

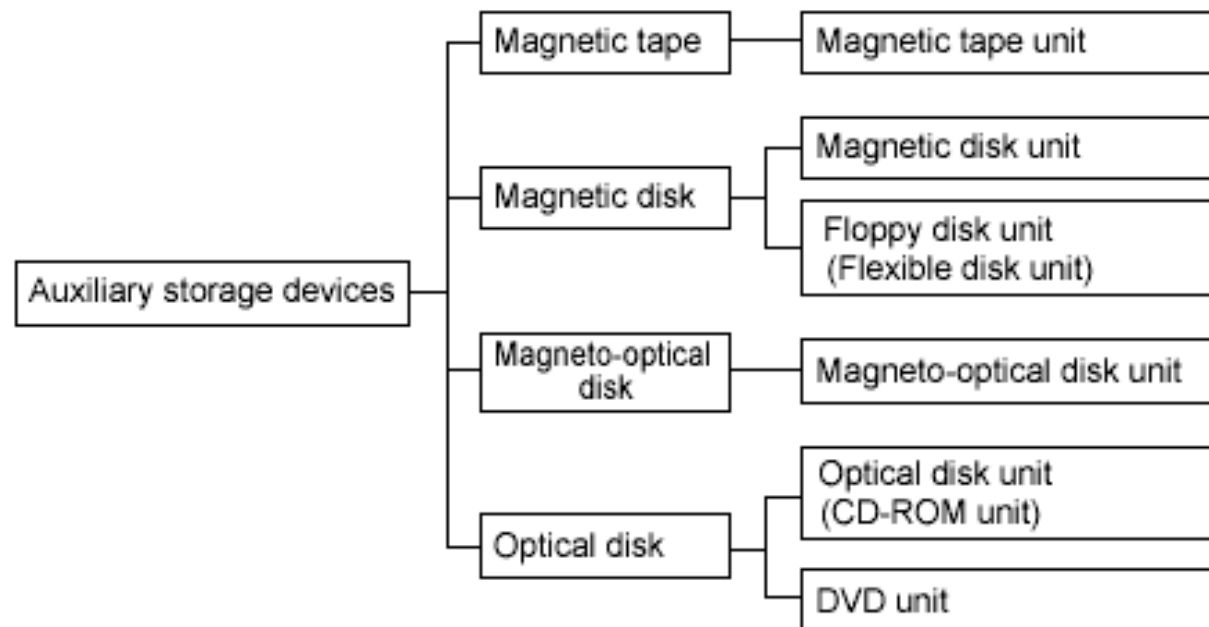
Computer Systems (Auxiliary Storage Devices)

Auxiliary Storage Devices

- ▶ Types and characteristics of storage devices

- Main storage unit

- Auxiliary storage unit



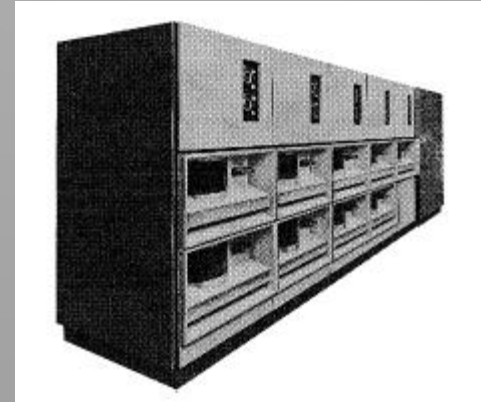
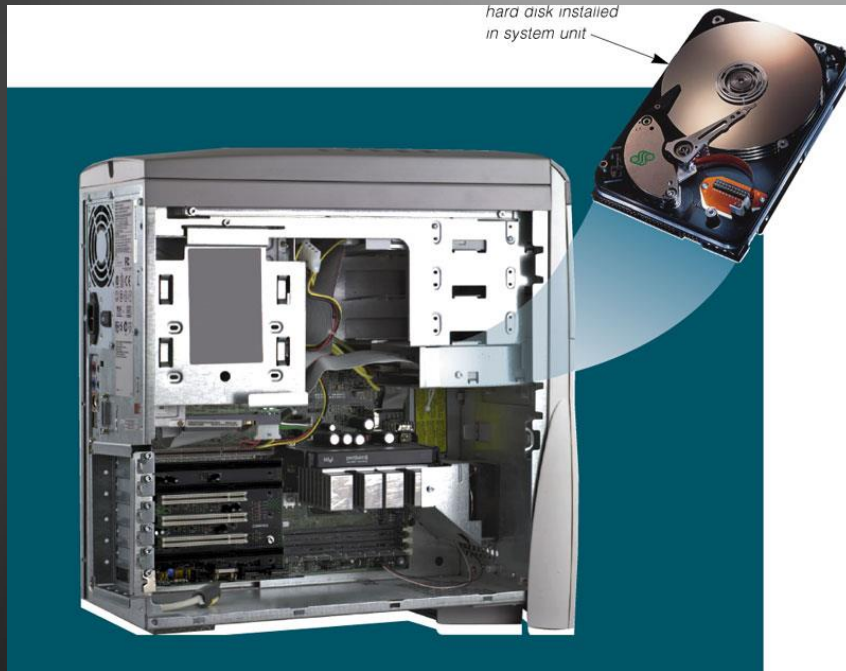
Magnetic Tape



Magnetic Disk Unit

- ▶ Devices that store data using magnetic disks.
- ▶ Most widely used auxiliary storage device
- ▶ Magnetic disks for personal computers or workstations are also called fixed disks or hard disks but the mechanism is the same.

