

Chapter 4

Memory

Memory is considered an asset of a human being. When we say that a person is experienced, that actually means that the data stored in the mind of that person is huge. He has the data related to past experiences. The ability of a human being to store, retrieve & correlate information in his brain make him distinctive from the other species. The computers may not have acquired the important position today, if they were only doing some calculations & not storing and retrieving the information.

The computers are now storing huge amount of information in very small sized devices. As we know that a computer only understands the binary Language, So every Number & Alphabet or special character has to be represented & stored in the binary format.

The fundamental unit of storage is bit. A **Bit** is short form for a **Binary Digit**. Bits can either have the value of 1 or 0, which corresponds to true and false. Initially when Punched cards were used then there were two stages either there is a hole or there is not a hole. So that time also a hole represents zero & otherwise the value was 1. Similarly in the Magnetic storage devices & optical devices we have two states to represent data.

All machines have a **word size** - a unit of storage, for example 8-bits, 16-bits (half word), 32-bits (word), 64 bits (double word) or 128 bits (quad word). Before we can go into this, you need to understand about the *word size* of your computer. The word size is the computer's preferred size for moving units of information around; technically it's the width of your processor's *registers*, which act as the temporary storage devices for your processor to do arithmetic and logical calculations. When people write about computers having bit sizes (calling them, say, ``32-bit" or ``64-bit" computers), this is what they mean. The size of a **word** (in bytes) differs between machines. A Pentium based machine is 32-bit. Intel 80286 machines were 16 bit machines. The computer views your memory as a sequence of words numbered from zero up to some large value dependent on your memory size.

Classification of Memory

The memory can be classified on the basis of performance, cost & functionality.

1.Primary Memory

It is also called the **main memory** or **internal memory**. It is where the computer holds current programs and data that are in use. In order for a computer to store and move information it needs some place to put it. Information that is currently being accessed (used) by the CPU is stored in **Primary Memory**, also called **RAM**. For example, if we are using a word processing program to write a letter then the letter is stored in Primary Memory. In fact the word processing program itself is stored in Primary Memory as well. Primary Memory is necessary because the CPU cannot access data directly from disk. The data must first be copied from disk to Primary Memory to make it accessible to the CPU. Primary Memory is **volatile**. This means that if power of the computer is cut-off the information in Primary Memory will be lost. That is why it is important to save our work to hard disk frequently when using a computer application such as a word processor or a spreadsheet.

The RAM contains switches that are all turned off when the power to the computer is turned off. The RAM switches are activated when we do something on the computer depending on whatever we choose to do on the computer. If we load a word processing program from disk the RAM switches will be set according to how they were stored on the disk. If we type a letter, additional RAM switches will be set according to whatever we decide to type. If we load a computer game, the RAM switches will be set according to how they were stored on the game disk and give us another unique use for the computer.



Fig 4.1 RAM chip

There are various types of RAM available

DRAM (Dynamic random access memory)

It needs to be continually refreshed. This comes in 80, 70, or 60 nanosecond (ns) speed. The lower the number, faster the memory.

SRAM (Static RAM)

It is powered once and doesn't need to be continually refreshed, unlike dynamic RAM.

CDRAM (Cached RAM)

Mitsubishi Electronics invented this. It combines an SRAM cache with 4 or 16 MB of DRAM within a single chip. This onboard SRAM can be used as both a cache and a buffer and gives the RAM an approximate 15 ns access time.

EDRAM (Enhanced DRAM)

Ramtron International Corporation of Colorado Springs developed it. Like CDRAM also incorporates an on-chip SRAM cache.

EDO RAM (Extended Data Out RAM)

It is a form of DRAM that works by extending the time during which data can be read from memory. Provide from 4 to 15 per cent greater performance than standard DRAM.

RDRAM (Rambus DRAM)

Toshiba and Samsung developed it. It's similar to SDRAM, but faster.

SDRAM (Synchronous DRAM)

Texas Instruments developed it. It has its timing synchronized to the system clock. IT is about 10 per cent faster than EDO RAM.

SGRAM (Synchronous Graphics RAM)

It is a form of DRAM for graphics controllers and printers. According to Fujitsu, it produces data bandwidth up to five times that of standard DRAM.

