Digital Circuits

ECS 371

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Lecture 25

Office Hours:
BKD 3601-7
Monday 9:00-10:30, 1:30-3:30
Tuesday 10:30-11:30

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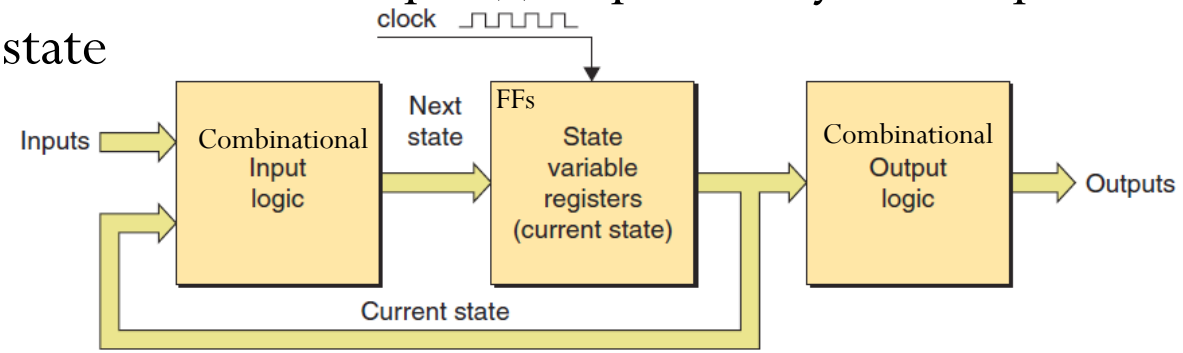
Announcement

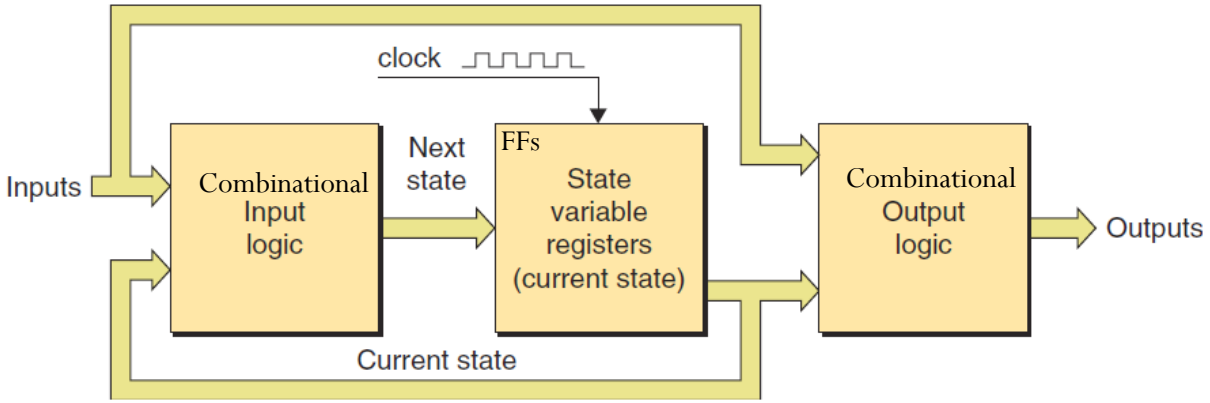
- Reading Assignment:
  - Chapter 7: 7-1, 7-2, 7-4
  - Chapter 8: 8-1, 8-2, 8-4, 8-5
  - Chapter 9: 9-1 to 9-5
  - Chapter 10: 10.1 to 10.3
- HW9 is posted.
  - Due date: Wednesday (Sep 16)

More on Sequential Circuits

- In general, sequential circuits can be classified into two types
  1. **Moore circuits**: the output(s) depend only on the present internal state

