ANDIJAN STATE PEDAGOGICAL INSTITUTE

Lecture materials · 2026–2027 academic year

SUBJECT

Information Systems and Digital Technologies

Lecture 9 · Data Storage

2 hours

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LECTURE 09 · 2 HOURS

FUNDAMENTALS OF COMPUTERS · CHAPTER 3, PART 2

Data Storage

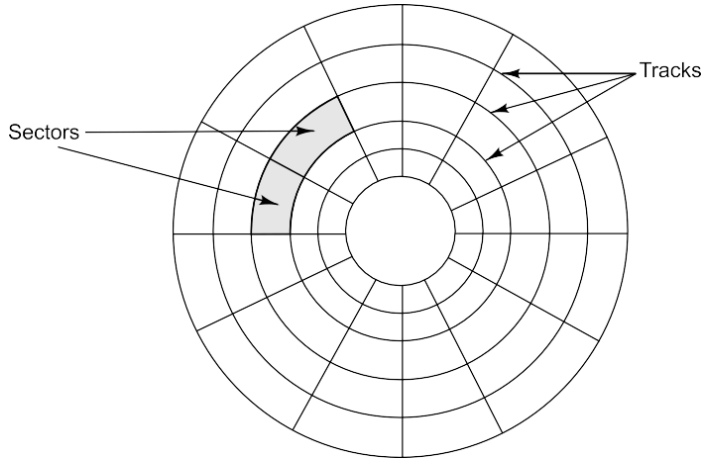
Keeping data safe for later: tapes, disks, lasers and chips

Magnetic

Optical

Magneto-optical

Solid state



Tracks and sectors on a magnetic disk — textbook Fig. 3.9

Continues from Part 1: Memory (RAM & ROM)

Why can a CD skip to song 3, but a cassette can’t?



Cassette tape

`song 1 → song 2 → song 3`



CD

`jump → song 3`



Think – Pair – Share (2 min)

1. Answer the question in the title.
2. List every place you saved a file this week.
3. Which lasts longest: a USB stick, a CD or a hard disk?

By the end of this lesson, you can…

1. **Classify** storage systems as magnetic, optical, magneto-optical or solid-state.
2. **Describe** how data is laid out on magnetic tape (BOT, IBG, EOT) and disks (tracks, sectors).
3. **Compare** read-only, write-once (WORM) and rewritable optical disks.
4. **Explain** how magneto-optical systems record data using the Curie temperature.
5. **Evaluate** a storage device by access mode, access time, capacity, storage type and cost.
6. **Label** the parts of a hard disk drive and explain how it reads and writes data.
7. **Compare** HDDs and SSDs on speed, cost, capacity and durability.

