are small and portable drives that are connected to computers through USB ports. The storage capacity of flash memory ranges from 2GB to 256GB. Flash drives are shown in Fig 2.13.

Fig-2.13. Flash Drive (USB Drive)

2. Flash Memory Cards

Memory cards are used with laptop computers and other electronic devices such as digital cameras, mobile phones and video games. They come in various sizes and with different storage capacity. Flash memory cards are shown in Fig.2.14.

Fig 2.14 Flash Memory Cards

Advantages of using Flash/Chip memory

1. It allows fast read/write operations.
2. It is non-volatile semiconductor memory.
3. It is very light and very small in size.
4. It is very reliable.
5. Its operation is noiseless since it has no moving part.

KEY POINTS

- Computer memory is a storage device that holds instructions, data and the results produced after processing by the computer.
- Main memory is high-speed IC chip memory that stores programs and data that the computer is currently executing
- Cache memory is small amount of high-speed semiconductor memory, which exists inside the microprocessor and it is faster than main memory.
- Registers are small memory units inside the processor, used to temporarily store binary information and pass it on to the other parts of the processor or main memory during execution of instructions.
- ROM is Read Only-Memory used to store small programs that are frequently required and are not to change during the operation of the computer.
- Secondary memory, also known as backing storage, has huge storage capacity and stores information permanently
- Optical disk is a plastic-coated disk that can store data in digital form using laser technology as tiny bumps etched on the surface.
- Flash memory is a type of EEPROM It is solid-state storage device having no moving parts and it is used as hard disk

EXERCISE

Q.1 Select the best answer for the following MC Qs.

i. Which of the following is the fastest memory?
A. RAM B. ROM C. Cache memory D. USB flash drive

ii. How much is 1 MB memory equal to?
A. 1024 Bytes B. 1024TB C. 1024KB D. 1024GB

iii. Which of the following is volatile memory?
A. RAM B. ROM C. PROM D. EEPROM

iv. Which of the following has highest storage capacity?
A. DVD B. Blu-ray Disk C. CD D. Floppy Disk

v. USB flash drive is what type of memory?
A. Magnetic memory B. Optical memory
C. Electronic memory D. Primary memory

vi. Which of the following memory devices has the smallest storage capacity?
A. RAM B. Cache memory
C. CD D. Memory card

vii. Which of the following storage device is obsolete now days?
A. Hard disk B. CD C. Memory card D. Floppy disk

viii. Which memory communicates directly with the CPU?
A. Main memory B. Secondary memory
C. Hard disk D. USB flash drive

ix. Which of the following memory devices has sequential access to data?
A. Magnetic disk B. Optical memory
C. Magnetic tape D. Chip memory

x. Where are the registers located?
A. Inside hard disk B. Inside DVD
C. Inside RAM D. Inside Microprocessor