VRAM (Video RAM)

It is also called "dual port" memory types that allow the graphics processor to read from memory and redraw the screen simultaneously.

WRAM (Window RAM)

Samsung Electronics developed it. It is both faster and less expensive than VRAM.

RAM chips used to be sold as individual chips, but today several RAM chips are soldered together onto a plug-in board called a module. This RAM module is called a **SIMM** (Single In-line Memory Module). SIMMs come in three basic designs: an older design that has 30 connector pins, a newer design that has 72 connector pins, and the newest design that has 168 connector pins (also called SDRAM). Each computer is designed to use one or the other of these SIMM designs, but today most all computers use the 72-pin design.

SIMMs come in several different speeds. The most common speed is called 70 nanoseconds (ns). The rule in RAM is the lower (or smaller) the nanosecond number, the faster the RAM will operate. Therefore, 60 ns SIMM is faster than a 70 ns SIMM. The new SDRAM has a speed of 10ns, which is 6 times faster than the fastest 72 pin SIMMS. All Pentium III and most new Pentium computers incorporate SDRAM.

Several new memory technologies seek to close the gap between processor and RAM performance. The goal is to increase the chip's speed and widen the bandwidth with which they communicate with the processor. The players include double data rate RAM, or DDRAM (also known as SDRAM II), SLDRAM, Direct RDRAM (Direct Rambus) and Concurrent RDRAM (Concurrent Rambus). Out of all these, Direct Rambus, endorsed by Intel, offers the greatest speed improvements, moving the peak bandwidth from SDRAM's 125MBps to an astounding 1.6GBps.

2. ROM (Read Only Memory): Even before installing any software on to your new computer there is something that is already stored & helps to interact with the computer. These instructions are responsible for making the computer operate properly from the moment you turn it on. Since these instructions never disappear and never change they are called **ROM** or **Read Only Memory**.

To summarize, we have learned that computers operate with thousands of tiny switches that can be either off or on. The ROM contains switches that have been permanently set at the factory to control how the computer operates.

There are several types of ROM available like PROM, EPROM and EEPROM.

PROM (Programmable Read Only Memory) it is a special type of ROM in which we can programme the ROM supplied by the manufacturer with the help of some software.

EPROM (erasable programmable read-only memory) it is a special type of PROM that can be erased by exposure to ultraviolet light.

EEPROM (electrically erasable programmable read-only memory) it is a Special type of PROM that can be erased by exposure to an electrical charge.

3. Cache Memory

It is pronounced as cash. It is a special high-speed storage mechanism. The speed is faster than RAM memory also. So it is to further reduce the gap between the speed of the CPU & The memory. It can be either a reserved section of main memory or an independent high-speed storage device. Two types of caching are commonly used in personal computers: memory caching and disk caching.

a) Memory Caching: A memory cache, sometimes called a cache store or RAM cache, is a portion of memory made of high-speed static RAM (SRAM) instead of the slower and cheaper dynamic RAM (DRAM) used for main memory. Memory caching is effective because most programs access the same data or instructions over and over. By keeping as much of this information as possible in SRAM, the computer avoids accessing the slower DRAM.

L1 Cache

Some memory caches are built into the architecture of microprocessors. The Intel 80486 microprocessor, for example, contains an 8K memory cache, and the Pentium has a 16K cache. Such internal caches are often called Level 1 (L1) caches.

L2 Cache

Most modern PCs also come with external cache memory, called Level 2 (L2) caches. These caches sit between the CPU and the DRAM. Like L1 caches, L2 caches are composed of SRAM

but they are much larger. So L2 Cache is not part of the microprocessor, but it is externally available on the Motherboard.

b) Disk caching It works under the same principle as memory caching, but instead of using high-speed SRAM, a disk cache uses conventional main memory. The most recently accessed data from the disk (as well as adjacent sectors) is stored in a memory buffer. When a program needs to access data from the disk, it first checks the disk cache to see if the data is there. Disk caching can dramatically improve the performance of applications, because accessing a byte of data in RAM is thousands of times faster than accessing a byte on a hard disk.

Cache Hit

During processing when certain data is required & data is found in the cache, it is called a cache hit, and the effectiveness of a cache is judged by its hit rate. Many cache systems use a technique known as smart caching, in which the system can recognize certain types of frequently used data. The strategies for determining which information should be kept in the cache constitute some of the more interesting problems in computer science.