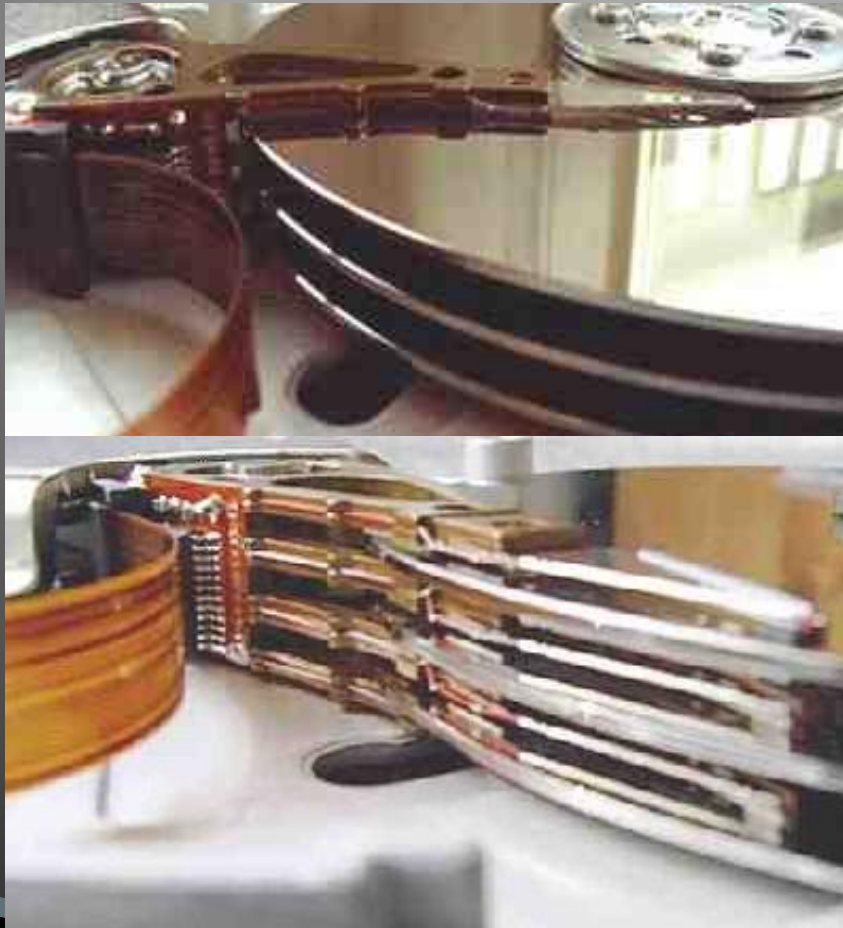
Magnetic Disk Unit



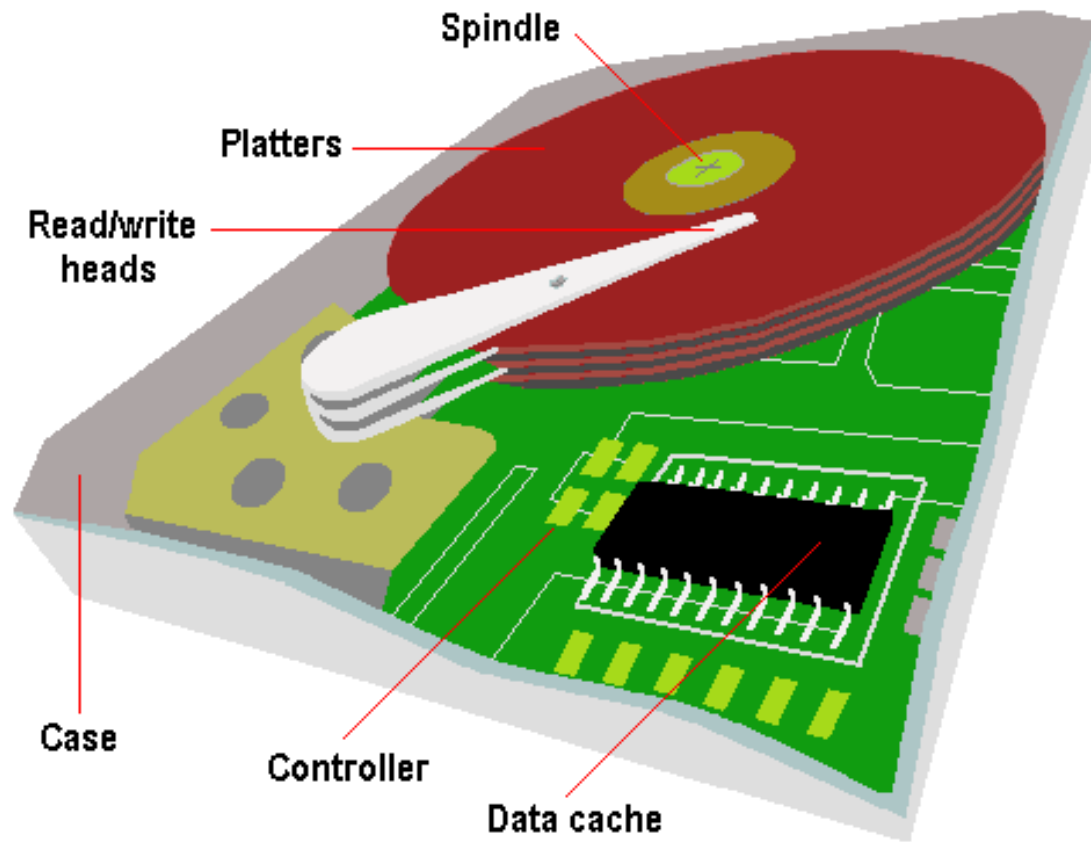
Opening Up Hard Disk



Platters and Heads



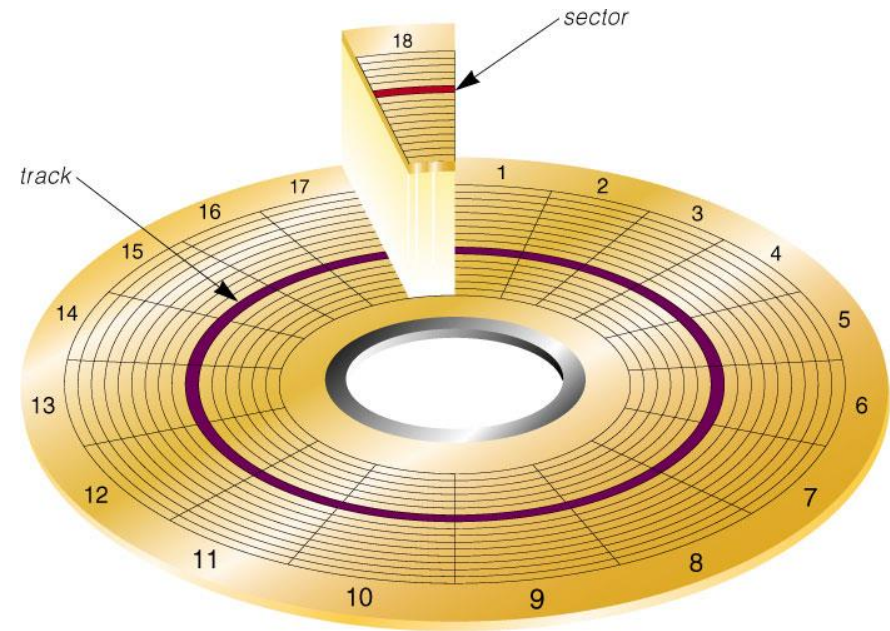
Inside Hard Disk



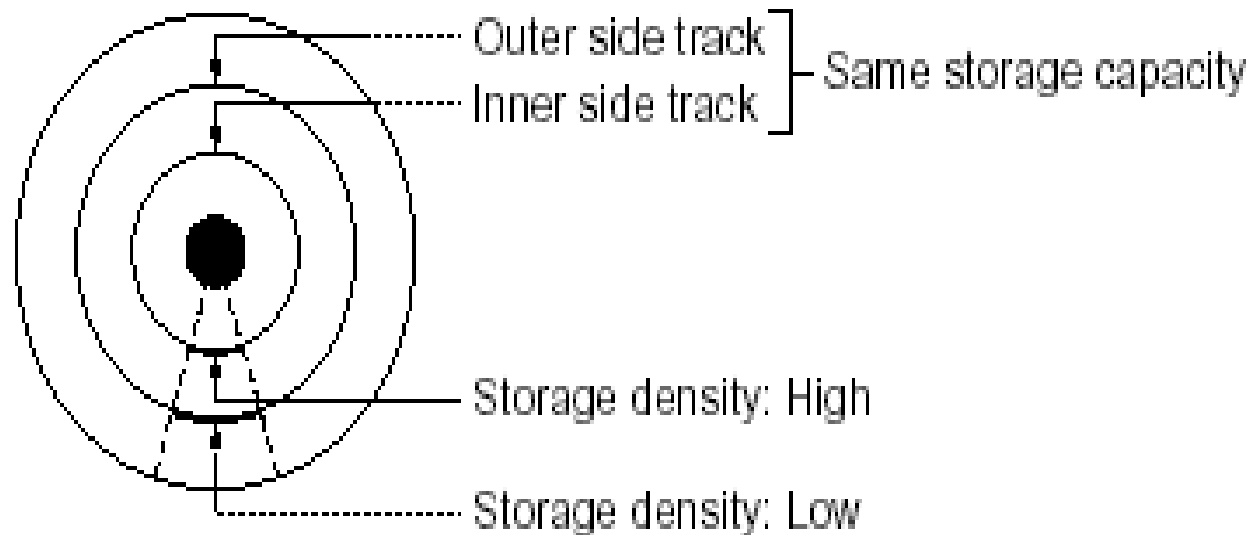
Magnetic Media

▶ Tracks

- Data recorded along rings called 'tracks'
- Length of the outer tracks are larger than that of the inner tracks differ but:
 - Storage capacity is the same
 - Storage density increases from outer to inner



