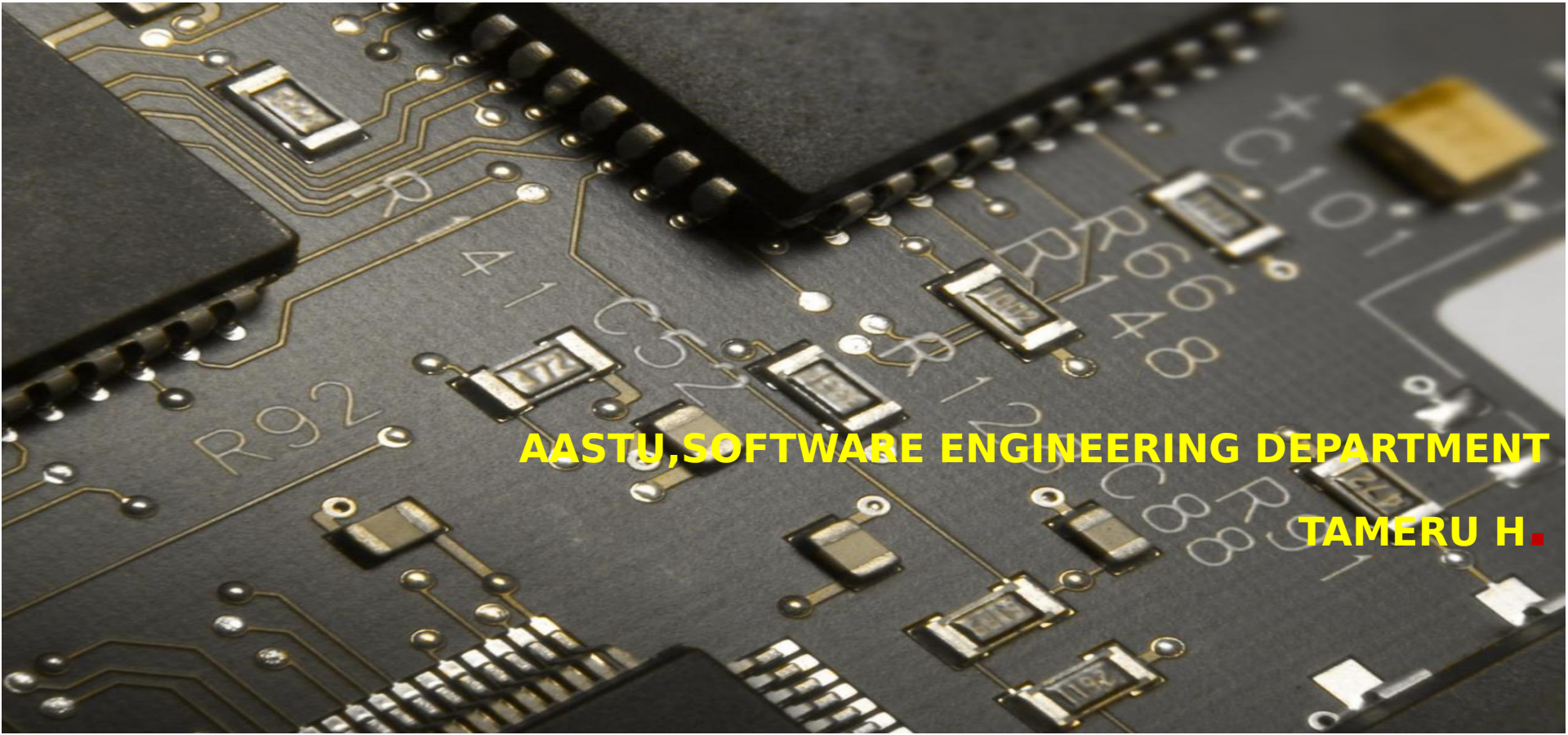
Chapter 5
External Memory
Part Two



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TAMERU H.