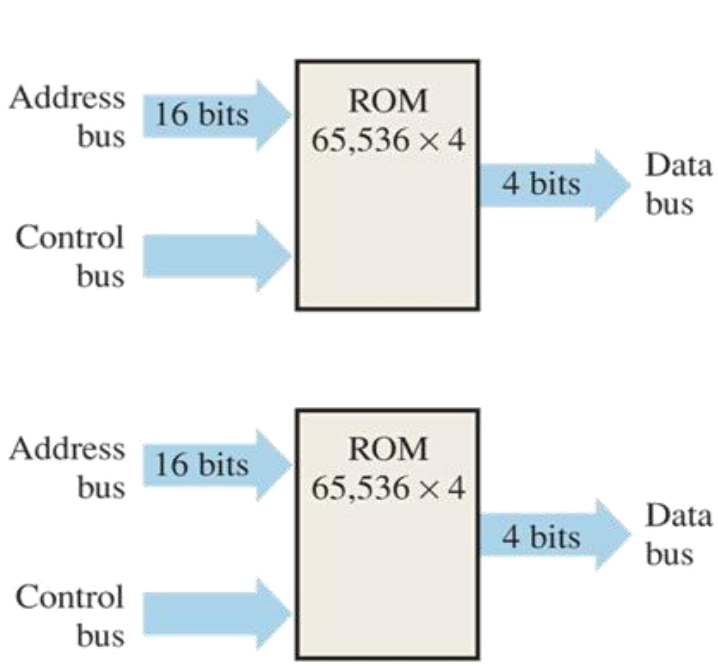


  2. **Mealy circuits**: the output(s) depend on both the present state and the input(s).

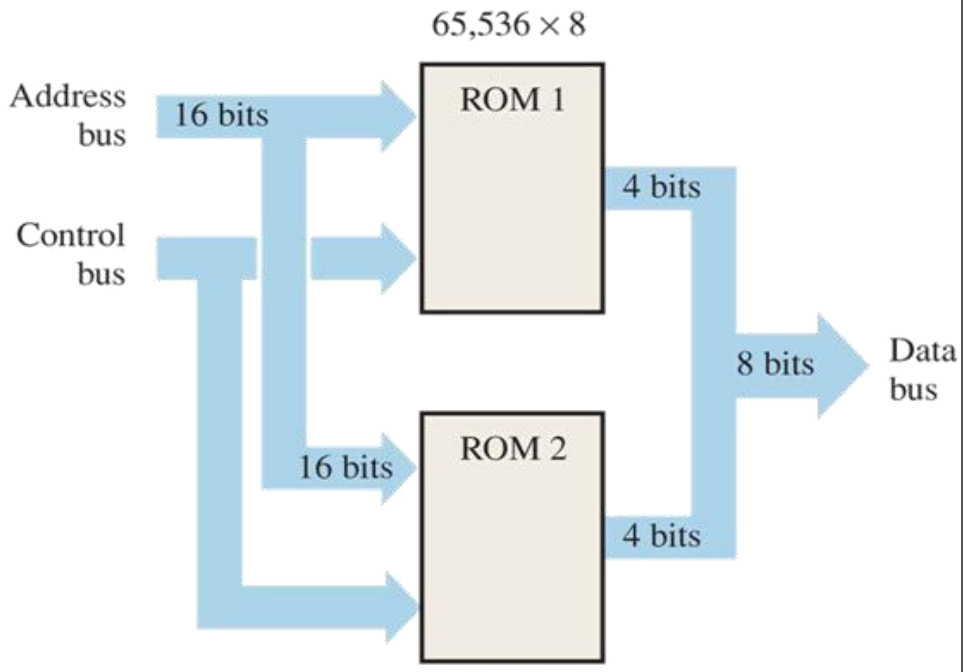


Memory Expansion: Word-Length

- Memory can be expanded in either word length or word capacity or both.
- Word-Length Expansion:
  - the #bits in the data bus is increased
  - Example: One 65536 × 8 ROM from two 65536 × 4 ROMs