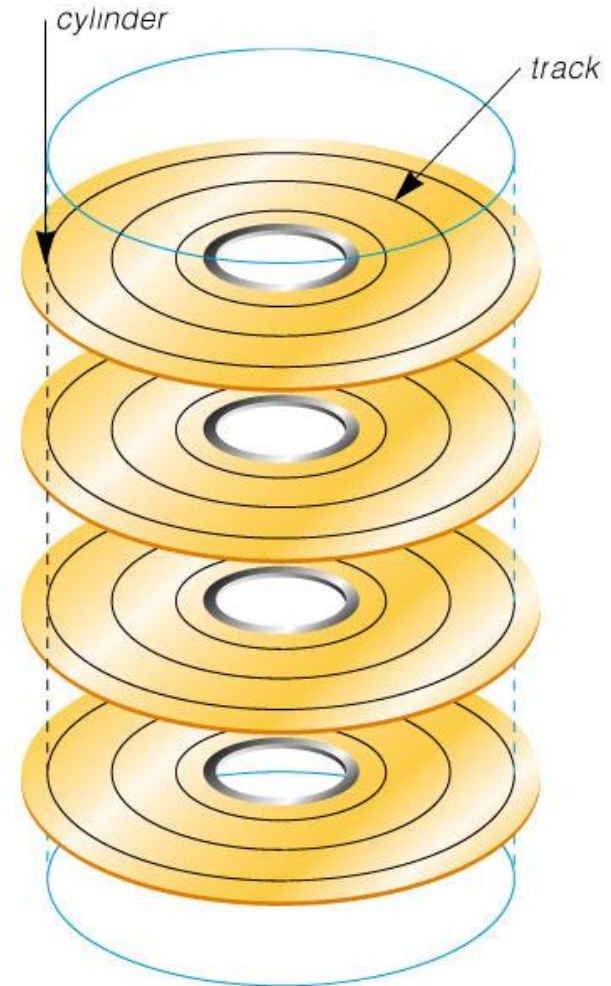
Magnetic Media



Magnetic Media

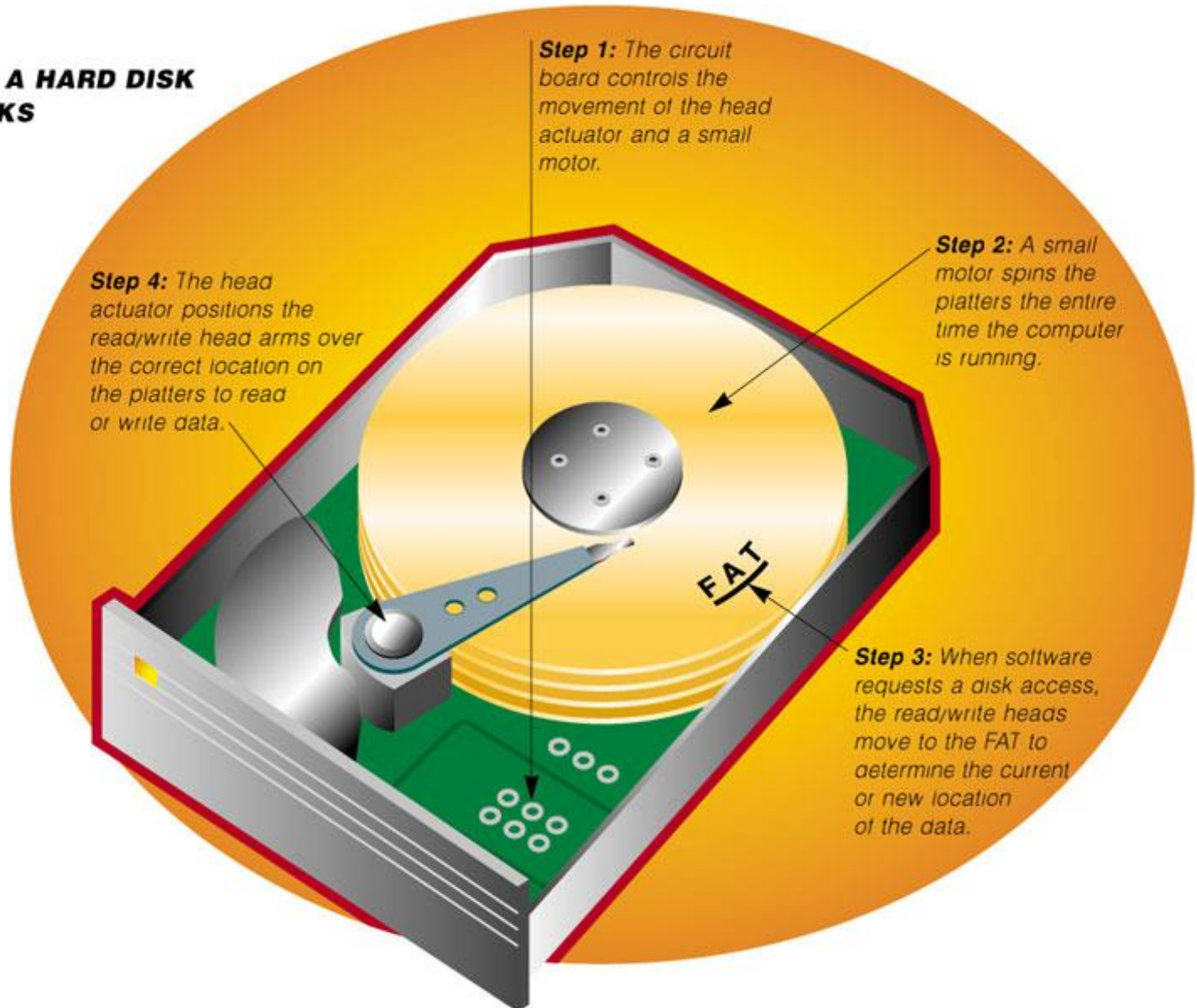
► Cylinders

- In magnetic disk units
 - Multiple magnetic disks
 - Groups of tracks with the same radius on each of the disks is set as one data storage area called a 'cylinder'
 - Makes for more efficient data retrieval
 - Multiple fixed arm magnetic heads

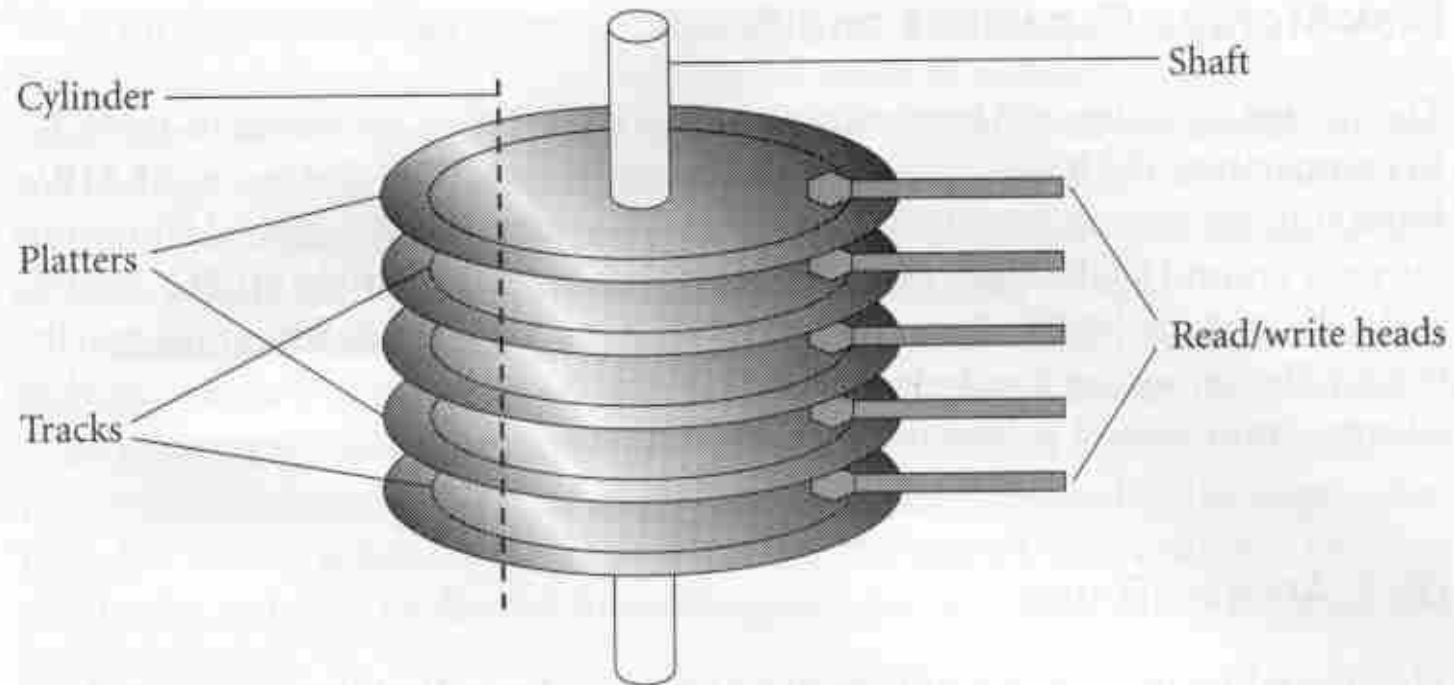


Magnetic Media

HOW A HARD DISK WORKS



Inside Hard disk



Magnetic Media

Storage Capacity

= storage capacity of 1 track *
number of tracks per cylinder *
number of cylinders of the magnetic disk