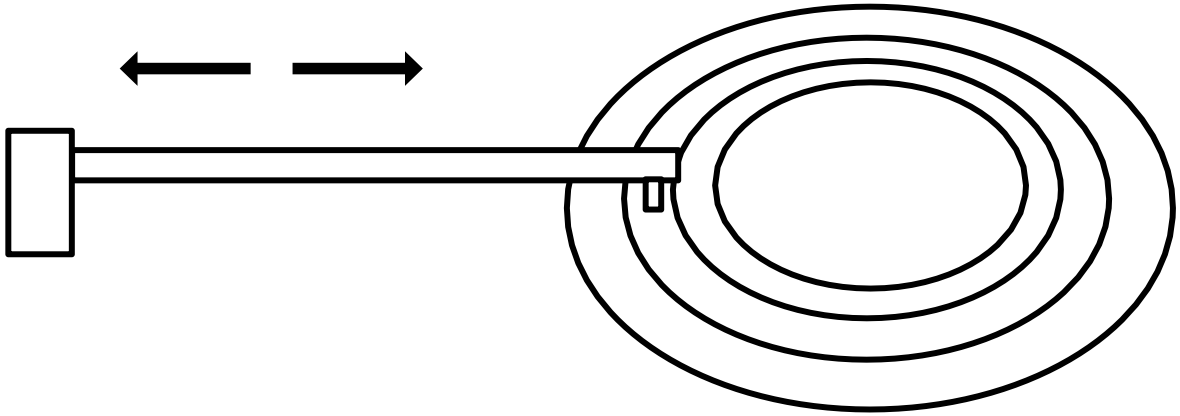
Types of External Memory

- Magnetic Disk
  - RAID
- Magnetic Tape
- Optical
  - CD-ROM
  - CD-R
  - CD-RW
  - DVD

