

# **William Stallings**

# **Computer Organization**

# **and Architecture**

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## **Chapter 6**

## **External Memory**

# Types of External Memory

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## ⌘ Magnetic Disk

- ☑ Fixed/Removable

- ☑ RAID

## ⌘ Magnetic Tape

## ⌘ Optical

- ☑ CD-ROM

- ☑ CD-R

- ☑ CD-RW

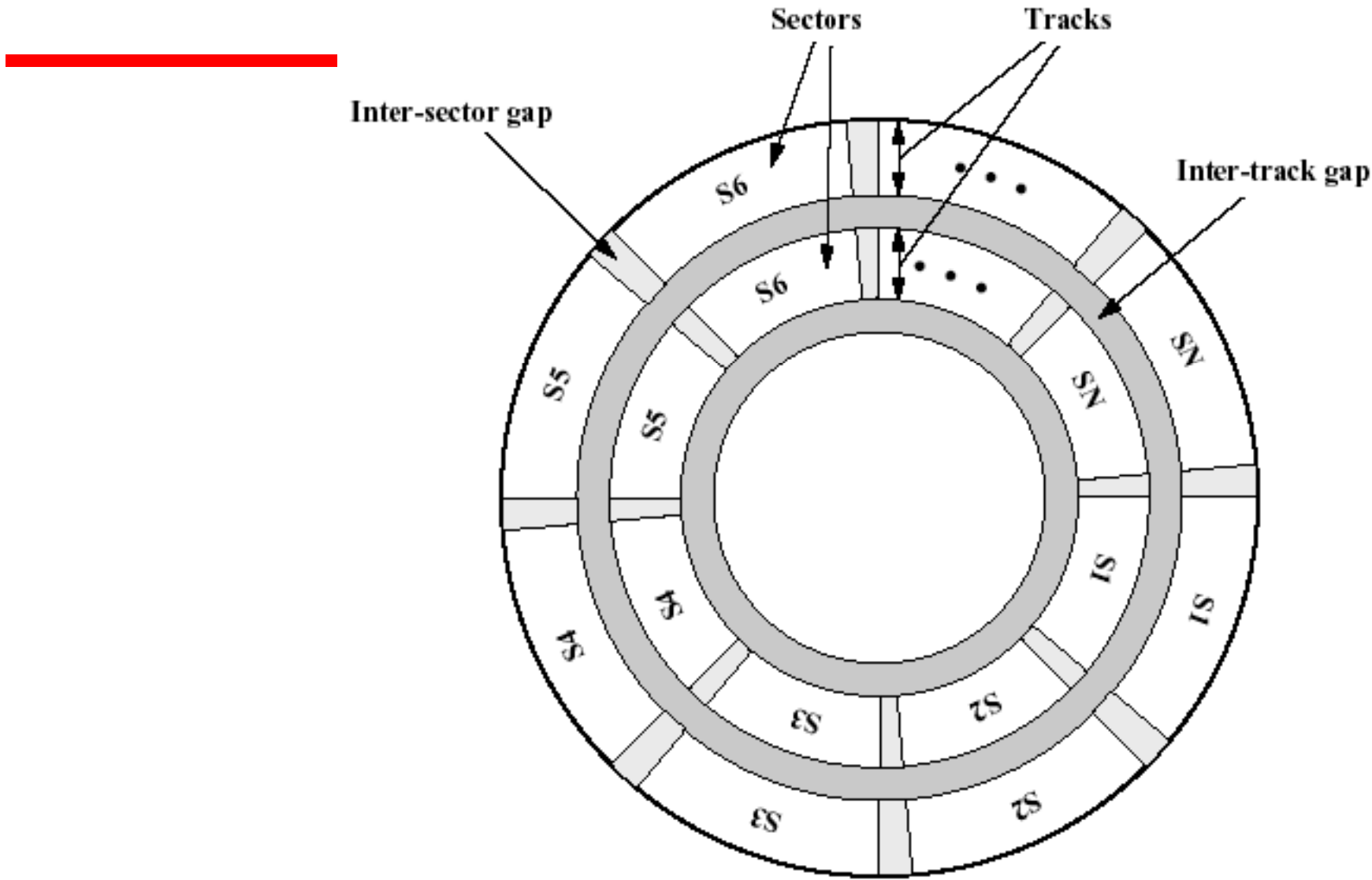
- ☑ DVD

# Magnetic Disk

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- ⌘ Metal or plastic disk coated, on one or both sides, with magnetizable material (iron oxide, i.e. rust)
- ⌘ Data read and written through a magnetic head (coil) by means of induction
- ⌘ Range of packaging
  - ☑ Floppy
  - ☑ "Winchester" hard disk
  - ☑ Removable hard disk