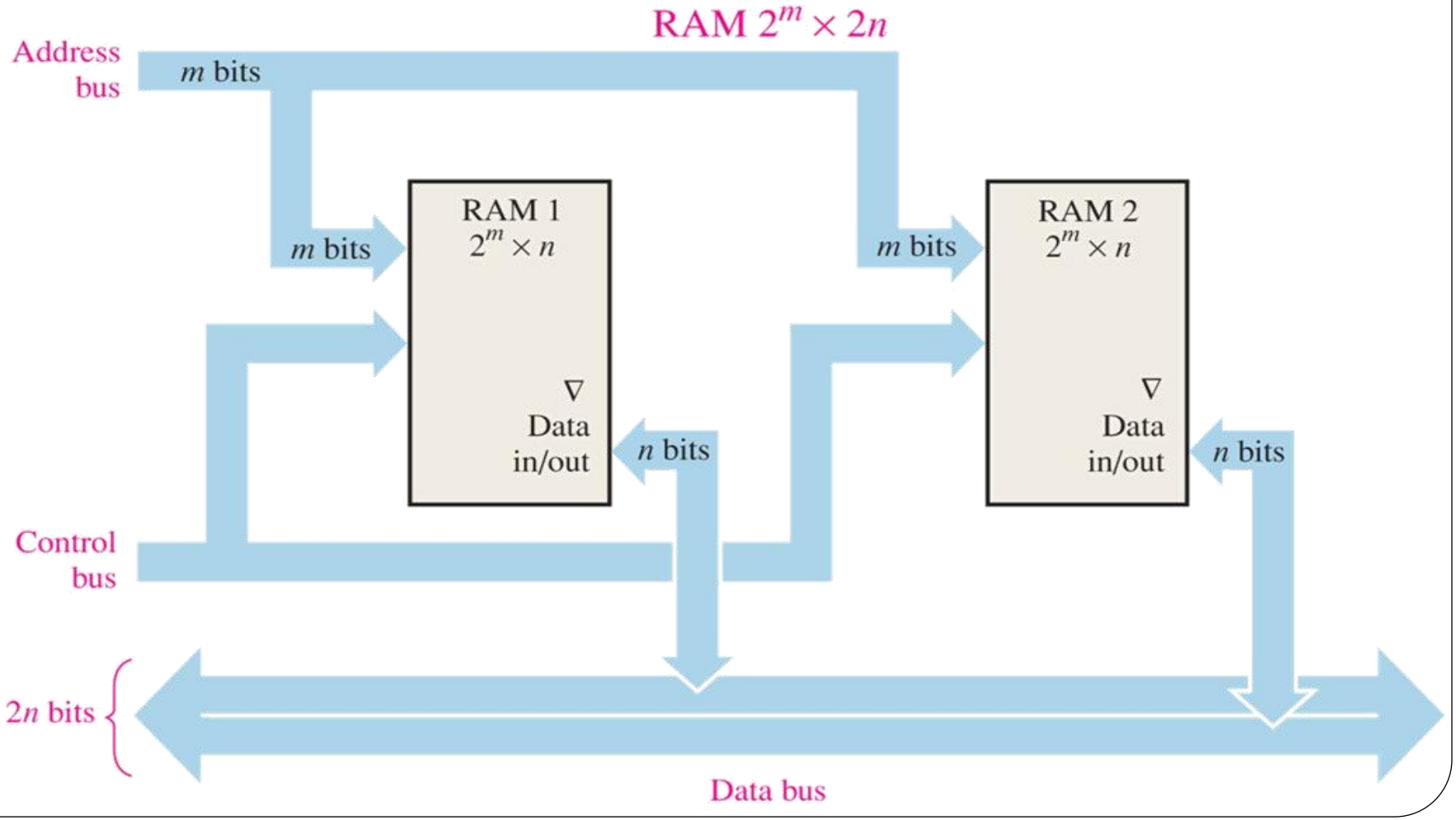
(a) Two separate 65,536 × 4 ROMs



(b) One 65,536 × 8 ROM from two 65,536 × 4 ROMs

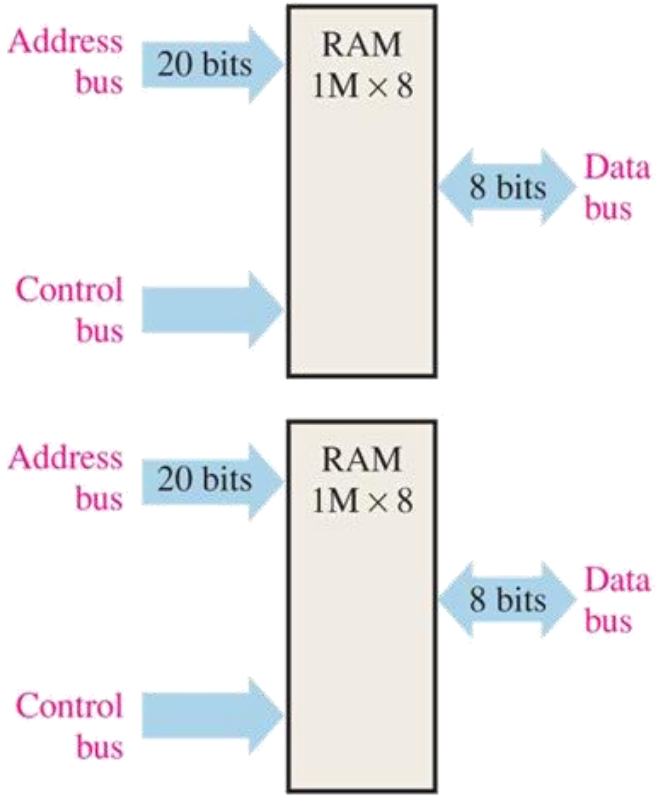
Word-Length Expansion (con't)