Calculating Storage Capacity

- ▶ Specifications

- Number of cylinders: 800
- Number of tracks per cylinder: 19
- Storage capacity per track: 20,000 bytes

Calculating Storage Capacity

► Specifications

- Number of cylinders: 800
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Calculations

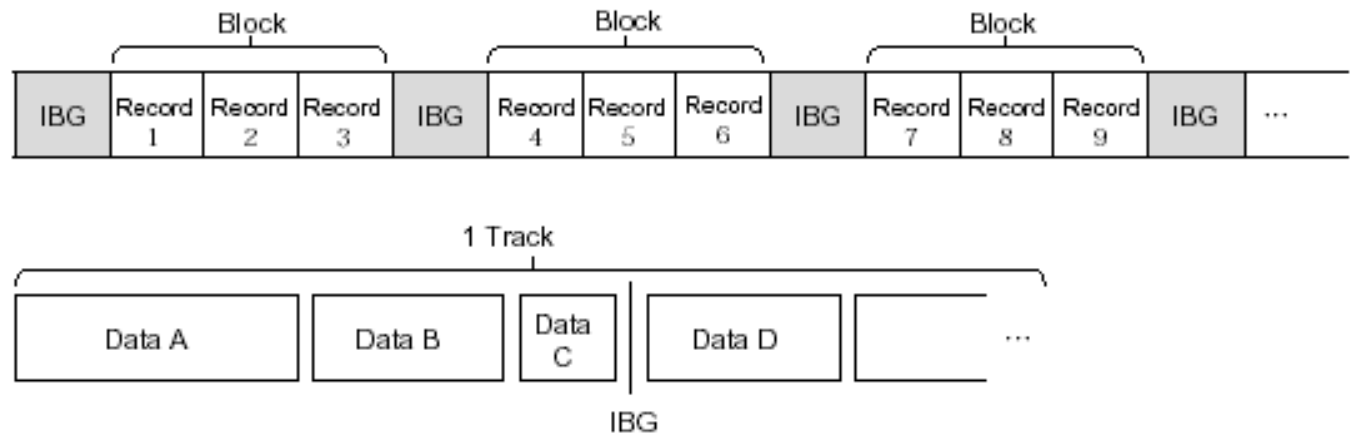
- Storage capacity per cylinder
 - $20,000 \text{ bytes} * 19 \text{ tracks} = 380,000 \text{ bytes/cylinder} = \text{app. } 380\text{KB}$
- Storage capacity of disk
 - $380\text{KB} * 800 \text{ cylinders} = 304,000 \text{ KB} = \text{app. } 304 \text{ MB}$