# Disk Data Layout



# Data Organization and Formatting

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## ⌘ Concentric rings or tracks

- ☒ Gaps between tracks
- ☒ Reduce gap to increase capacity
- ☒ Same number of bits per track (variable density)
- ☒ Constant angular velocity

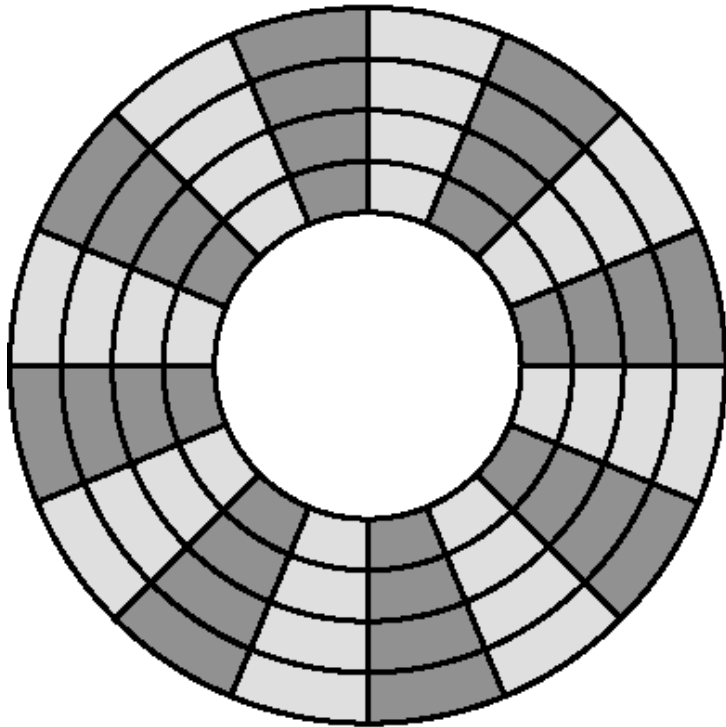
## ⌘ Tracks divided into sectors

## ⌘ Data read/written in blocks

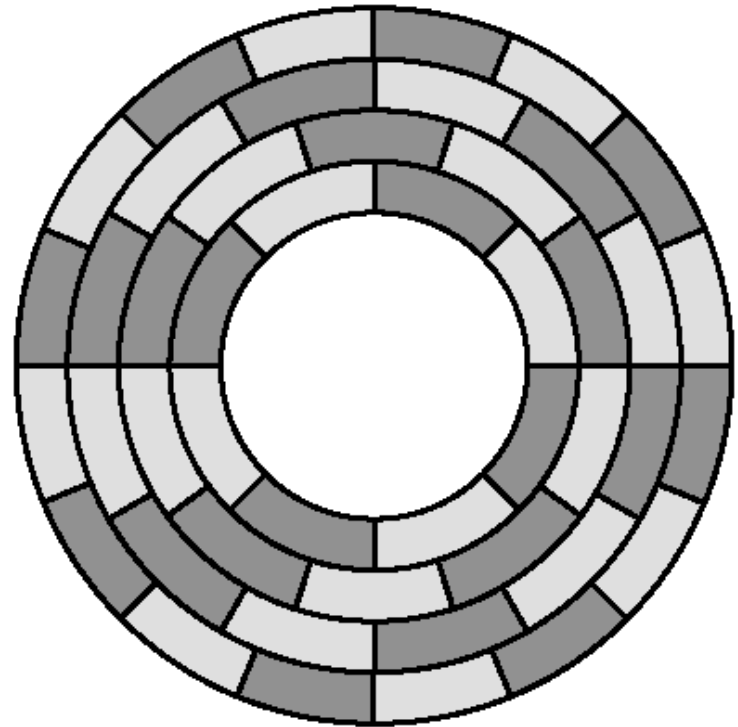
- ☒ Minimum block size is one sector
- ☒ May have more than one sector per block

# Comparison of variable/fixed density

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(a) Constant angular velocity



