



# Storage

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- Storage holds data, instructions, and information for future use.
- The operating system and applications are loaded into memory from storage.
- Storage requirements among users vary.

# Storage

- A storage medium is the physical material on which a computer keeps data, instructions, and information.
- Examples: Hard disks, solid state drives, memory cards, USB flash drives, ExpressCard modules, optical discs, smart cards, magnetic stripe cards, and microfilm.
- Cloud storage is another storage option, in which the actual storage media used is transparent to the user.

# Storage



# Storage

- Capacity is the number of bytes (characters) a storage medium can hold.
- A typical hard disk has 320 GB (320 billion bytes) of storage capacity.

## Storage Terms

Storage Term	Approximate Number of Bytes	Exact Number of Bytes
Kilobyte (KB)	1 thousand	$2^{10}$ or 1,024
Megabyte (MB)	1 million	$2^{20}$ or 1,048,576
Gigabyte (GB)	1 billion	$2^{30}$ or 1,073,741,824
Terabyte (TB)	1 trillion	$2^{40}$ or 1,099,511,627,776
Petabyte (PB)	1 quadrillion	$2^{50}$ or 1,125,899,906,842,624
Exabyte (EB)	1 quintillion	$2^{60}$ or 1,152,921,504,606,846,976
Zettabyte (ZB)	1 sextillion	$2^{70}$ or 1,180,591,620,717,411,303,424
Yottabyte (YB)	1 septillion	$2^{80}$ or 1,208,925,819,614,629,174,706,176

# Storage

- A storage device is the computer hardware that records and/or retrieves items to and from storage media.
- Writing is the process of transferring data, instructions and information from memory to a storage medium.
- Reading is the process of transferring these items from a storage medium into memory.

# Storage

- Access time measures
  - The amount of time it takes a storage device to locate an item on a storage medium, or
  - The time required to deliver an item from memory to the processor.
- The access time of storage devices is slow, compared with the access time of memory.
  - Memory: billionths of a second (nanoseconds)
  - Storage: thousandths or millionths of a second (milliseconds or microseconds)

# Hard Disks

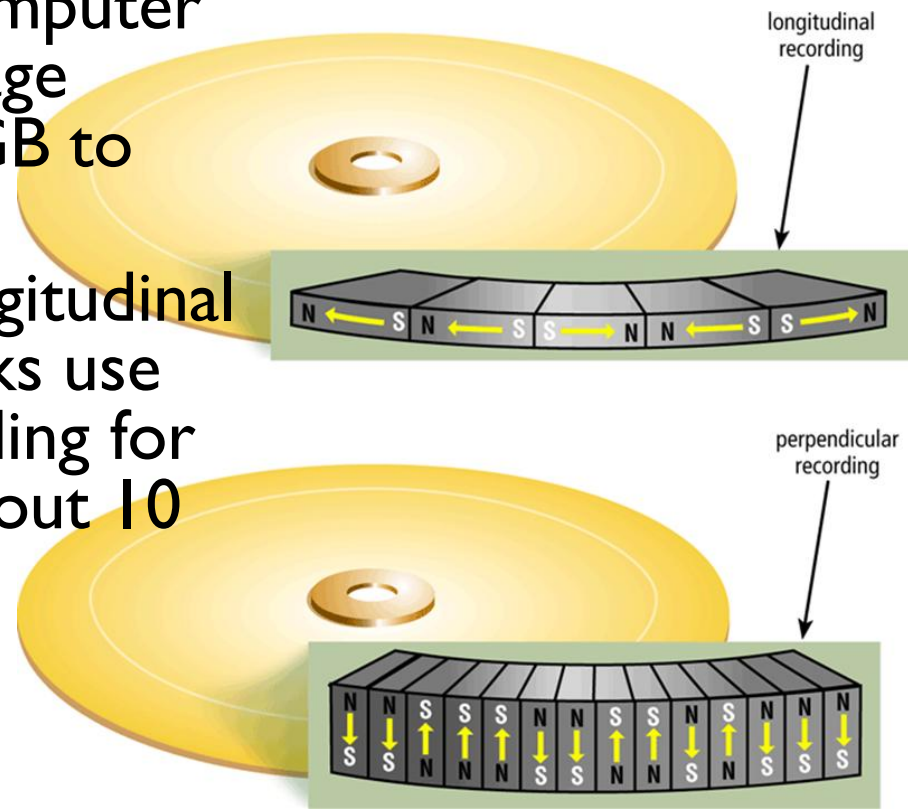
- A hard disk, also called a hard disk drive or hard drive, is a storage device that contains on or more inflexible, circular platters that use magnetic particles to store data, instructions and information.