Magnetic Disk Unit

▶ Recording Type

◦ Variable type

- Data reading, writing performed on **block** basis.
- Read/write can be started from any track position
- Used in magnetic disks
- IBG = Inter-Block Gap



Calculating Storage Capacity (Blocking)

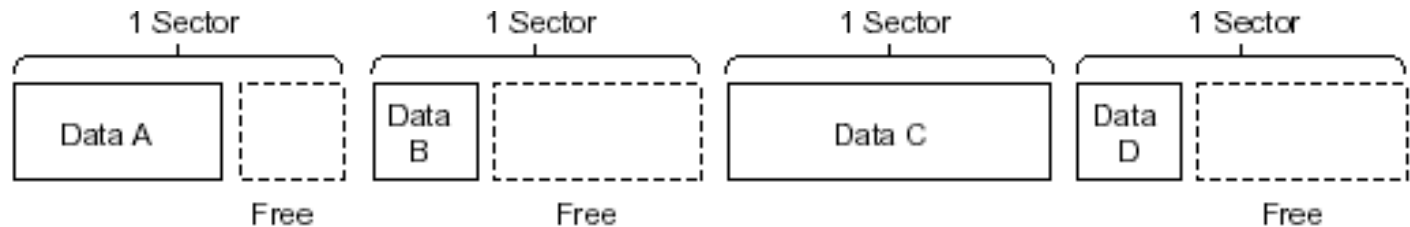
- ▶ Calculate the number of cylinders required when 80,000 records of 200 bytes each are stored in a sequential access file of 10 records/block.
- ▶ Blocking cannot be extended over multiple tracks.
- ▶ Number of cylinders :400
- ▶ Number of tracks/cylinder :19
- ▶ Storage capacity/track :20,000 bytes
- ▶ Inter-block gap (IBG) :120 bytes

Calculating Storage Capacity (Blocking)

- ▶ Number of blocks for the whole file = number of records/blocking factor
 - $80,000 / 10 = 8,000$ blocks
- ▶ Length of 1 block, including the IBG
 - $200 \text{ bytes/record} * 10 \text{ records/block} + 120 \text{ bytes/block} = 2,120 \text{ bytes/block}$
- ▶ Number of blocks on 1 track
 - $20,000 \text{ bytes/track} / 2,120 \text{ bytes/block} = \text{app. } 9.43 \text{ blocks/track}$
 - Because blocking cannot be extended over multiple tracks, $\text{floor}(9.43) = 9 \text{ blocks/track}$
- ▶ Number of tracks for the whole file
 - $8,000 \text{ blocks} / 9 \text{ blocks/track} = \text{app. } 888.88 \text{ tracks}$
 - $\text{Ceil}(888.88) = 889 \text{ tracks}$
- ▶ Number of cylinders required to write the whole file = number of tracks / number of tracks/cylinder
 - $889 / 19 = \text{app. } 46.78 \text{ cylinders}$
 - $\text{Ceil}(46.78) = 47 \text{ cylinders.}$

Magnetic Media

- ▶ Structure and operation principles
 - Sector type
 - Each track divided into approximately 20 small sectors.
 - Reading/writing specified with sector number of selected track.
 - Used in hard disks and floppy disks.



Magnetic Disk

▶ Parity check

- Magnetic head reads/writes data to track bit by bit appending an extra bit for parity check.

▶ Defragmentation

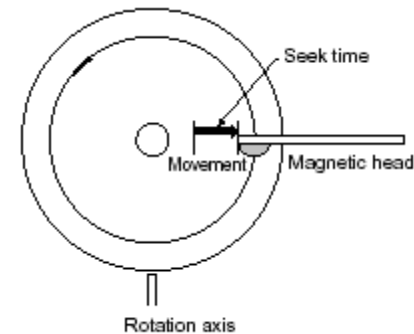
- Data written on hard disks are not contiguous resulting in slow access time.
- Defragmentation will arrange data contiguously thereby speeding up read/write time

Magnetic Disk

- ▶ Access is the generic term for the act of reading specific data from the magnetic disk and writing it on a specific cylinder or track. Access time is calculated through the addition of the following:
 - Seek time
 - Search time
 - Data transfer time

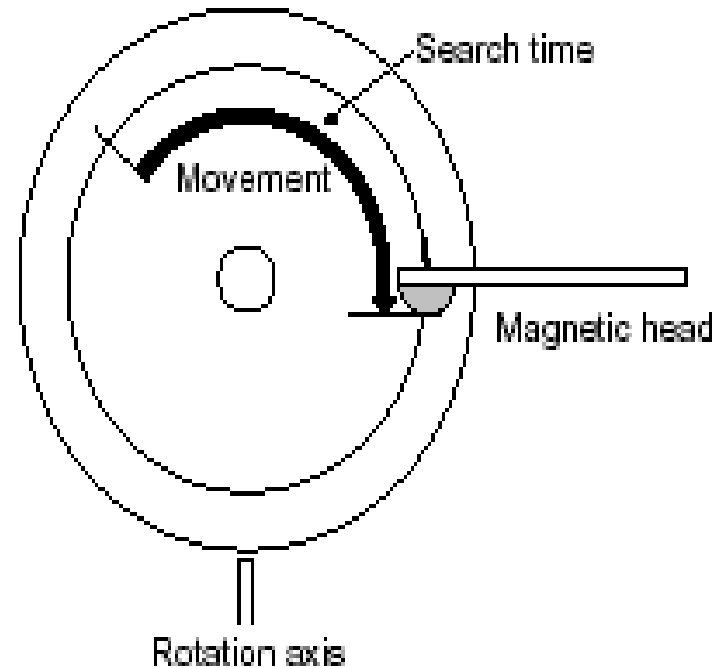
Magnetic Disk

- ▶ Seek time
 - Refers to the time a program or device takes to locate a particular piece of data. For disk drives, the terms *seek time* and *access time* are often used interchangeably. Technically speaking, however, the access time is often longer than seek time because it includes a brief latency period.