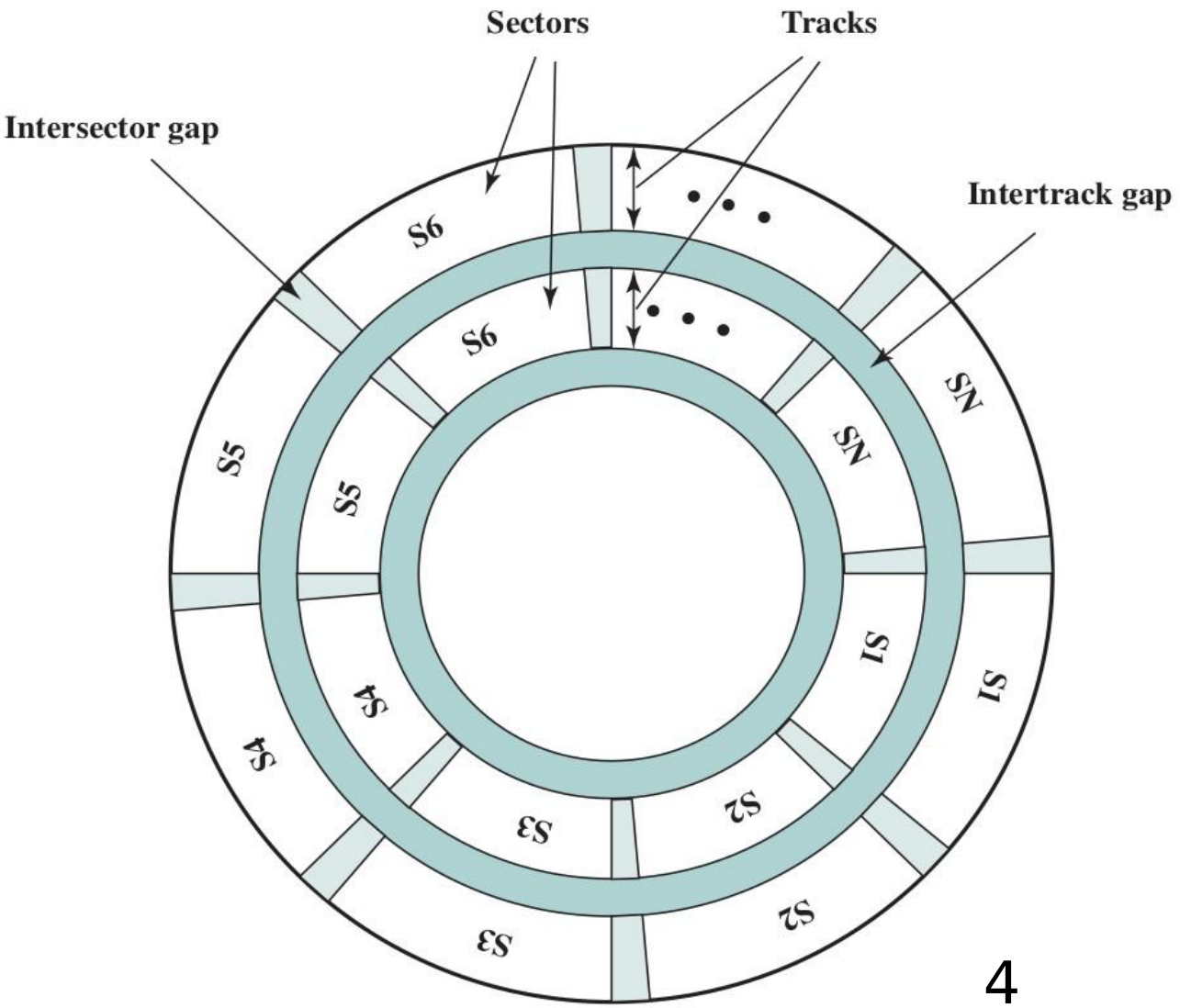
Magnetic Disk

- Metal or plastic disk coated, on one or both sides, with **magnetizable** material