Storage systems keep data for the future

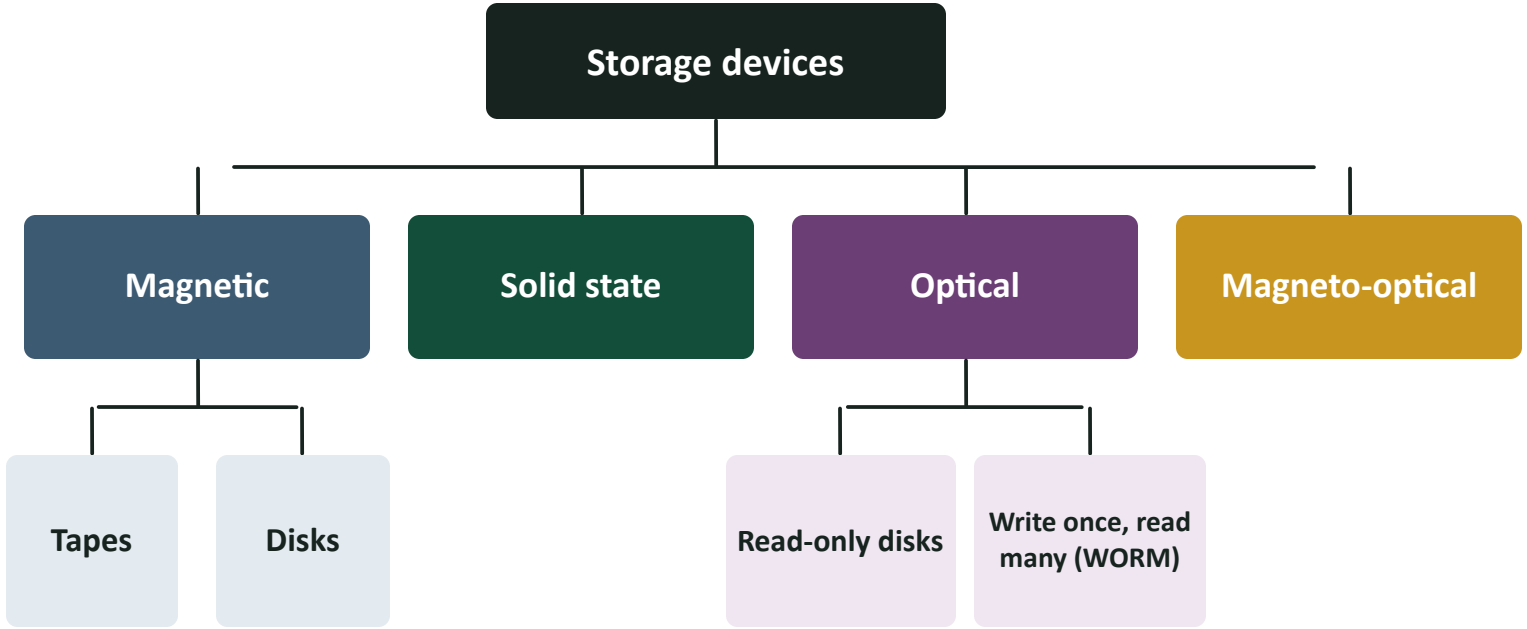
Stores data permanently

Holds any type: text, images, video

Use it at any time

Capacity varies — e.g. a CD holds 700 MB

This is the secondary memory from Part 1.



Redrawn from textbook Fig. 3.7

Magnetic storage: data in magnetised particles

- Stores data on a magnetised medium
- Non-volatile — keeps data with power off
- Any data: text, audio, video, images

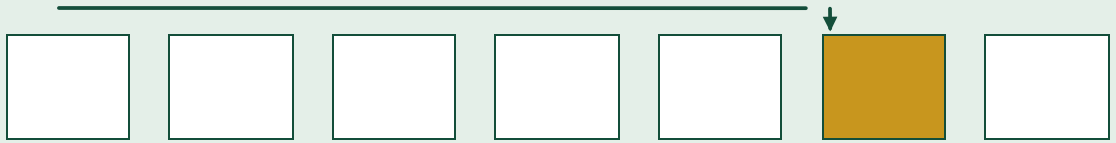
Examples: magnetic tapes, magnetic disks, hard disks, floppy disks

SEQUENTIAL ACCESS — magnetic tape



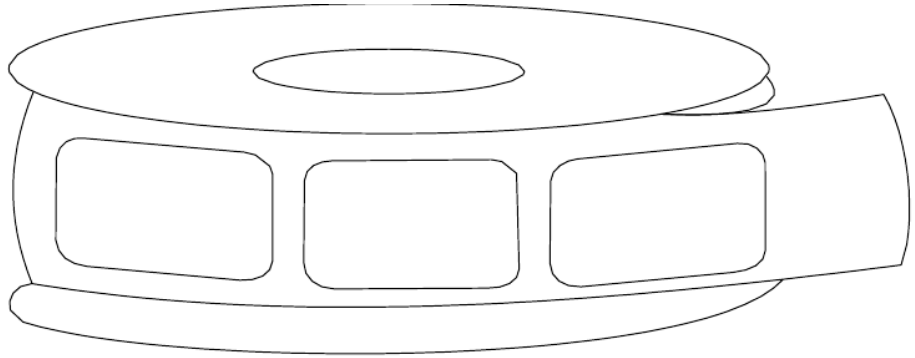
Far data = longer wait: go past everything before it.

RANDOM ACCESS — magnetic disk



Go straight to the data: less access time.