Magnetic Disk

- ▶ Search time or latency
 - Lapse of time until target data reaches the magnetic head position



Magnetic Disk

- ▶ Data transfer time
 - Time elapsed between when the magnetic head data access starts and when the transfer is completed

Access Time

- ▶ Access Time of Magnetic Disk Unit
 - = Average Seek Time
 - + Average Search Time
 - + Data Transfer Time

Calculating Access Time

► Specifications

- Capacity/track : 15,000 bytes
- Rotation speed : 3000 rpm
- Average seek time : 10 ms
- Find the access time (ms) for 9,000 bytes of data

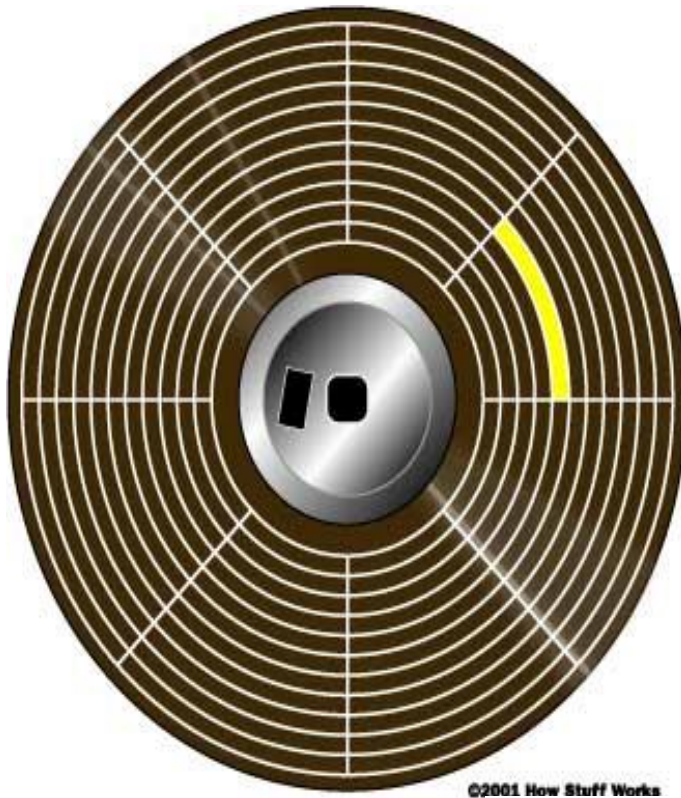
► Calculation

- Average search time
 - Revolution speed = 3,000 rpm
 - 3,000 rev in 60 sec
 - $n(\text{revolutions}) \text{ in } 1 \text{ second} = 3000 / 60 = 50 \text{ rev/sec}$
 - $1 \text{ rev in } (1 / 50) \text{ sec} = 0.02 \text{ sec/revolution} = 20 \text{ ms/rev}$
 - Average search time = $20 \text{ ms} / 2 = 10 \text{ ms}$

Calculating Access Time

- ▶ Data Transfer Speed
 - In 1 revolution, the information contained in 1 track passes through the magnetic disk head
 - The disk makes 50 rev/sec
 - Data transfer speed = 50 tracks/sec * 15,000 bytes/track = 750,000 = $750 * 10^3$ bytes/sec
 - Data transfer time for 9,000 bytes of data = $(9 * 10^3) / (750 * 10^3) = 0.012$ sec = 12 ms
- ▶ Access Time = Average Seek Time + Average Search Time + Data Transfer Time
 - 10ms + 10ms + 12ms = 32 ms

Floppy Disk

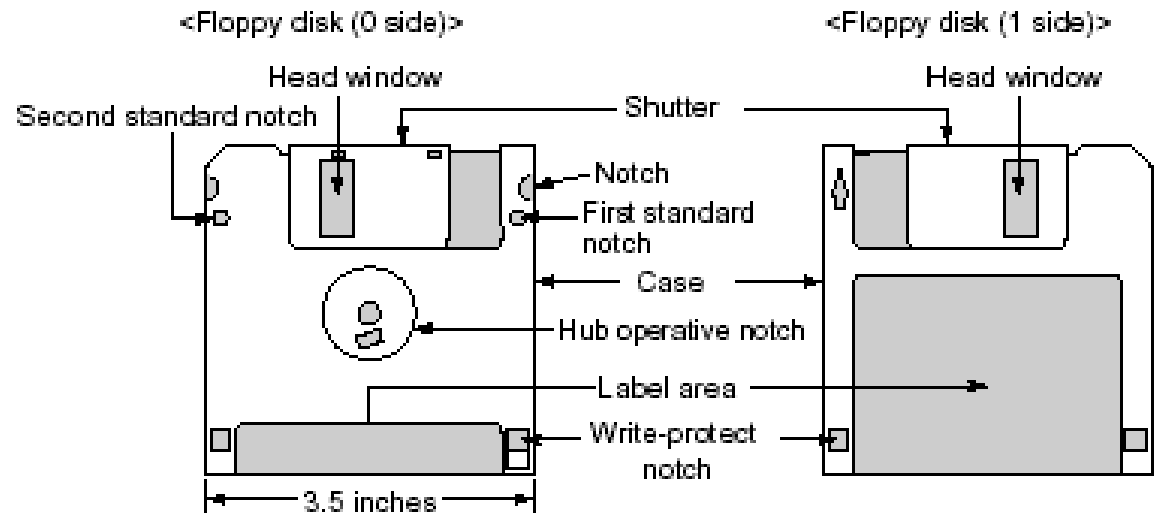


Track – Concentric ring of data on a side of a disk.

Sector – A subset of a track, similar to wedge or a slice of pie.