- Data read and written through a magnetic head (coil) by means of **induction**



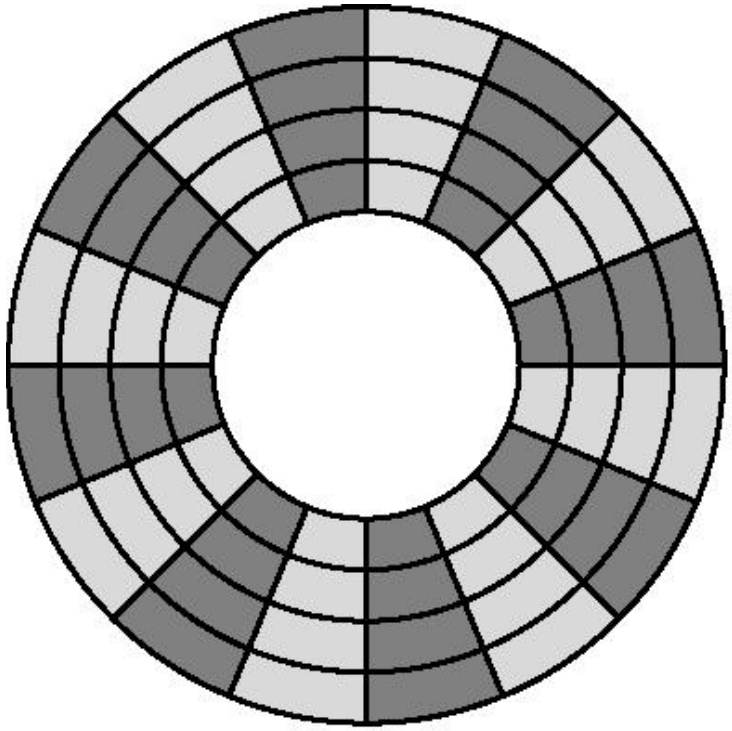
Disk Data Layout



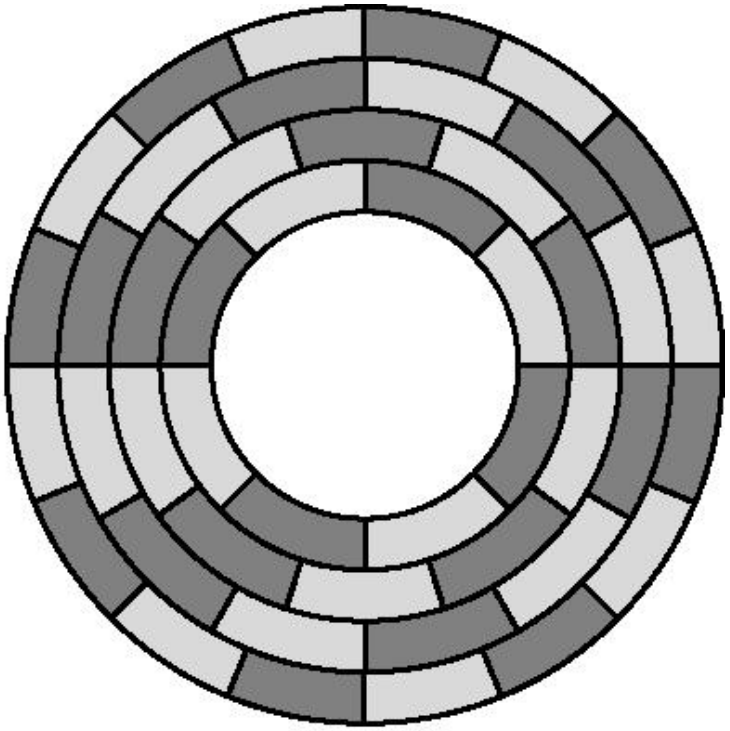
Data Organization and Formatting

- Concentric rings or tracks
  - Gaps between tracks
  - Reduce gap to increase capacity
  - Same number of bits per track
  - Constant angular velocity
- Tracks divided into sectors
- Data read/written in blocks
  - Minimum block size is one sector
  - May have more than one sector per block