(b) Constant linear velocity

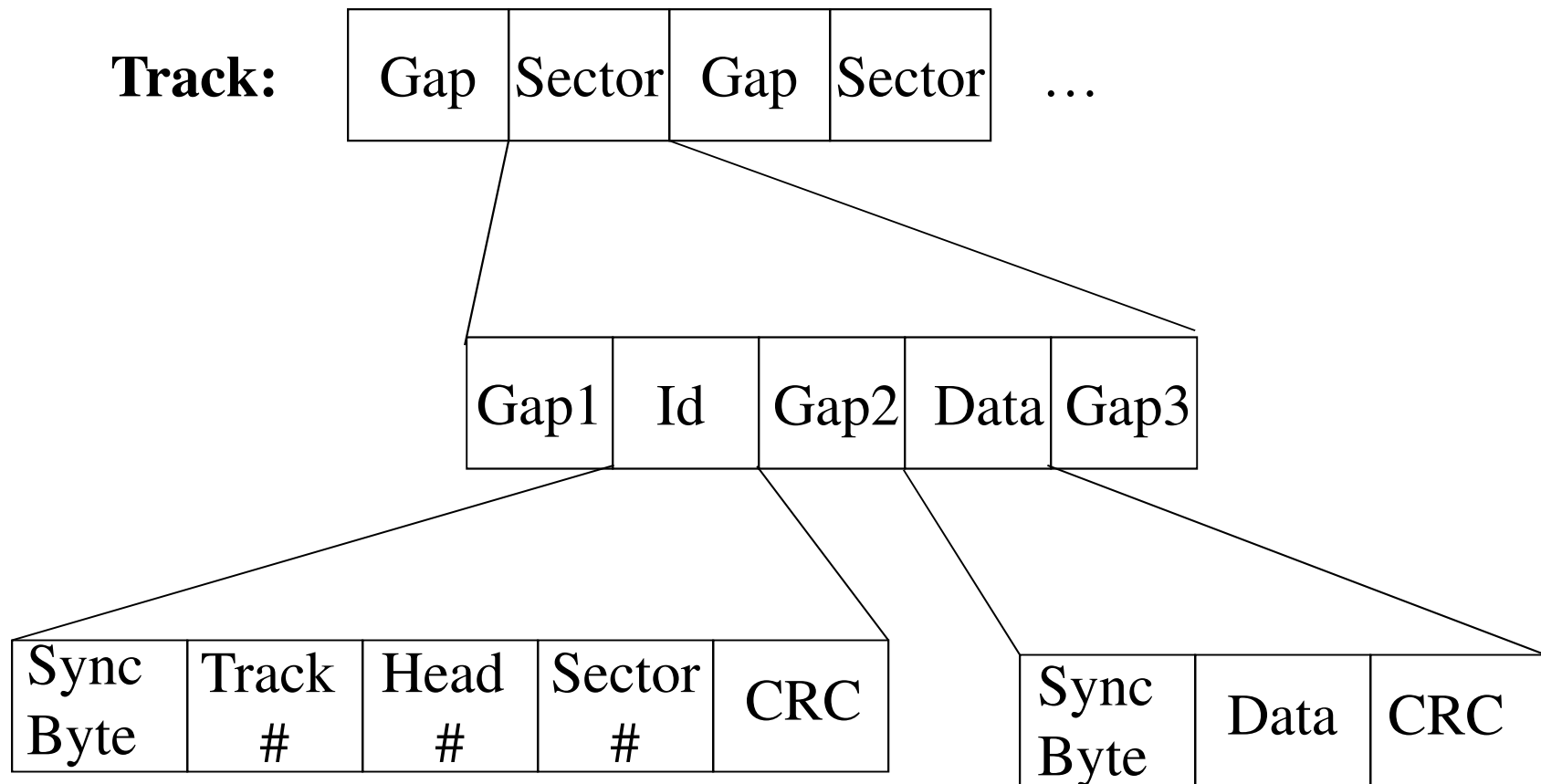
# Finding Sectors

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- ⌘ 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

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# Characteristics of magnetic disks

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- ⌘ Removable or fixed
- ⌘ Fixed or movable head
- ⌘ Single or double (usually) sided
- ⌘ Single or multiple platter
- ⌘ Speed
- ⌘ Head mechanism
  - ☒ Contact (Floppy)
  - ☒ Fixed gap
  - ☒ Aerodynamic gap or flying head (Winchester)

# Removable or Not

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## ⌘ 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