Memory buffer: It is a temporary storage area usually in RAM. The purpose of most buffers is to act as a holding area, enabling the CPU to manipulate data before transferring it to a device.

Because the processes of reading and writing data to a disk are relatively slow, many programs keep track of data changes in a buffer and then copy the buffer to a disk. For example, when you change something on the already existing word file, it asks you that whether you want to save the changes made to the file. So this is enabled by word processors by employing a buffer to keep track of changes to files. Then when you save the file, the word processor updates the disk file with the contents of the buffer. This is much more efficient than accessing the file on the disk each time you make a change to the file.

The point to be noted is that because your changes are initially stored in a buffer, not on the disk, all of them will be lost if the computer fails during an editing session. For this reason, it is a good idea to save your file periodically. Most word processors automatically save files at regular intervals.

Another common use of buffers is for printing documents. When you enter a PRINT command, the operating system copies your document to a print buffer (a free area in memory or on a disk) from which the printer can draw characters at its own pace. This frees the computer to perform other tasks while the printer is running in the background. Print buffering is called **spooling**.

4. Secondary Memory

Hard Disk

It is the main secondary storage device in all the computers that is present in all the computers. The size of the data a hard disk can store is increasing very rapidly.

A hard drive is made up of several unique components. The most popular of these components are the platters and the read/write heads. The platters are disc-shaped, usually made out of aluminum or glass. Why we call it as “Hard Disk” is because unlike the flexible media in floppy diskettes, these platters cannot bend or flex. Another popular term to describe a hard drive is **fixed disk**, which is derived from the fact that the platters are fixed firmly in place and are not removable.

Storing the Data

Data is stored on the surface of a platter in sectors and tracks. Tracks are concentric circles, and sectors are pie-shaped wedges on a track, like this:

A typical track is shown in yellow; a typical sector is shown in blue. A sector contains a fixed number of bytes -- for example, 256 or 512. Either at the drive or the operating system level, sectors are often grouped together into clusters.

The process of low-level formatting a drive establishes the tracks and sectors on the platter. The starting and ending points of each sector are written onto the platter. This process prepares the drive to hold blocks of bytes. High-level formatting then writes the file-storage structures, like the file-allocation table, into the sectors. This process prepares the drive to hold files.

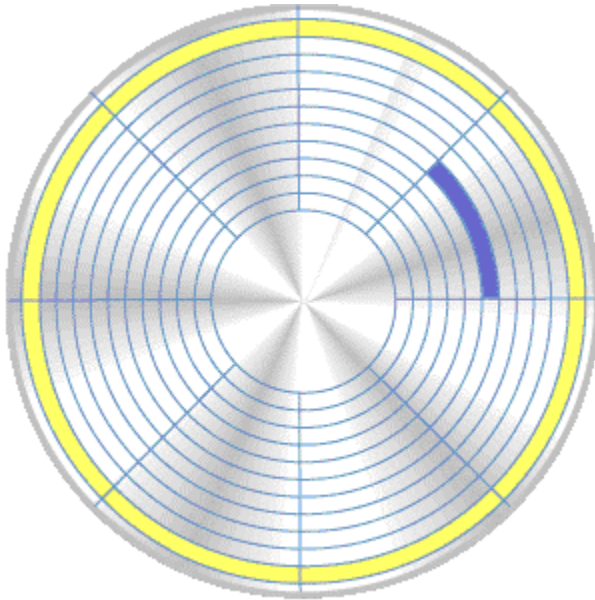


Fig 4.2 Platter of the hard disk

The discs spin while the heads move over them to store or read data in tracks and sectors. Hard drives contain multiple platters with two sides each, where data is stored. For every platter, there is a read/write head, all of which move across the discs at the same time since they are all connected to one arm. Although it is these heads that are responsible for writing data to the discs, they will never actually come into physical contact with the platters. These heads are kept suspended by an extremely thin cushion of air, and thereby float just a fraction of a millimeter above or below the platter. If dust or other small particles ever get into this part of the drive, it would easily be enough to cause the head to come into contact with the platter and do physical damage to it. Also, if a sufficiently large shock were to be applied to the drive while under power, the force could be enough to cause the heads to go crashing into the spinning platters and once again causing physical damage to the drive, not to mention data loss. This is known as a "head crash" or "Disk crash".