Comparison of variable/fixed density



(a) Constant angular velocity

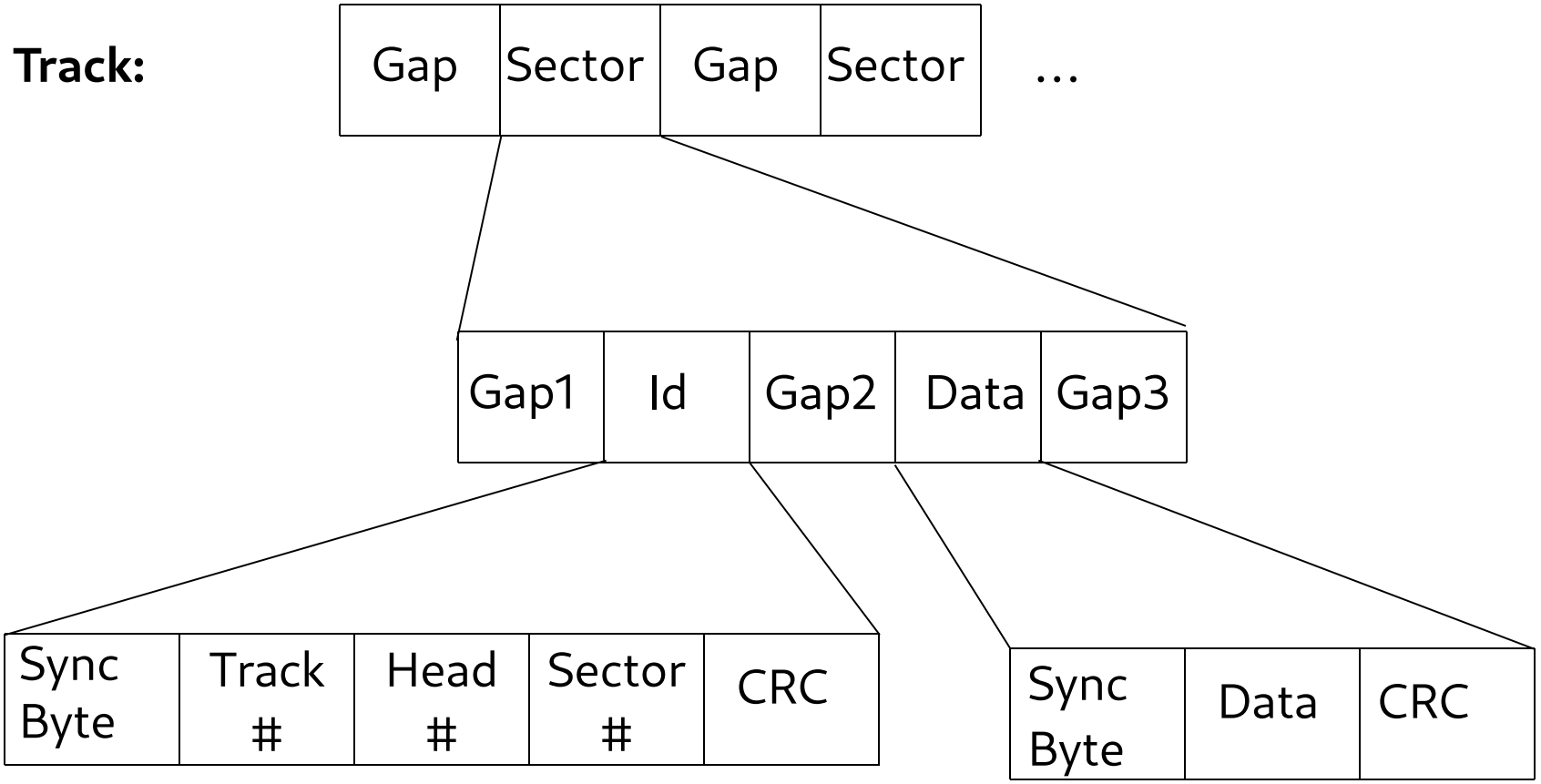


(b) Constant linear velocity

Finding Sectors

- Must be able to identify start of track and sector
- Format disk
  - Additional information not available to user
  - Marks tracks and sectors

An example format



Characteristics of magnetic disks

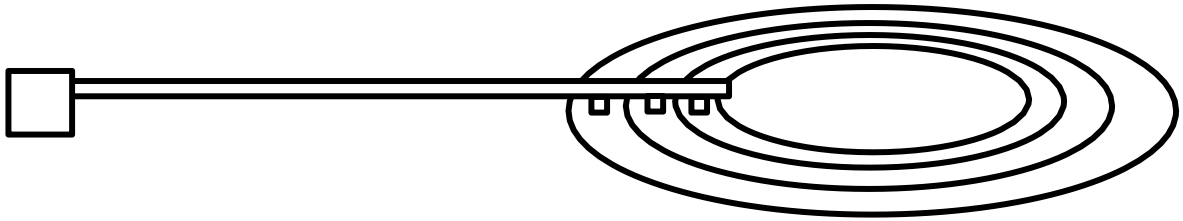
- Single or double (usually) sided
- Removable or fixed
- Fixed or movable head
- Single or multiple platter
- Head mechanism
- Speed

Removable or Not

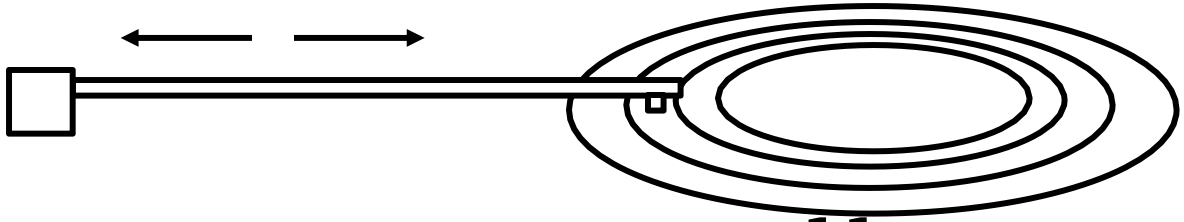
- Removable disk
  - Can be removed from drive and replaced with another disk
    - Provides unlimited storage capacity (by changing disk)
    - Easy data transfer between systems
- Nonremovable disk
  - Permanently mounted in the drive