- Example: One $2^m \times 2n$ RAM from two $2^m \times n$ RAMs

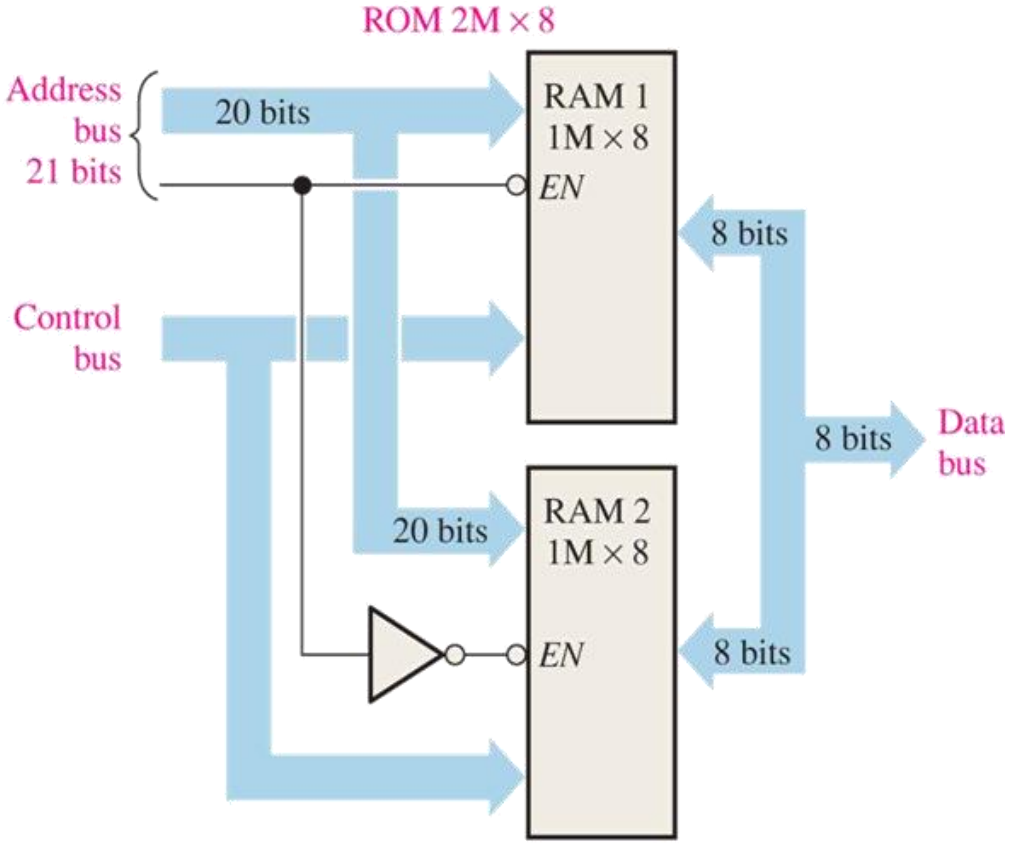


Word-Capacity Expansion

- When memories are expanded to increase the word capacity, the number of addresses is increased.