Magnetic tape: cheap, big and in order



Magnetic tape — textbook Fig. 3.8

½ or ¼ inch wide

600–3,000 ft long, on a reel or cartridge

7 or 9 tracks on ½-inch tape

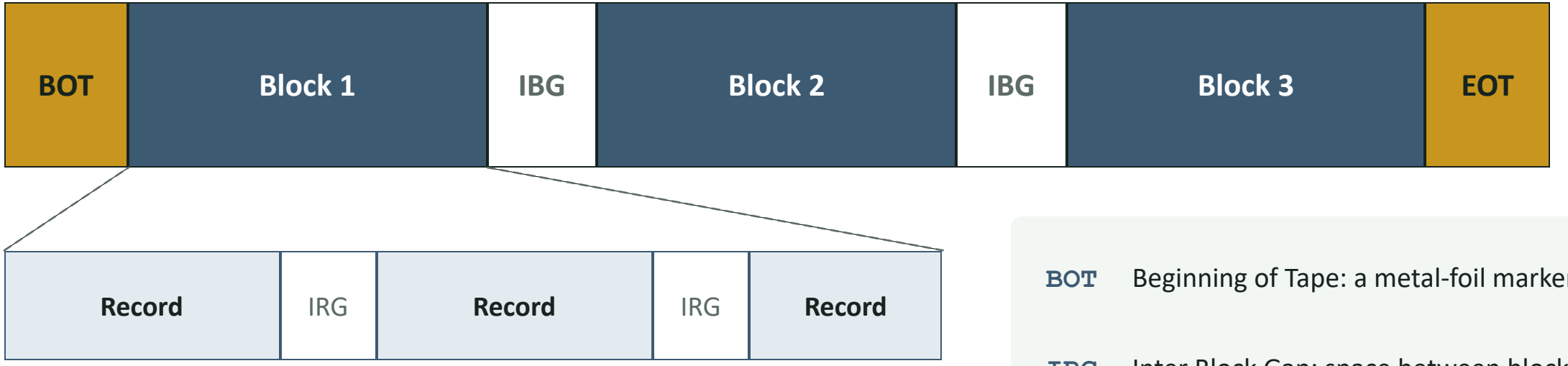
Plastic tape with a magnetic coating — like an audio cassette.

Sequential access only: to reach song 3 you pass songs 1 and 2.

Best for backups: lots of data, when speed is not important.

Magnetised spot = 1, non-magnetised = 0.

How data is written along a tape



Inside one block

Records → a file. After writing, the tape is rewound, ready for reading.

BOT	Beginning of Tape: a metal-foil marker
IBG	Inter Block Gap: space between blocks
IRG	Inter Record Gap: space between records
EOT	End of Tape marker

CHECK FOR UNDERSTANDING

Tape detective

FILL IN	The metal-foil marker at the start of a tape is the ____.
FILL IN	The gap between two blocks is called the ____.
TRUE / FALSE	You can jump straight to the 3rd record on a tape.
TRUE / FALSE	Magnetic tape is a good choice for backups.
PREDICT	A tape holds 10,000 records. Which one takes longest to reach — the 5th or the 9,000th? Why?

Magnetic disk: jump straight to the data

A flat disk covered with magnetic coating.

Tiny magnetised "needles": one direction = 1, opposite = 0.

Random access — and data can be erased and re-recorded many times.

Cheaper than RAM, but slower than main memory.

Two popular types

Hard disk

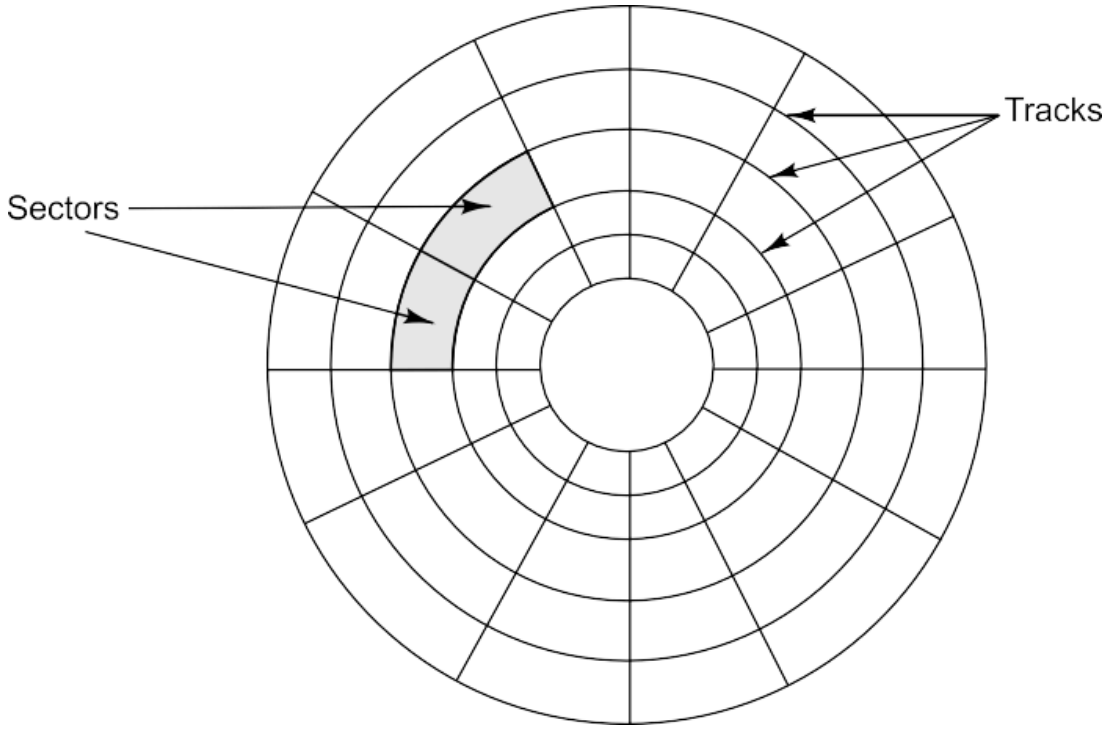
Also called a fixed disk. Holds a large volume of data; used with large computers.