Fixed/Movable Head Disk

- Fixed head
  - One read/write head per track
  - Heads mounted on a fixed arm

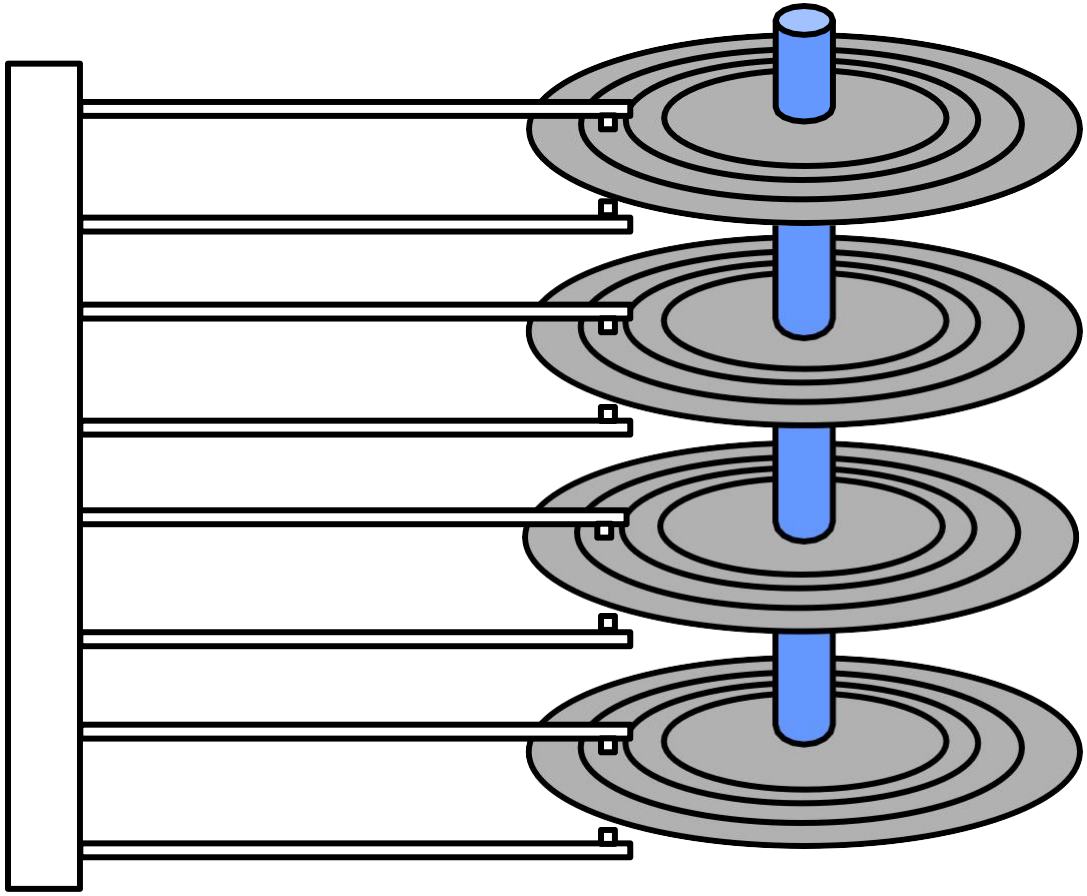


- Movable head
  - One read/write head per side
  - Mounted on a movable arm



Multiple Platters

- One head per side
- Heads are joined and aligned
- Aligned tracks on each
- platter form cylinders
- Data is striped by cylinder
- reduces head movement
- increases speed (transfer rate)



Head mechanism

- Contact
  - Floppy
- Fixed gap
- Aerodynamic gap or flying head
  - Winchester

Winchester Hard Disk (1)