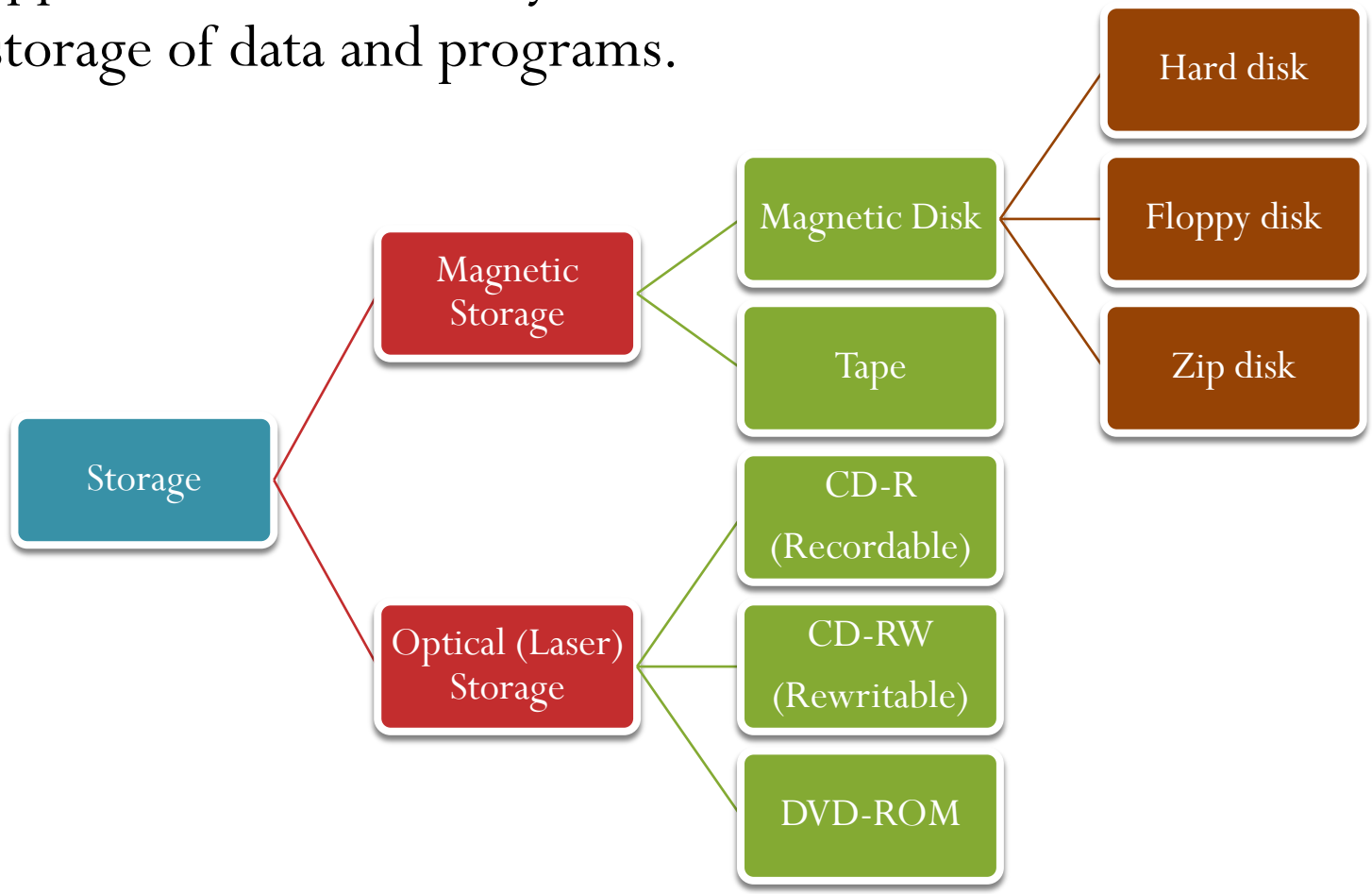
(a) Individual memories each store 1,048,576 8-bit words



(b) Memories expanded to form a 2M × 8 RAM requiring a 21-bit address bus

Storage

- Storage media are important, particularly in computer applications, where they are used for mass **nonvolatile** storage of data and programs.