# Hard Disks

- Depending on how the magnetic particles are aligned, they represent a 0 or 1 bit.
- Current personal computer hard disks have storage capacities from 160GB to 1.5TB.
- Older disks used longitudinal recording, newer disks use perpendicular recording for storage capacities about 10 times greater.

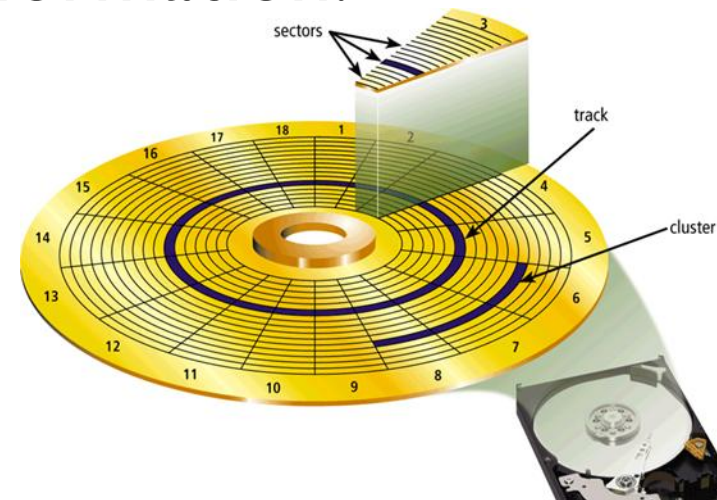


# Characteristics of a Hard Disk

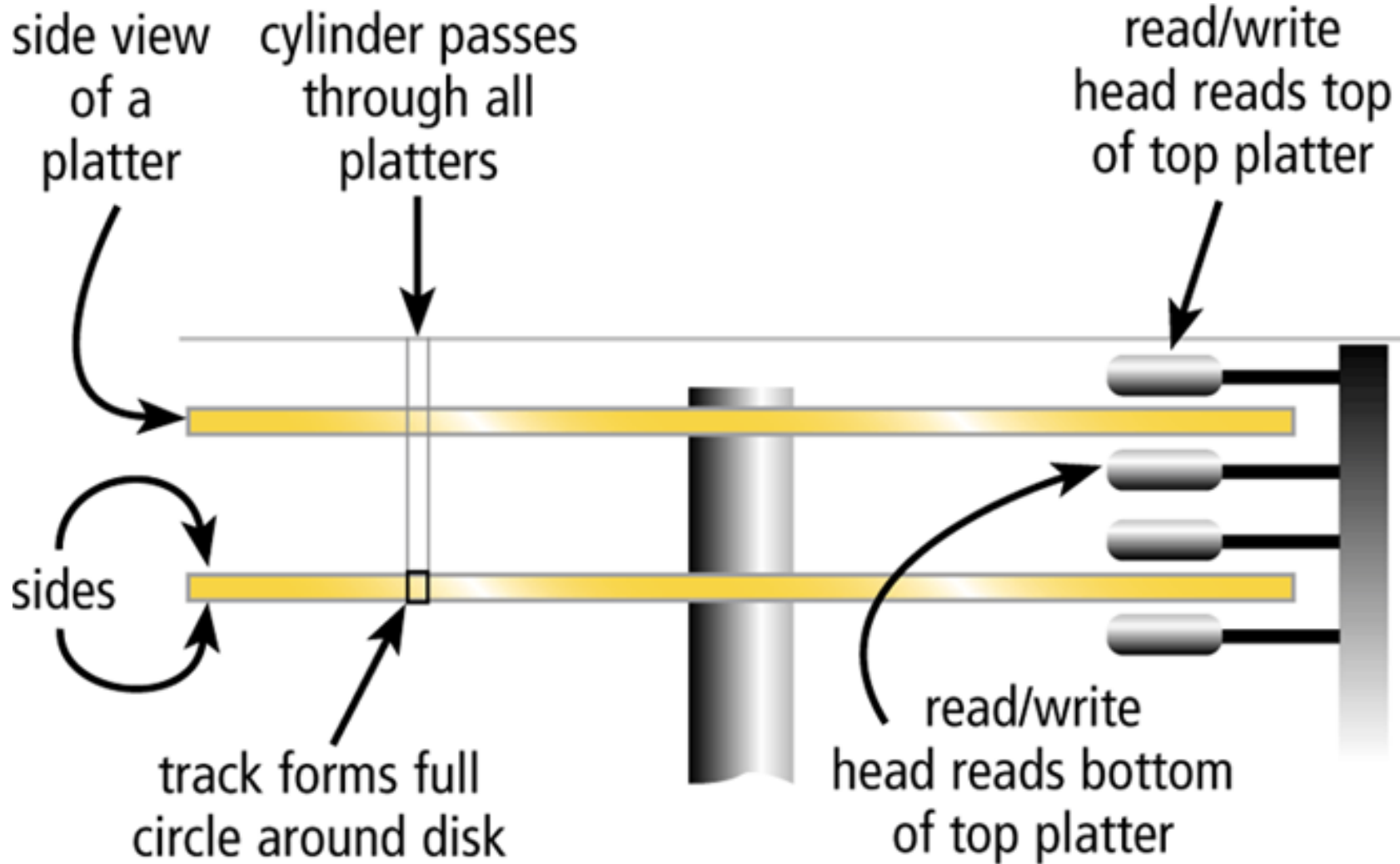
- The platter is made of aluminum, glass, or ceramic and is coated with an alloy material that allows items to be recorded magnetically on its surface.
- Formatting is the process of dividing the disk into tracks and sectors, so that the operating system can store and locate data and information on the disk.