Floppy Disk

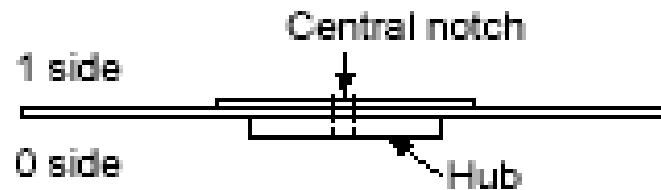
- ▶ Recording method is sector type.
 - Within the outer protective casing is a circular flexible disk, hence “floppy”
 - Low priced storage unit and easily transported, it is widely used



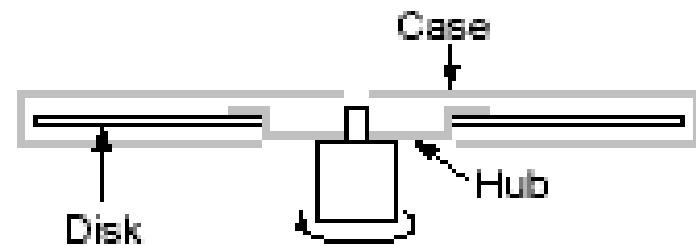
(There are also disks of 5 inches and 8 inches)

Floppy Disk Structure

<Cross section of the disk and the hub>



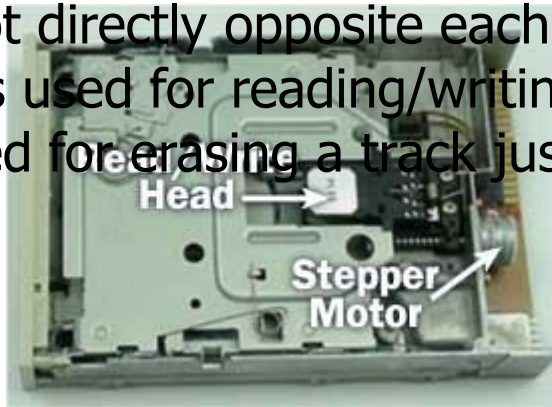
< Cut cross section of the floppy disk>



Floppy Disk

Read/Write

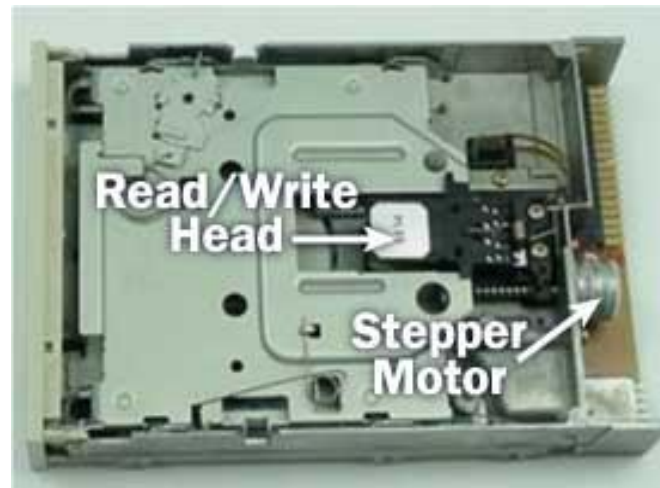
- Located on both sides of a diskette
- The heads are not directly opposite each other
- The same head is used for reading/writing, while a second wider head is used for erasing a track just prior to it being written.



Floppy Disk

Stepper 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



Floppy Disk

- ▶ Storage capacity =
Storage capacity per sector *
Number of sectors per track *
Number of tracks per side *
Number of sides (One side or both sides)

Calculating Floppy Disk Capacity

▶ Specifications

- Sides available for use: 2 sides
- Track number/side: 80 tracks
- Sector number/track: 9 sectors
- Storage capacity/sector: 1,024 bytes

▶ Storage capacity of 1 track

- $1,024 \text{ bytes/sector} \times 9 \text{ sectors/track} = 9,216 \text{ bytes/track}$

▶ Storage capacity of 1 side is as follows:

- $9,216 \text{ bytes/track} \times 80 \text{ tracks} = 737,280 \text{ bytes} = \text{app. } 737\text{kB}$

▶ Both sides used:

- ▶ $737\text{kB} \times 2 = 1,474\text{kB} = \text{app. } 1.44\text{MB}$

High Capacity Floppy Disks

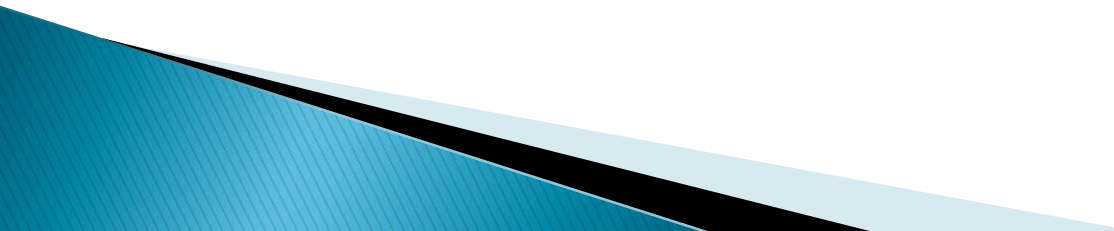
- 100 MB or greater capacity
- Store large files such as graphics, audio, or video
- Used for backups
- SuperDisk drive
- Zip drive



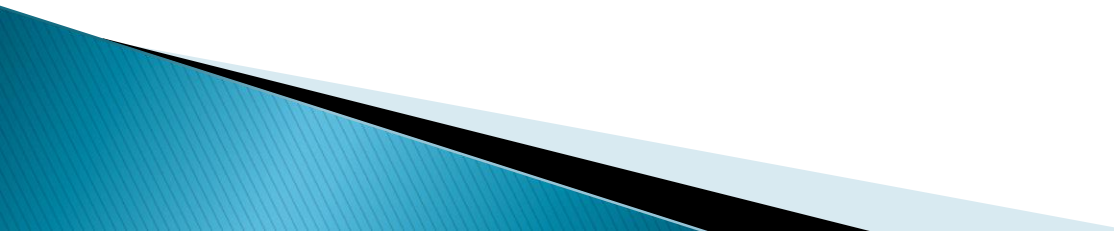
Optical Disk (CD, DVD) Unit

- ▶ Optical disk units
 - Store/save image processing data of extremely large volume or as storage devices of large volume packaged software.
 - These devices can store large volumes of data through a mechanism that reads out information using light reflection
 - Widely used form of multimedia storage and distribution