Seek Time

The average seek time of the drive is the amount of time it takes for the heads to move from one cylinder on the drive to any other cylinder.

Access Time

The average access time, takes into account the drive's latency. Latency is defined as the average time (in milliseconds) that it takes for a sector to be available after the heads have reached a track. This figure is generally half of the time it would take for the disk to fully rotate once. On a drive with a spin rate of 4,500 RPM, a full rotation would take 13.33 ms; thereby making your latency equal to 6.67 ms. The average access time of the drive is the sum of its average seek time and latency. This gives us the average amount of time that is needed before a sector (chosen at random) can be accessed.

Disk transfer rate

The disk transfer rate represents the speed at which data is moved to and from the drive. This is the number most often reported by hard-drive benchmarking software because it shows you the actual number of kilobytes that can be transferred in any given period of time. The disk transfer rate of a drive depends on the spin rate of the drive. A drive with a spin rate of 5400 RPMs will outperform a similar drive at 4500 RPMs.



Fig 4.3 Hard Disk

Partitions of the Hard Disk

Every file you store on a hard drive relies on some kind of file addressing system to organize all your data. Between PC's, the most common file system is known as FAT (File Allocation System). Windows 95 uses a modified version of FAT called VFAT (virtual FAT), which adds support for long filenames.

Windows NT supports both FAT, and its own NTFS format. NTFS is the most advanced file system. It allows access to partitions up to 16 PB (petabyte) in size. [Equal 16 million terabytes - 16 followed by 18 zeroes].]

Each file system organizes data into segments called clusters. Under the FAT file system, the maximum size of any one cluster is 32KB (32,768 bytes). The maximum number of these clusters is limited to 65,536. When you multiply these two numbers, you come up with what has come to be termed the "2.1GB barrier," referring to the maximum number of bytes that can be allocated on the drive.



Fig 4.4 Interior of a hard Disk

Under the FAT system, your cluster size is determined by your partition size. By dividing the partition size by the maximum number of clusters the drive can hold, we get the individual cluster size. The larger the partition size, the larger the cluster size. A 2 GB partition will give you a 32KB cluster size. Keep in mind that every file on your hard drive must occupy at least one cluster. This means that if you had a tiny batch file that was 156 bytes long, the FAT system would automatically allocate an entire cluster to that file, despite the fact that it's so small. So here is the wastage of space.

It is a sealed aluminum box with controller electronics attached to one side. The electronics control the read/write mechanism and the motor that spins the platters. The electronics also assemble the magnetic domains on the drive into bytes (reading) and turn bytes into magnetic domains (writing). The electronics are all contained on a small board that detaches from the rest of the drive:

Underneath the board are the connections for the motor that spins the platters, as well as a highly filtered vent hole that lets internal and external air pressures equalize:

Removing the cover from the drive reveals an extremely simple but very precise interior:

The platters spin at 3,600 or 7,200 rpm when the drive is operating. These platters are manufactured to amazing tolerances and are mirror-smooth. The arm that holds the read/write heads is controlled by the mechanism in the upper-left corner, and is able to move the heads from the hub to the edge of the drive. The arm and its movement mechanism are extremely light and fast. The arm on a typical hard-disk drive can move from hub to edge and back up to 50 times per second. In order to increase the amount of information the drive can store, most hard disks have multiple platters. This drive has three platters and six read/write heads: The mechanism that moves the arms on a hard disk has to be incredibly fast and precise. It can be constructed using a high-speed linear motor.

Floppy Drive & Floppy

Basically, a floppy disk drive reads and writes data to a small, circular piece of metal-coated plastic similar to audiocassette tape.

The computer program passes an instruction to the computer hardware to write a data file on a floppy disk, which is very similar to a single platter in a hard disk drive except that it is spinning much slower, with far less capacity and slower access time. The computer hardware and the floppy-disk-drive controller start the motor in the diskette drive to spin the floppy disk.

The disk has many concentric tracks on each side. Each track is divided into smaller segments called sectors, like slices of a pie.

A second motor, called a stepper motor, rotates a worm-gear shaft (a miniature version of the worm gear in a bench-top vise) in minute increments that match the spacing between tracks.