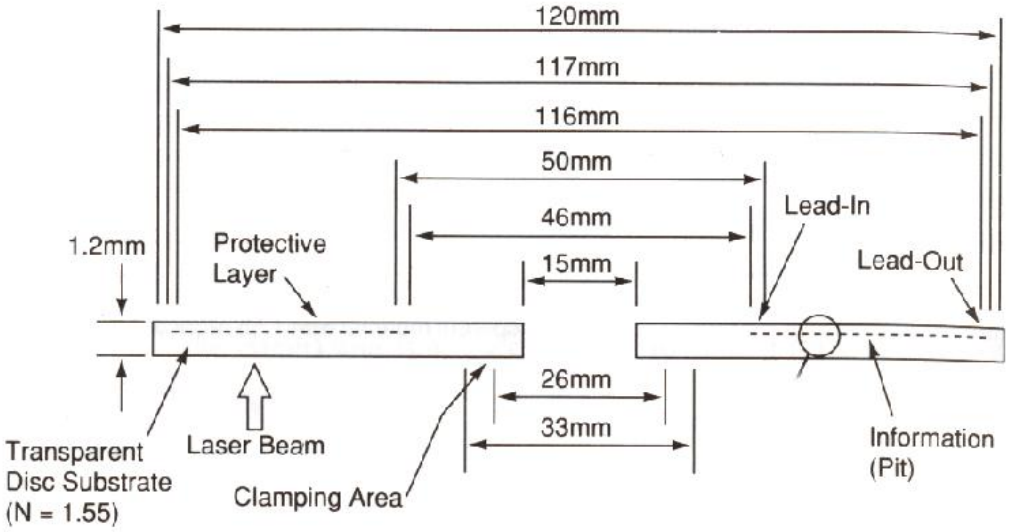


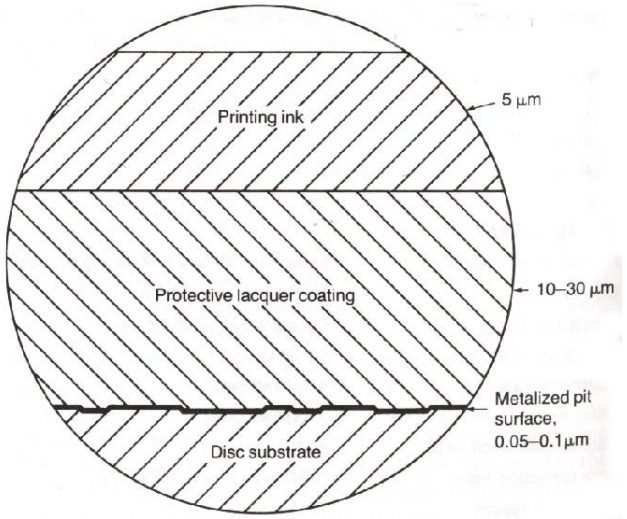
Spelling

- “Compact disc” (CD) is spelled with a “C”
- A computer hard disk is spelled with a “K”
  - Disks are usually sealed inside a metal or plastic casing (often, a disk and its enclosing mechanism are collectively known as a "hard drive").
- In modern technological contexts,
  - A disc refers to optical media, such as an audio CD, CD-ROM, DVD-ROM, DVD-RAM, or DVD-Video disc
  - A disk refers to magnetic media, such as a floppy disk, the disk in your computer's hard drive, an external hard drive.

CD

- All optical media is constructed of layers of different materials.
- The information on a CD is recorded as a series of pits (or bumps) on a polycarbonate substrate roughly 1.2 mm thick
- The pits are coated with a thin layer of Al or gold (few 100s nm thick) and then protected by a 2-30 μm shellac (lacquer) coating.
- The lacquer coating is screen printed.