# Characteristics of a Hard Disk

- A track is a narrow recording band that forms a full circle.
- A sector is a pie-shaped section, breaking the tracks into arcs.
- A cluster is the smallest unit of disk space that stores data and information.



# Characteristics of a Hard Disk



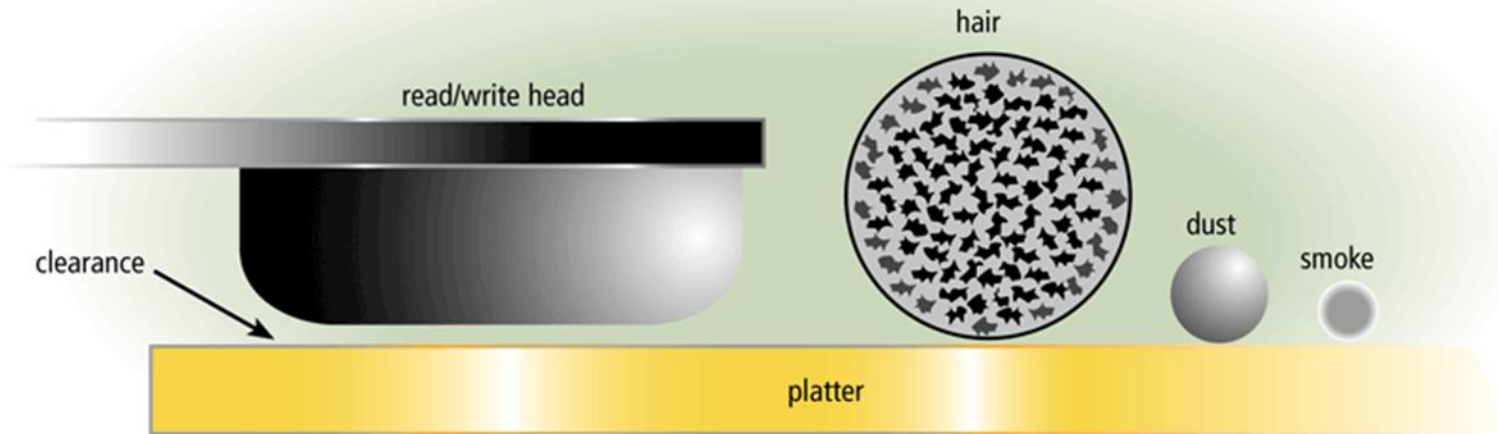
# Characteristics of a Hard Disk

- Platters most often have a form factor, or size, of approximately 3.5 inches in diameter.
- On mobile devices, the form factor is 2.5 inches or less.
- While the computer is rudding, the platters in the hard disk rotate at a high rate of speed, usually 5,400 to 15,000 revolutions per minute (rpm).

# Characteristics of a Hard Disk

- The read/write heads are kept at a distance of about two millionths of an inch away from the disk.
- If the read/write head touches the surface of a platter, a head crash occurs, usually resulting in a loss of data or sometimes the entire disk.
- A backup is a duplicate of a file, program, or disk placed on a separate storage medium that you can use in case the original is lost, damaged or destroyed.

# Characteristics of a Hard Disk



# Characteristics of a Hard Disk

- Disk cache consists of a memory chip(s) on a hard disk that stores frequently accessed items.
- Today, the size of disk cache ranges from 2MB to 32MB.



# RAID

- A group of two or more integrated hard disks is called a redundant array of independent disks, or RAID.
- The disks in a RAID function, together, as one large disk.

# NAS

- A network attached storage (NAS) device is a server connected to a network with the sole purpose of providing storage.