# Removable Hard Disk

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## ⌘ Old technology

### ⊞ ZIP

- ⊞ Cheap
- ⊞ Very common
- ⊞ Only 100M

### ⊞ JAZ

- ⊞ Not cheap
- ⊞ 1G

## ⌘ Now

### ⊞ USB Keys

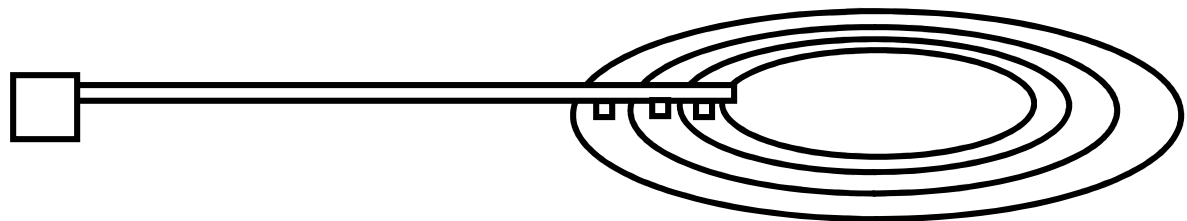
- ⊞ up to 4GB

# Fixed/Movable Head Disk

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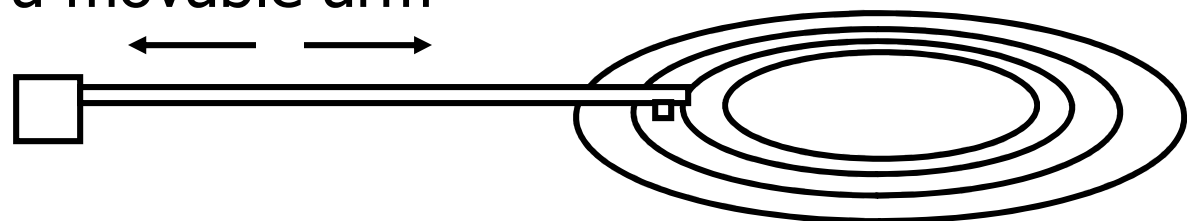
## ⌘ Fixed head

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



## ⌘ Movable head

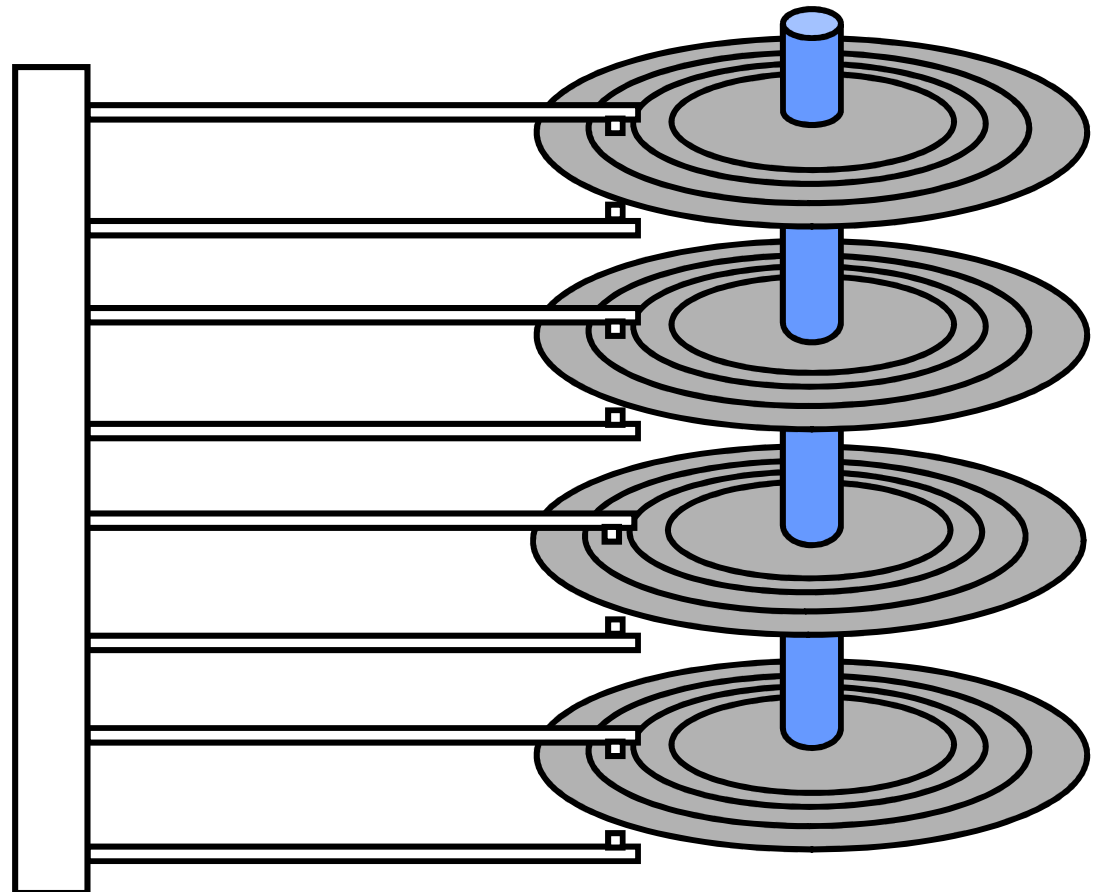
- ☑ One read/write head per side
- ☑ Mounted on a movable arm