Floppy disk

Removable, flexible "diskette". Less capacity; used with personal computers.

`OPTIONAL MODERN NOTE` Floppy disks are no longer used — their shape lives on as the "Save" icon. Hard disks are still common.

Tracks, sectors and spots



Magnetic disk surface — textbook Fig. 3.9

Track

A concentric circle on the disk — a circle within a circle — holding a block of data.

Sector

A broken-up unit of a track. One sector = 512 bytes.

Spot

A tiny dot on a track where data is stored.

More capacity: tracks closer together and smaller spots.

Inside a hard disk drive (HDD)

01

Platters

Aluminium or glass disks coated with magnetic material, stacked on one spindle.

02

Spindle and motor

Spin the platters at 5 400 or 7 200 rotations per minute.

03

Read/write heads

One per surface; they fly a few nanometres above the platter.

04

Actuator arm

Moves all the heads together across the platters.

05

Tracks, sectors, cylinders

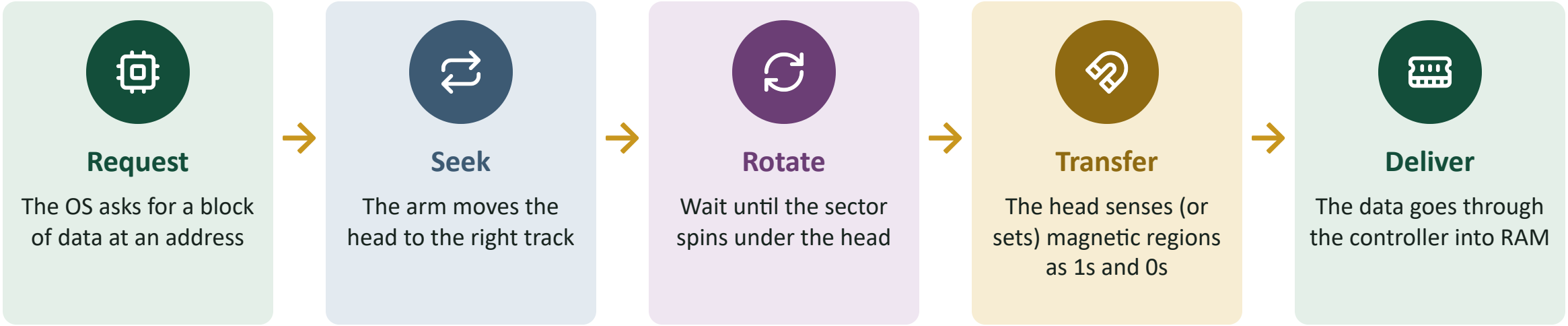
A cylinder is the same track on every platter surface.

06

Controller and cache

A circuit board manages the drive and connects it (e.g. SATA).

How an HDD reads and writes data



Bits as magnetism

Each tiny region is magnetised one way (1) or the other (0).

The data stays when the power is off.

Access time

Access time = seek time + rotational latency + transfer time

Usually several milliseconds — slow compared with RAM.

CHECK FOR UNDERSTANDING

Inside the drive

A	The part that moves the heads across the platters.
B	The same track on every platter surface.
C	The time spent waiting for the sector to spin under the head.
D	The time spent moving the head to the right track.
E	Why it is dangerous to drop a running hard disk.
F	How an HDD stores a 1 or a 0.

Key words

- actuator arm
- cylinder
- rotational latency
- seek time
- head crash
- magnetised regions

Magnetic tape vs magnetic disk

	Magnetic tape	Magnetic disk
Access	Sequential only	Easy, direct (random) access
Speed	Low data transmission speed	Better transfer rate than tape
Cost	Low cost	More than tape; less than RAM
Updating	Insertion or deletion is difficult	Erase and re-record many times
Care needed	Protected storage; wears out fast	Dust-free environment
Watch out	Not suitable for random access	Online: risk of corruption and theft
Good for	Large backups; easy to carry and store	Programs and files; high capacity

CHECK FOR UNDERSTANDING

Tape or disk?