The time it takes to get to the correct track is called "access time." This stepping action (partial revolutions) of the stepper motor moves the read/write heads like the jaws of a bench-top vise. The floppy-disk-drive electronics know how many steps the motor has to turn to move the read/write heads to the correct track.

The read/write heads stop at the track. The read head checks the prewritten address on the formatted diskette to be sure it is using the correct side of the diskette and is at the proper track.



Fig 4.5 Floppy

Before the data from the program is written to the diskette, an erase coil (on the same read/write head assembly) is energized to "clear" a wide, "clean slate" sector prior to writing the sector data with the write head. The erased sector is wider than the written sector -- this way, no signals from sectors in adjacent tracks will interfere with the sector in the track being written.

The energized write head puts data on the diskette by magnetizing minute, iron, bar-magnet particles embedded in the diskette surface. The magnetized particles have their north and south poles oriented in such a way that their pattern may be detected and read on a subsequent read operation.

The diskette stops spinning. The floppy disk drive waits for the next command

The Disk

A floppy disk is a lot like a cassette tape: Both use a thin plastic base material coated with iron oxide. This oxide is a ferromagnetic material, meaning that if you expose it to a magnetic field it is permanently magnetized by the field. Both can record information instantly. Both can be erased and reused many times. Both are very inexpensive and easy to use.

If you have ever used an audio cassette, you know that it has one big disadvantage -- it is a sequential device. The tape has a beginning and an end, and to move the tape to another song later in the sequence of songs on the tape you have to use the fast forward and rewind buttons to find the start of the song, since the tape heads are stationary. For a long audio cassette tape it can take a minute or two to rewind the whole tape, making it hard to find a song in the middle of the tape.

The tracks are arranged in concentric rings so that the software can jump from "file 1" to "file 19" without having to fast forward through files 2-18. The diskette spins like a record and the heads move to the correct track, providing what is known as direct access storage.

The major parts of a FDD include:

Read/Write Heads: Located on both sides of a diskette, they move together on the same assembly. The heads are not directly opposite each other in an effort to prevent interaction between write operations on each of the two media surfaces. The same head is used for reading and writing, while a second, wider head is used for erasing a track just prior to it being written. This allows the data to be written on a wider "clean slate," without interfering with the analog data on an adjacent track.

Drive Motor: A very small spindle motor engages the metal hub at the center of the diskette, spinning it at either 300 or 360 rotations per minute (RPM).

Stepper Motor: This motor makes a precise number of stepped revolutions to move the read/write head assembly to the proper track position. The read/write head assembly is fastened to the stepper motor shaft.

Mechanical Frame: A system of levers that opens the little protective window on the diskette to allow the read/write heads to touch the dual-sided diskette media. An external button allows the diskette to be ejected, at which point the spring-loaded protective window on the diskette closes.

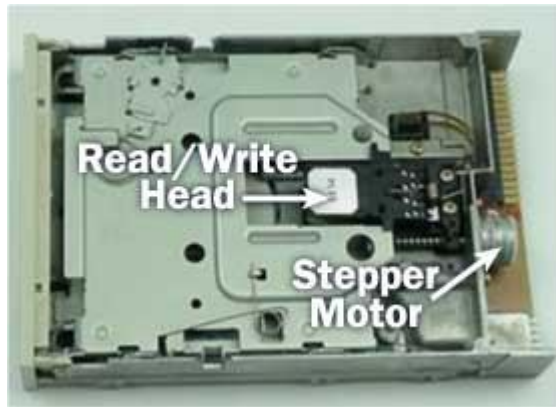


Fig 4.6 Interior of Floppy Drive

Circuit Board: Contains all of the electronics to handle the data read from or written to the diskette. It also controls the stepper-motor control circuits used to move the read/write heads to each track, as well as the movement of the read/write heads toward the diskette surface.

The read/write heads do not touch the diskette media when the heads are traveling between tracks. Electronic optics check for the presence of an opening in the lower corner of a 3.5-inch diskette (or a notch in the side of a 5.25-inch diskette) to see if the user wants to prevent data from being written on it.

Zip Drive

Zip drives attach to your computer in a number of different ways. Some attach to the parallel port of your PC, others attach via USB ports, and others attach via SCSI and EIDE connectors.