# Multiple Platters

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- ⌘ 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

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⌘ Contact

☑ Floppy

⌘ Fixed gap

⌘ Aerodynamic gap or flying head

☑ Winchester

# Speed

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## ⌘ Seek time

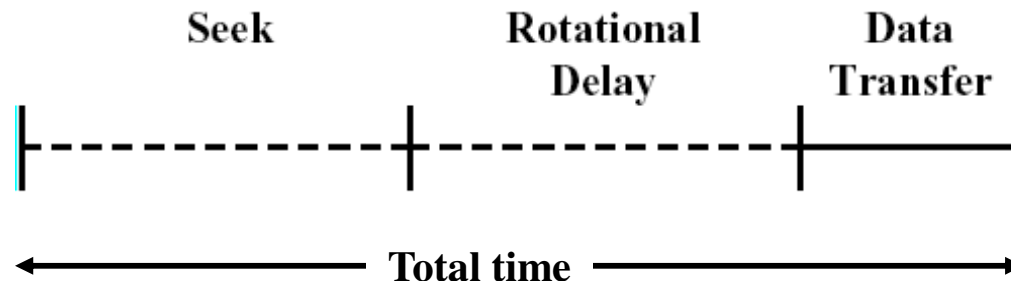
☑ Moving head to the right track

## ⌘ (Rotational) latency

☑ Waiting for data to rotate under head

⌘ Access time = Seek + Latency

⌘ Transfer rate: speed of copying bytes from disk



# Floppy Disk

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- ⌘ 8" (very old), 5.25" (old), 3.5"
- ⌘ Small capacity
  - ☒ Up to 1.44Mbyte (2.88M never popular)
- ⌘ Slow
- ⌘ Universal
- ⌘ Very cheap



# Winchester Hard Disk (1)

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- ⌘ 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)

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

# RAID

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- ⌘ Redundant Array of **Independent** Disks, originally Redundant Array of **Inexpensive** 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 tolerants
- ⌘ Used in servers

# Magnetic Tape

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

# Digital Audio Tape (DAT)

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- ⌘ Uses rotating head (like video)
- ⌘ High capacity on small tape
  - ☒ 4 Gbyte uncompressed
  - ☒ 8 Gbyte compressed
- ⌘ Backup of PC/network servers

# Optical Storage: CD-ROM

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- ⌘ 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
- ⌘ Constant packing density
- ⌘ Constant linear velocity

# CD-ROM Drive Speeds

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⌘ Audio is single speed

- ☑ Constant linear velocity

- ☑ 1.2 m/s

- ☑ Track (spiral) is 5.27km long

- ☑ Gives 4391 seconds = 73.2 minutes

⌘ Other speeds are quoted as multiples, e.g. 24x

⌘ The quoted figure is the maximum the drive can achieve

# Random Access on CD-ROM

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



# CD-ROM for & against

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- ⌘ Large capacity
- ⌘ Easy to mass produce
- ⌘ Removable
- ⌘ Robust
  
- ⌘ Expensive for small runs
- ⌘ Slower than magnetic disk
- ⌘ Read only

# Other Optical Storage

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## ⌘ 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

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- ⌘ 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)
- ⌘ Full length movie on single disk
  - ☒ Using MPEG-2 compression
- ⌘ Drives are CD-ROM compatible
- ⌘ Also writable (DVD-R, DVD-RW), but not yet fully standardized

# HD-ROM – Blue Ray?

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- ⌘ High-Density ROM
- ⌘ Very narrow laser beam (50 nm vs 350 for DVD and 800 for CD)
- ⌘ Capable to store up to 165 GB on a CD-sized disk