A bank copies 20 years of records for backup. Speed does not matter.

A program must open any file instantly, in any order.

Files are edited and saved again many times a day.

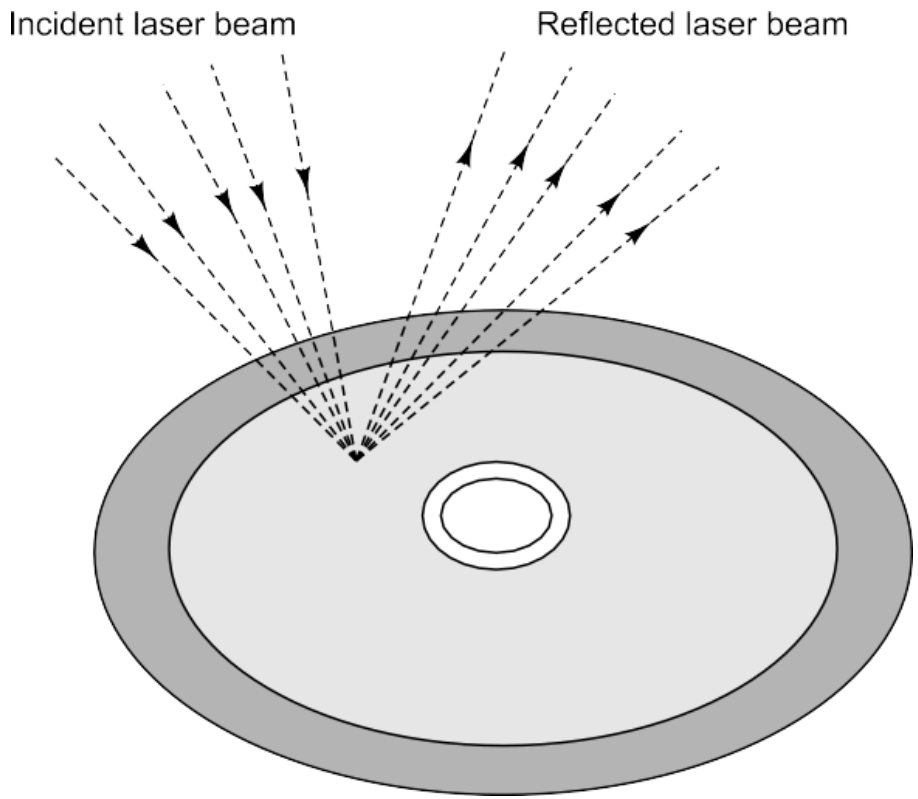
You need the lowest possible cost for a huge amount of data.

Quick maths

`1 sector = ? bytes`

How many sectors for a 2 KB file?

Optical storage: reading with laser light



Laser light on an optical disk — textbook Fig. 3.10

- Uses laser light — not magnetism — to record and read data.
- Non-volatile, like other storage.
- More reliable than magnetic storage: less prone to mechanical damage.
- Either read-only or writable — not fully read/write like magnetic disks.

DVDs hold much more than CDs.

Can you write on it? Three kinds of optical disk

Read-only

Data is already on it. You can only read.

- `CD-ROM`
- `DVD`

Writable (once)

You can write data once, then read it many times.

- `CD-R`
- `DVD-R`

Rewritable

You can write data many times.

- `CD-RW`
- `DVD-RW`

Names: CD = Compact Disc · DVD = Digital Video Disc · R = Recordable · RW = Rewritable · ROM = Read Only Memory

OPTIONAL MODERN NOTE The textbook's list writes "CD-WR" and "DVD-WR"; the standard names are CD-RW and DVD-RW.

Read-only disks vs WORM disks



Read-only optical disk

- Data burnt in from a master disk by the manufacturer
- Stores audio, video and text permanently
- Random access; about 700 MB
- Users read it with a disk drive



WORM disk (Write Once, Read Many)

- Starts empty — also called a blank disk
- Write once with a CD writer + burning software
- Read as many times as you like
- For long-term backup; much cheaper than read-only disks

What makes an optical disk good or bad?