A disk for an Iomega Zip drive looks much like a floppy disk. It's about the same size, although slightly thicker. But the Zip drive can hold many more times the capacity of a normal floppy disk—up to 250 megabytes.

Inside the disk is a magnetic-coated Mylar disk called a cookie. A hard plastic shell, with a metal plate that slides open to give read/write heads access to the cookie, protects it. The cookie is coated with special magnetic particles that allow it to hold more data than a normal floppy drive. The heads on a Zip drive are much smaller than those on a floppy drive, which allows more data tracks to be used per inch, also increasing the disk's storage capacity.

A metal shield in the drive slides to one side to expose a small opening along the edge of the plastic case when you insert a Zip disk. A motor, spinning at 3,000 rpm, engages a metal hub in the cookie. The hole in the disk's casing matches up with a hole in the housing that surrounds the read/write heads, which reduces the damage done to the cookie by dust and other contaminants in the air.

Two read/write heads—one for each side of the cookie—read and write data to the Zip drive. The heads touch the cookie, but very lightly compared to a floppy drive. (In this way, they're unlike hard drive heads, which never touch the surface of the disk.) Because the heads touch the Zip disk lightly, there is less wear and tear on the cookie, and there can be a higher spin rate.

Compact Disk (CD)

CD is also a storage media that stores huge amount of data as compared to the floppy disk. It

stores around 783 megabytes (MB) onto a disc only 4.8 inches (12 cm) in diameter .

A CD is made of plastic, about four one-hundredths (4/100) of an inch (1.2 mm) thick. Most of a CD consists of an **injection-molded piece of clear polycarbonate plastic**. During manufacturing, this plastic is impressed with microscopic bumps arranged as a single, continuous, extremely long spiral track of data. Once the clear piece of polycarbonate is formed, a thin, reflective aluminum layer is sputtered onto the disc, covering the bumps. Then a thin acrylic layer is sprayed over the aluminum to protect it. The label is then printed onto the acrylic. A cross section of a complete CD (not to scale) looks like this:

A CD has a single spiral track of data, circling from the inside of the disc to the outside. The fact that the spiral track starts at the center means that the CD can be smaller than 4.8 inches (12 cm) if desired, and in fact there are now plastic baseball cards and business cards that you can put in a CD player. CD business cards hold about 2 MB of data before the size and shape of the card cuts off the spiral.

The data track is -- it is approximately 0.5 microns wide, with 1.6 microns separating one track from the next. (A micron is a millionth of a meter.) And the elongated bumps that make up the track are each 0.5 microns wide, a minimum of 0.83 microns long and 125 nanometers high. (A nanometer is a billionth of a meter.)

The incredibly small dimensions of the bumps make the spiral track on a CD extremely long. If you could lift the data track off a CD and stretch it out into a straight line, it would be 0.5 microns wide and almost 3.5 miles (5 km) long!

CD Player or CD drive

The CD player has the job of finding and reading the data stored as bumps on the CD. drive consists of three fundamental components:

drive motor spins the disc. This drive motor is precisely controlled to rotate between 200 and 500 rpm depending on which track is being read.

A laser and a **lens system** focus in on and read the bumps.

A **tracking mechanism** moves the laser assembly so that the laser's beam can follow the spiral track. The tracking system has to be able to move the laser at micron resolutions.

The fundamental job of the CD player is to focus the laser on the track of bumps. The laser beam passes through the polycarbonate layer, reflects off the aluminum layer and hits an opto-electronic device that detects changes in light. The bumps reflect light differently than the "lands" (the rest of the aluminum layer), and the opto-electronic sensor detects that change in reflectivity. The electronics in the drive interpret the changes in reflectivity in order to read the bits that make up the bytes. The hardest part is keeping the laser beam centered on the data track. This centering is the job of the **tracking system**. The tracking system, as it plays the CD, has to continually

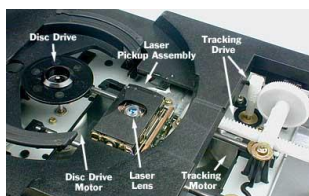




Fig: 4.8 Interior of CD Drive

move the laser outward. As the laser moves outward from the center of the disc, the bumps move past the laser faster -- this happens because the linear, or tangential, speed of the bumps is equal to the radius times the speed at which the disc is revolving (rpm). Therefore, as the laser moves outward, the **spindle motor** must slow the speed of the CD. That way, the bumps travel past the laser at a constant speed, and the data comes off the disc at a constant rate.