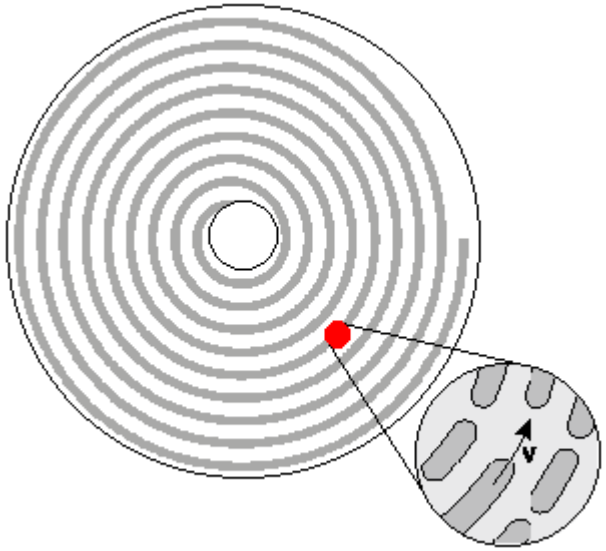


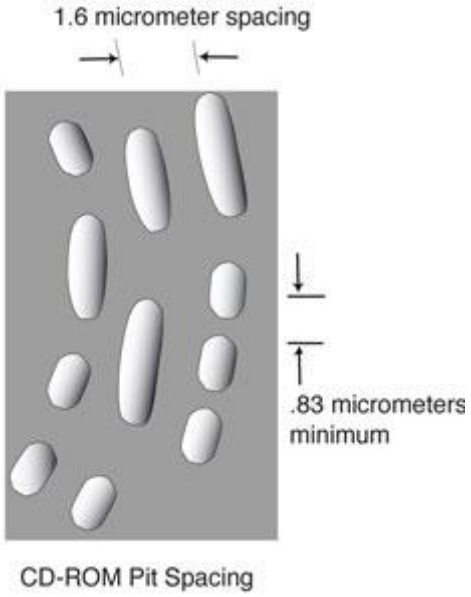
CD

- The bottom of a CD is made of a relatively thick piece of polycarbonate plastic.
  - Scratches on the polycarbonate are out of focus when the disc is read, and minor scratches are ignored completely.
  - It takes a deep scratch in the polycarbonate to affect the readability of a disc.
- The top is protected by a thin coat of lacquer.
  - Even a small scratch in the lacquer can damage the reflector.
- Scratching the top of a disc can render it unreadable, which is something to consider the next time you place a disc on your desk top-down "to protect it."

CD

- Pits are arranged as a single spiral.
  - This spiral is over 3.7 miles (or 6 km) in length on a CD, and 7.8 miles (or 12.5 km) for a DVD.
- The starting point for the spiral is towards the center of the disc with the spiral extending outward.
  - Outer area: generally more prone to manufacturing defects
  - Facilitate adoption of smaller or larger diameter discs





CD-ROM Pit Spacing

CD

- The disc is read and written from the inside out, which is the opposite of how hard drives organize data.
- With spiral organization, there are no cylinders or tracks like those on a hard drive. (The term “track” refers to a grouping of data for optical media.)
- The information along the spiral is spaced linearly, thus following a predictable timing.
  - Spiral contains more information at the outer edge of the disc than at the beginning.
  - If this information is to be read at a constant speed, the rotation of the disc must change between different points along the spiral.

CD

- Playing time: **74 minutes** and **33 seconds** max (4473 sec)
- Back-of-the-Envelope Calculation:
  - Original audio (data) bit rate

$$16\frac{\text{bit}}{\text{channel}} \times 2\frac{\text{channel}}{\text{sample}} \times 44.1\text{k}\frac{\text{samples}}{\text{sec}} = 1411200\frac{\text{bits}}{\text{sec}}$$

  - Disc Capacity

$$1.4\text{M}\frac{\text{bits}}{\text{sec}} \times 4473\frac{\text{secs}}{\text{CD}} = 6.312 \times 10^9 \frac{\text{bits}}{\text{CD}} = 789\ \text{M}\frac{\text{bytes}}{\text{CD}}$$

CD

- Little has changed in CD physics since the origin of CD audio discs in 1980.
- This is due in part to the desire to maintain physical compatibility with an established base of installed units, and because the structure of CD media was both groundbreaking and nearly ideal for this function.
- DVDs are an evolutionary growth of CD's with slight changes.
- Considering the development of DVD follows the CD by 14 years, you can see that the CD was truly a revolutionary creation in its time.

DVD

- No single company "owns" DVD. The official specification was developed by a **consortium** of ten companies
  - Hitachi, JVC, Matsushita, Mitsubishi, Philips, Pioneer, Sony, Thomson, Time Warner, and Toshiba.
- In May 1997, the DVD Consortium was replaced by the **DVD Forum**
- Q: What Does DVD Stand For?
- A: "Nothing."
  - The original meaning was **digital video disc**.
  - Some members of the DVD Forum have pointed out that DVD goes far beyond video and have offered the painfully contorted phrase **digital versatile disc** as a solution, but this has never been officially accepted by the DVD Forum.
- The DVD Forum decreed in 1999 that DVD, as an international standard, is simply three letters.

DVD

- Introduced in the U.S. in 1997
- Use the same diameter platter as a CD (120mm/4.75" diameter)
- Hold 4.7GB rather than 700MB.
- Pit length and track pitch are about half of CD's → 4x capacity
  - More efficient recording algorithms (Mathematics) → more capacity increase