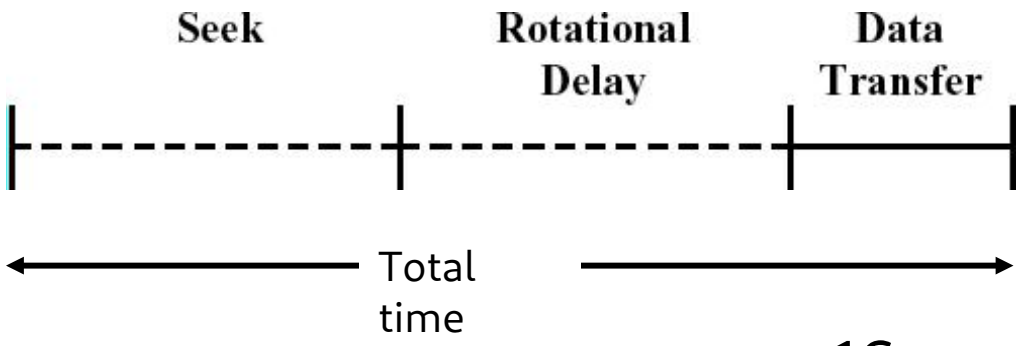
- Developed by IBM in Winchester (USA)
- Sealed unit
- One or more platters (disks)
- Heads fly on boundary layer of air as disk spins
- Very small head-to-disk gap
- Getting more robust

Winchester Hard Disk (2)

- Universal
- Cheap
- Fastest external storage
- Getting larger all the time
  - Multiple Gigabyte now usual

Speed

- Seek time
  - Moving head to the right track
- (Rotational) latency
  - Waiting for data to rotate under head
- Access time = Seek + Latency
- Transfer rate: speed of copying bytes from disk



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TRANSFER TIME The transfer time to or from the disk depends on the rotation speed of the disk in the following fashion:

$$T = \frac{b}{rN}$$

where

T = transfer time

b = number of bytes to be transferred

N = number of bytes on a track

r = rotation speed, in revolutions per second

Thus the total average access time can be expressed as

$$T_a = T_s + \frac{1}{2r} + \frac{b}{rN}$$

RAID

- Redundant Array of Independent Disks
- At least 7 different versions in common use (Not a hierarchy)
- Set of physical disks viewed as single logical drive by the operating system
- Data distributed (striped) across physical drives
- Can use redundant capacity to store parity information and provide fault tolerance

Magnetic Tape

- Only sequential access
- Slower than magnetic and optical disks
- Very very cheap
- Backup and archive

Optical Storage: CD-ROM

- Originally for audio
- 650 Mbytes giving over 70 minutes audio
- Polycarbonate coated with highly reflective coat, usually aluminum
- Data stored as pits
- Read by reflecting laser
- Audio is single speed
  - Constant linear velocity
  - 1.2 m/s
  - Track (spiral) is 5.27km long
  - Gives 4391 seconds = 73.2 minutes

Random Access on CD-ROM

- Difficult, due to constant density and single track
- Move head to rough position
- Set correct speed
- Read address
- Adjust to required location

CD-ROM Pros and Cons

- Large capacity
- Easy to mass produce
- Removable
- Robust

- Expensive for small runs
- Slower than magnetic disk
- Read only

Other Optical Storage

- CD-R (for Recordable)
  - Writable, but … Write Once Read Many (WORM)
  - Now affordable
  - Compatible with CD-ROM drives
- CD-RW (for ReWritable)
  - Erasable, hence writable many times (~1000)
  - Different technology (phase change vs pit)
  - Getting cheaper
  - Mostly, but not always, CD-ROM drive compatible

DVD - Digital Video/Versatile Disk

- Optical (CD-sized) disk with a very high capacity:
  - 4.7 GB per layer (smaller pits and closer tracks)
  - Up to 2 layers on each of the 2 sides (total 17 GB)
- Drives are CD-ROM compatible
- Also writable (DVD-R, DVD-RW), but not yet fully standardized