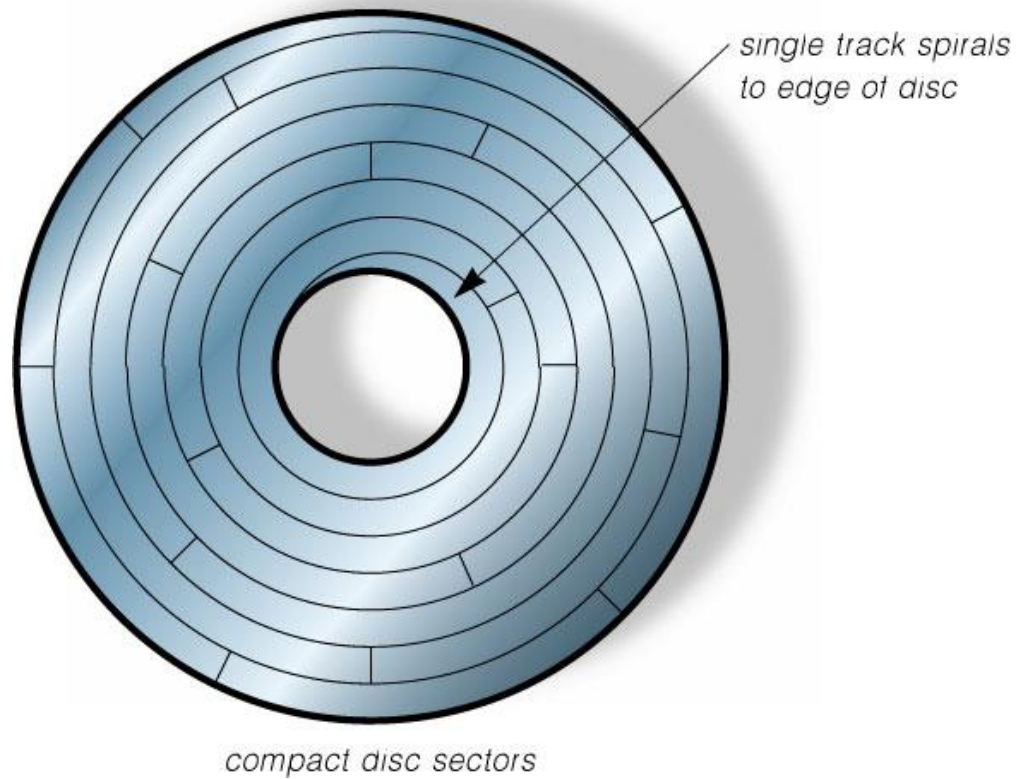
CD-ROM

- ▶ Compact disc read-only memory
 - ▶ Can contain text, graphics, and video as well as sound
 - ▶ Cannot be erased or modified
 - ▶ Use CD-ROM drive or CD-ROM player to read
 - ▶ Holds about 650–850 MB
 - ▶ Used to distribute software
- 

Optical Disk (CD, DVD) Unit

- ▶ Music (Audio) CD (CDA)
 - ▶ CD-ROM
 - CD-G (CD-Graphic) for image data
 - CD-I (CD-Interactive) for interactive applications
 - Photo-CD
 - ▶ CD-R (CD-Recordable)
 - ▶ CD-RW (CD-Rewritable)
 - ▶ Multi-session
- 

CD-ROM Structure

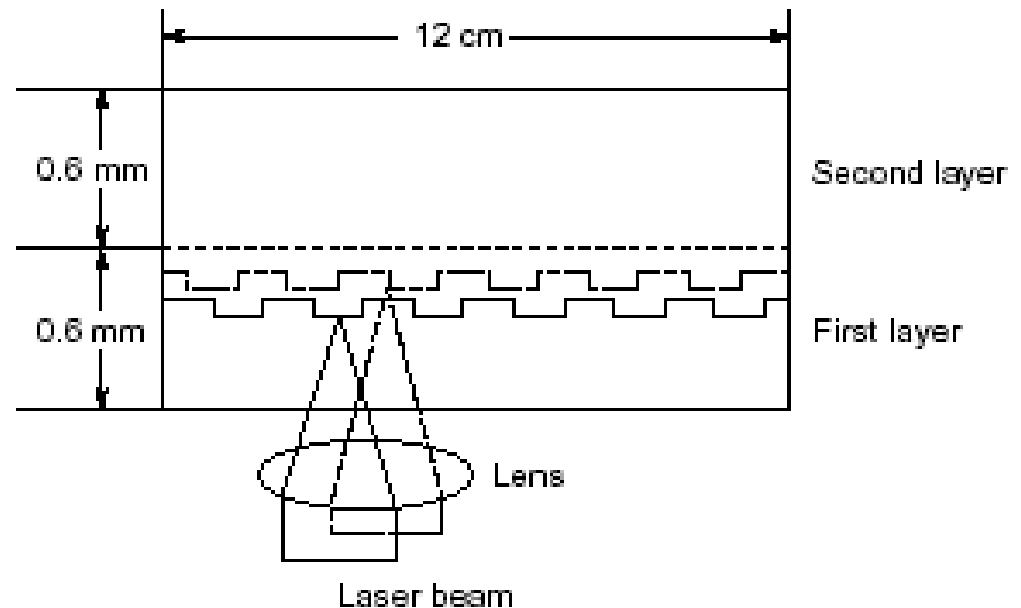


CD-ROM Performance

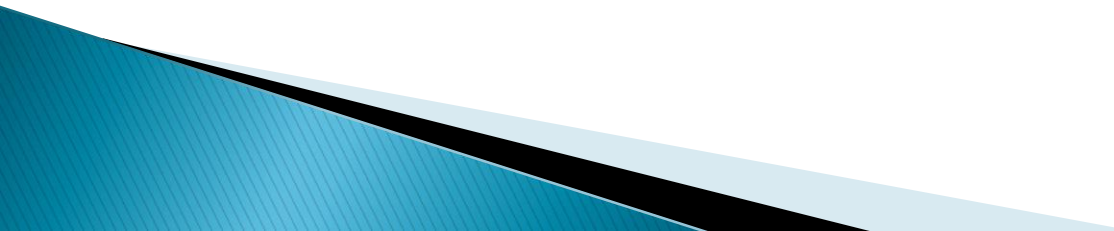
- ▶ Seek time
 - Slow compared to magnetic disks due to heavy lens in the read head and the spiral structure
- ▶ Transfer rate
 - Expressed in numeric values that represent how much data can be transferred in comparison with audio CDs.
 - Audio CD player : 150kB/s
 - CD-ROM units with transfer speeds 2 times or 3 times as fast as the transfer rate for audio CDs began to be developed and today the transfer rate has reached levels of 50x.

DVD Structure

- ▶ Uses MPEG2 compression technology
 - High quality audio/video
- ▶ Variations
 - DVD-ROM
 - DVD-R
 - DVD-RAM
- ▶ Regional encoding



DVD Capacity

- ▶ Single layer single sided recording: 4.7 GB
 - ▶ Dual layer single sided recording: 8.5 GB
 - ▶ Single layer dual sided recording: 9.4 GB
 - ▶ Dual layer dual sided recording: 17 GB
- 

CD versus DVD

Specification	CD	DVD
Track Pitch	1600 nanometers	740 nanometers
Min Pit Length (Single layer)	830 nanometers	400 nanometers
Min Pit Length (Double layer)	NA	440 nanometers

Note that double layer is only applicable to DVD.



Semiconductor Disk Unit

- ▶ Storage unit of high speed and large capacity
 - ▶ Uses flash memories and other devices
 - ▶ Usually used in high-end mainframe computers as a storage unit positioned between the main storage unit and the auxiliary storage devices.
 - ▶ Several G bytes of storage capacity
 - ▶ Access time is 1/100th that of the magnetic disk unit
- 