THREE KEY PROPERTIES

Storage capacity

depends on spot size and the disk's dimensions

Data transfer rate

depends on linear density and drive rotation speed

Access time

depends on head weight and disk rotation speed

+ Advantages

- Large capacity
- Longer life than magnetic disks
- Low cost per bit
- Easy to carry and store

– Disadvantages

- Slower access than magnetic disks
- More complicated drive mechanism

CHECK FOR UNDERSTANDING

Sort the disks

CD-ROM

DVD-R

CD-RW

CD-R

DVD-RW

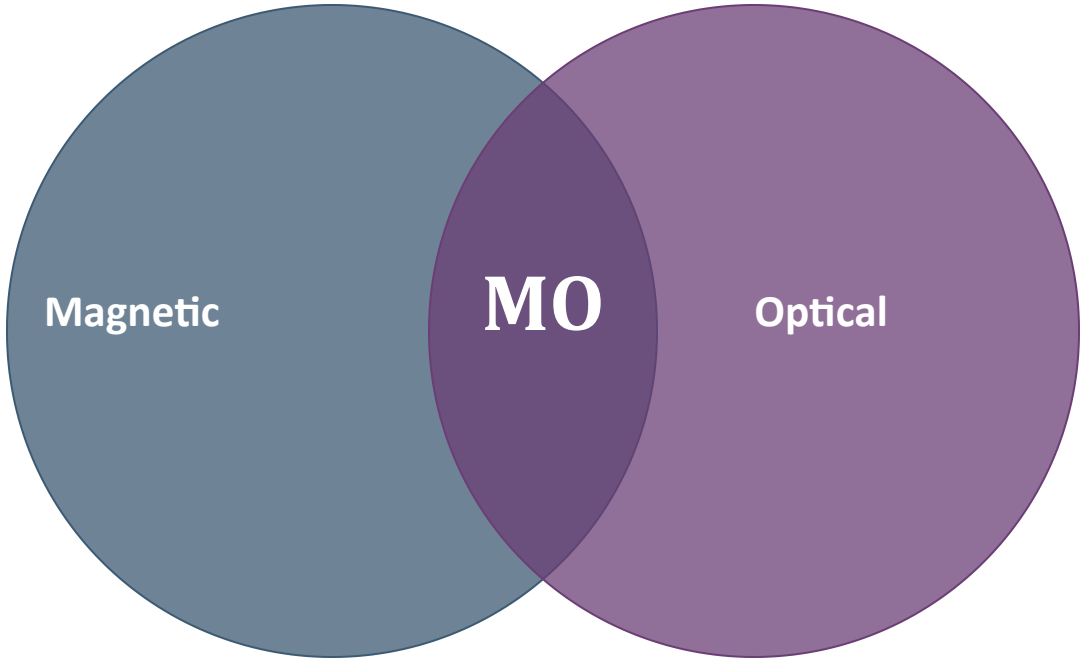
Movie DVD bought in a shop

Read-only	Write once	Rewritable

True or false?

1. Optical disks use magnetism to read data.
2. A WORM disk is also called a blank disk.
3. Optical disks are faster to access than magnetic disks.

Magneto-optical (MO): magnetic + optical



Available as 3.5-inch and 5.5-inch (textbook) disks

- Goal: store PC data for a long period of time.
- Reads and writes using laser and optical technologies.
- Ferromagnetic material inside a plastic coating; the laser reflects off the magnetic surface.
- Not popular: slower, and costlier to make than other storage.

OPTIONAL MODERN NOTE Standard MO sizes were 3.5-inch and 5.25-inch.

How MO records data: the Curie temperature

1. Heat

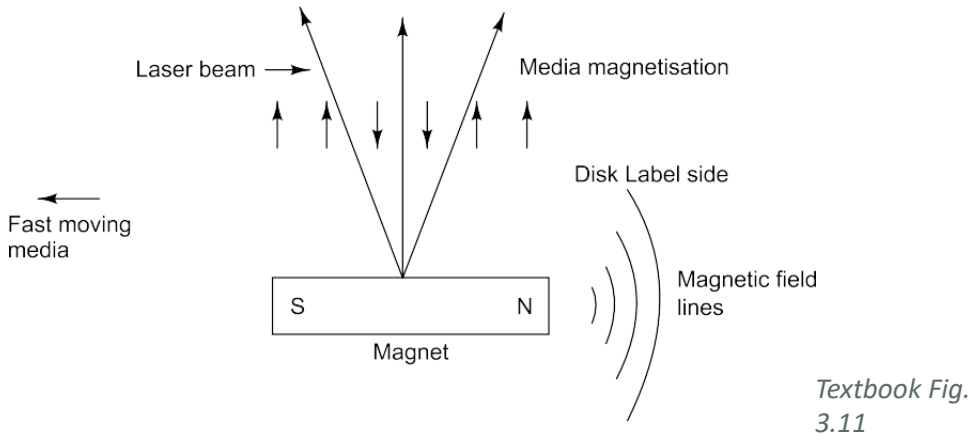
The spot reaches its Curie temperature (about 200 °C).