Thumb Drive

The ThumbDrive is the world's first and smallest portable storage drive. Based on Trek's patented technologies, the ThumbDrive combines flash memory technologies with the ubiquitous USB connection to create a self-contained drive and media package the size of a thumb. It plugs directly into the USB port of any computer and can store virtually any digital data from Documents and presentations to music and photos.

DVD

DVD offers a high capacity multimedia data storage medium, designed to accommodate a complete movie on a single disc, content rich multimedia or very high quality multi-channel audio. DVD has become the fastest growing consumer electronics technology of all time, growing much faster than CD or VHS did in their first few years.

Multiple-choice Questions:

1. Which is not a storage device.
 - a) RAM
 - b) KeyBoard
 - c) Hard Disk
 - d) Compact Disk
2. The Following is not a type of RAM.
 - a) SRAM
 - b) SDRAM
 - c) RDRAM
 - d) AC RAM
3. L2 cache is available on the _____.
 - a) Motherboard
 - b) Processor

- c) Hard Disk
d) CD Drive
4. CD Rom is made up of _____.
- a) ferrite Material
b) polycarbonate plastic
b) Magnetic material
c) Carbonated Iron plates
5. Hard Disk is a _____.
- a) Input Device
b) Primary Memory
c) small capacity memory
d) Secondary storage
6. The Device with Maximum storage capacity.
- a) Floppy
b) RAM
c) CD
d) Hard Disk
7. The most costly device if the memory capacity is same.
- a) Floppy
b) RAM
c) CD
d) Hard Disk
8. How many spiral tracks of data are there in a CD.
- a) One
b) Two
c) Three
d) Four
9. Which is not a unit of data storage in various devices.
- a) colony
b) track
c) sector
d) cylinder
10. Which is not a property of ROM.
- a) It is read only Memory
b) EEPROM is advanced ROM
b) It is not volatile
d) it is erased when power is switched off

11. The amount of time it takes for the heads to move from one cylinder on the drive to any other cylinder.
- a) Latency
 - b) Average time
 - c) Seek time
 - d) Access time
12. The storage capacity requirements of an individual are_____.
- a) Decreasing
 - b) constant
 - c) Increasing
 - d) zero
13. Which is not a part of FDD.
- a) stepper motor
 - b) lens system
 - c) drive motor
 - d) Mechanical Frame
14. Disk Transfer rate is_____.
- a) time to transfer the disk
 - b) time to erase the data from the disk
 - c) time to replace the disk
 - d) time to transfer data to & from the disk
15. when certain data is required & data is found in the cache.
- a) Cache Hit
 - b) RAM Hit
 - c) Data Hit
 - d) Memory Hit
16. Thumb drive is attached to _____.
- a) Serial Port
 - b) USB Port
 - c) Parallel Port
 - d) Any of the three
17. DVD can store
- a) A full Video Movie
 - b) Rich Multimedia
 - c) Sophisticated Software Packages
 - d) All the three

18. Which is not a computer Industry

- a) IBM
- b) HP
- c) Microsoft
- d) ENRON

19. The Memory & speed of computers is

- a) Decreasing
- b) increasing
- c) Constant
- d) none of these

20. The cost of size of the computer is

- a) Decreasing
- b) increasing
- c) Constant
- d) none of these

Review Questions

1. Explain the following terms

- a) Zip drive
- b) Floppy Drive
- c) CD Drive

2. Compare the various external storage mechanisms like Floppy, CD, Zip drive.

3. Compare the Primary & Secondary storage devices..

4. What is the need of L1 & L2 level Cache?

5. Explain the working of CD Drive & Zip Drive.

Discussion questions

1. The memory requirements of the companies are increasing exponentially. Where the road will end?

2. How you will calculate your memory requirements so that you can decide the memory configuration of your PC?
3. Explore the research in the area of quantum computing & DNA computing where we will have infinite memory space available to us.

Answers to Multiple Choice Questions:

1. c
2. a
3. d
4. a
5. d
6. a
7. c
8. b
9. d
10. d
11. b
12. c
13. b
14. d
15. c
16. d
17. d
18. d
19. b
20. a