2. Record

Coercivity drops, so a magnetic field can record the data.

3. Cool & keep

Back at room temperature, coercivity rises and the data is preserved.

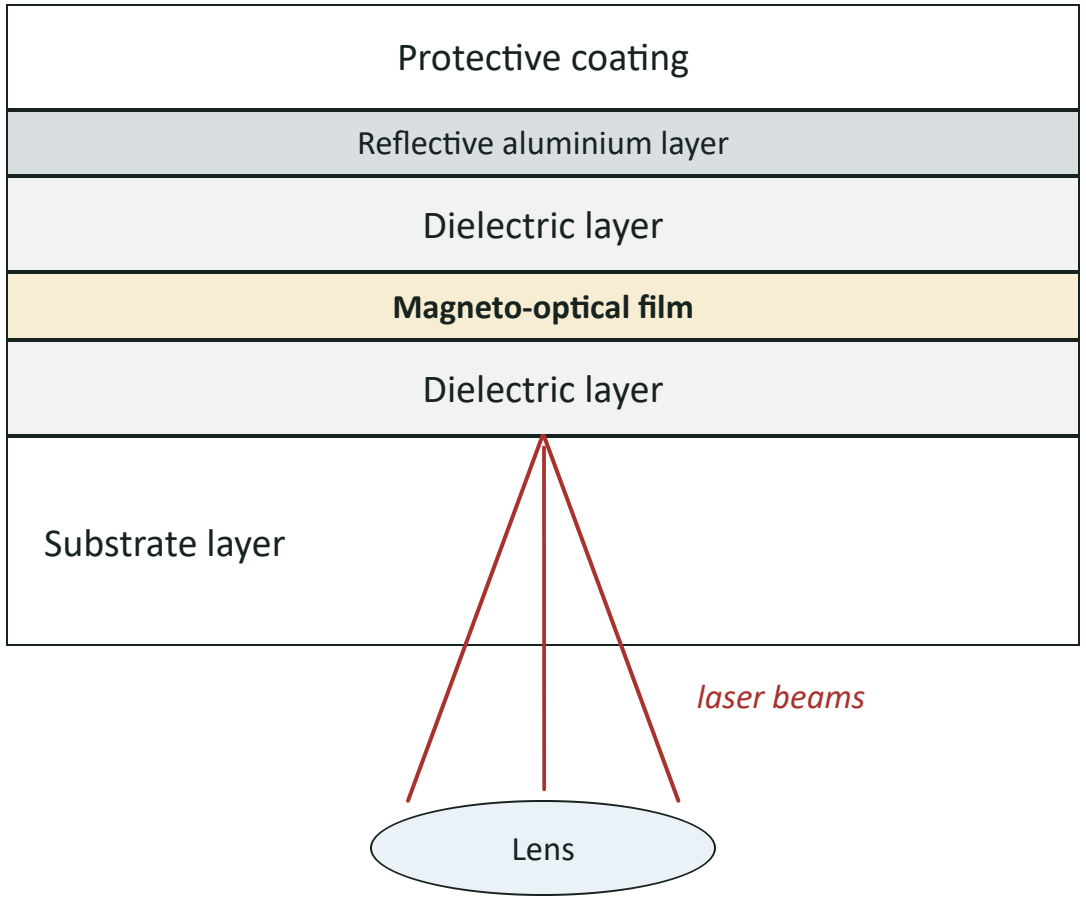


Textbook Fig. 3.11

Curie temperature: where a material loses its magnetic properties.

Coercivity: a material's resistance to being magnetised.

Inside an MO disk: layers



Redrawn from textbook Fig. 3.12

Anti-reflection layers

increase light absorption

Quadrilayers

decrease reflection, so less laser light is needed

Amorphous metal

is the MO media that stores the data

Solid-state storage (SSD): no moving parts

- Uses semiconductor chips — no magnetic or optical medium.
- No mechanical parts, so access is faster than any other storage.
- Examples: flash memory cards, USB devices.
- Used in laptops and critical defence applications.

Capacity is lower than a hard disk (textbook).

SSD TIMELINE (TEXTBOOK)



1978 — First SSDs, developed by StorageTek

1983 — Sharp-5000 laptop uses a 128 KB SSD

1995 — M-Systems builds a flash-based SSD

Two ways to build an SSD

Flash-memory-based SSD

- Built on NAND flash memory
- Slower than DRAM
- Non-volatile

DRAM-based SSD

- Built on DRAM
- Faster than hard drives and flash
- Battery + backup storage save the RAM data if power is lost
- Also works as buffer memory

Remember DRAM and NAND flash from Part 1? Here they are again.

SSD: strengths and weaknesses

+ Advantages

- Better performance: fast random access, no spin-up
- Low power and heat (except DRAM-based)
- High reliability: constant seek time, no moving parts
- Small and light, easy to carry
- Small form factor for ultra-mobile PCs

– Disadvantages

- High price (about 32× a hard disk, but falling)
- Lower capacity than hard disks
- Slower writing (flash-based)
- Low storage density
- Vulnerable to power loss, static and magnetic fields

OPTIONAL MODERN NOTE Since this textbook was written, SSD prices have fallen a lot and capacities now match many hard disks. Most new laptops use an SSD.

HDD vs SSD: head to head

FEATURE	Hard disk drive (HDD)	Solid-state drive (SSD)
How it stores data	Magnetic spinning platters	NAND flash memory chips
Moving parts	Yes — motor, platters, arm	None
Speed	About 100–250 MB/s; access in ms	About 500 MB/s (SATA) to 7 000 MB/s (NVMe)
Price per GB	Lower	Higher (but falling)
Typical capacity	1–20+ TB	256 GB – 4 TB
Durability	Sensitive to drops and shocks	Shock-resistant; limited write cycles
Noise and power	Audible; uses more power	Silent; uses less power

Choose: SSD for speed (system and programs); HDD for cheap, large storage (backups, archives).

CHECK FOR UNDERSTANDING

Hard disk or SSD?

A Has no moving parts. HDD / SSD

B Costs less for the same amount of storage (textbook). HDD / SSD

C Needs to spin up before use. HDD / SSD

D Can be damaged by electrostatic discharge. HDD / SSD

E Has higher storage density (textbook). HDD / SSD

F Has a constant seek time. HDD / SSD

Five questions before you choose a storage device



Access mode

How is data reached: random, sequential or direct?



Access time

How long does a read or write request take?



Storage capacity

How much data can it hold, in bytes?



Storage type

Temporary (volatile) or permanent (non-volatile)?



Cost

What is the cost per bit of storage?

Primary memory: faster access. Secondary memory: more capacity.

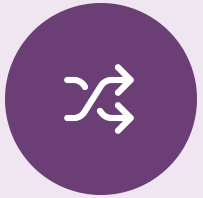
Three access modes



Sequential

Data is reached in order, one item after another.

e.g. **Cassette player; magnetic tape**



Random

Data is reached without regard to where it is stored.

e.g. **CD player; magnetic disk; RAM**



Direct

Uses both random and sequential access.

e.g. **CD player**

The textbook calls a CD player both random and direct access.

All storage families side by side

	Magnetic tape	Magnetic disk	Optical disk	Magneto-optical	Solid-state (SSD)
Records with	Magnetised coating on plastic tape	Magnetised needles on a coated disk	Laser light	Laser + magnetism (Curie temperature)	Semiconductor chips
Access & speed	Sequential; slow	Random (direct); faster than tape	Random; slower than magnetic disk	Slower than other storage	Random; the fastest
Big plus	Low cost, large capacity; backups	High capacity; erase & re-record	Long life; low cost per bit	Long-term PC storage	No moving parts; reliable
Big minus	Hard to update; wears out fast	Needs dust-free place; online risk	Complicated drive mechanism	Costly to make; not popular	High price; lower capacity
Example	Backup tape	Hard disk, floppy disk	CD-ROM, DVD-R, CD-RW	3.5-inch MO disk	USB device, flash card

Storage in the world around you



TODAY

Data-centre backup library

→ **Magnetic tape**



TEXTBOOK

Hard disk inside a desktop PC

→ **Magnetic disk**



TEXTBOOK

Film on a DVD from a shop

→ **Read-only optical disk**



TEXTBOOK

Class photos burnt onto a CD-R

→ **WORM optical disk**



TEXTBOOK

USB flash drive

→ **Solid-state device**



TODAY

Storage inside a new laptop

→ **SSD**

Review: can you answer these?

01 Name the four families of storage devices.

02 What do BOT, IBG and EOT stand for?

03 What is a track? What is a sector, and how big is it?

04 Give two advantages of magnetic tape.

05 What does optical storage use to read and record data?

06 How is a WORM disk different from a read-only disk?

07 What is the Curie temperature, and how do MO systems use it?

08 Name the five storage evaluation criteria.

Exit ticket

Answer on a slip of paper before you leave.

1. Which storage family is each? Hard disk · DVD · USB flash drive.

2. You burn your project onto a blank CD once and keep it for years. What kind of optical disk is that?

3. Give one reason to choose magnetic tape and one reason to avoid it.