# External or Removable Hard Disks

- An external hard disk is a separate free-standing hard disk that connects with a cable to a USB port or FireWire port on the system unit.
- A removable hard disk is a hard disk that you insert and remove from a drive.
- Although both are usually slower than internal hard disks, they offer advantages, such as transporting, backing up, and securing data.

# Miniature Hard Disks

- Used for both internal and external storage.
- Have form factors of 1.8 inch, 1 inch, and 0.85 inch.
- Used in some devices such as portable media players, digital cameras, and smart phones.



# Hard Disk Controllers

- A disk controller consists of a special-purpose chip and electronic circuits that control the transfer of data from a disk to and from the system bus.
  - SATA (serial advanced technology attachment)
  - EIDE (enhanced integrated drive electronics)
  - SCSI (small computer system interface)
  - SAS (serial-attached SCSI)

# Flash Memory Storage

- Flash memory chips are a type of solid state media, which means they consist entirely of electronic components, such as integrated circuits, and contain no moving parts.
- The lack of moving parts makes them more durable and shock resistant than other types of media.

# Solid State Drives

- A solid state drive (SSD) is a storage device that typically uses flash memory to store data.
- Form factors from 3.5 inches, 2.5 inches, and 1.8 inches.
- Used in all types of computers: servers, desktops, and notebooks.
- Storage capacities from 16GB to 256GB.

# Solid State Drives

- Access times of SSDs are about 0.1 ms, which is about 80 times faster than a hard disk.
- Faster transfer rates.
- Generate less heat and consume less power.
- Last more than 50 years, as opposed to 3-5 years for hard disks.



# Memory Cards

- A memory card is a removable flash memory device, usually no bigger than 1.5 inches in height or width.

Various Memory Cards			
Media Type		Storage Capacity	Use
CompactFlash (CF)		512 MB to 100 GB	Digital cameras, smart phones, PDAs, photo printers, portable media players, notebook computers, desktop computers
Secure Digital (SD)		512 MB to 8 GB	Digital cameras, digital video cameras, smart phones, PDAs, photo printers, portable media players
SDHC		4 to 32 GB	Digital cameras
microSD		1 to 2 GB	Smart phones, portable media players, handheld game consoles, handheld navigation devices
microSDHC		4 to 16 GB	Smart phones, portable media players, handheld game consoles, handheld navigation devices
xD Picture Card		256 MB to 2 GB	Digital cameras, photo printers
Memory Stick PRO Duo		1 to 16 GB	Digital cameras, smart phones, handheld game consoles
Memory Stick Micro (M2)		1 to 16 GB	Smart phones

# Memory Cards

- Memory cards can last from 10 to 100 years.
- They are quite price, per byte, than hard disks.
  - A 16GB CompactFlash card can cost as much as a 640GB external hard disk.

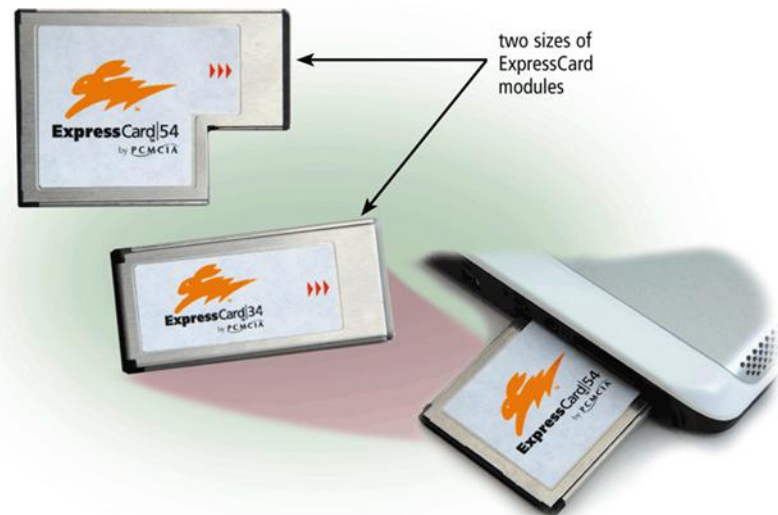
# USB Flash Drives

- A USB flash drive, also called a thumb drive, is a flash memory storage device that plugs in a USB port on a computer or mobile device.
- Convenient for mobile users because they are easy to transport.
- Current capacities ranging from 512MB to 100GB.



# ExpressCard Modules

- An ExpressCard module is a removable device that fits in an ExpressCard slot.
- About 75mm long and 34mm wide, or L-shaped with a width of 54mm.
- They are commonly used in notebook computers.



# Cloud Storage

- Cloud storage is an Internet service that provides storage to computer users.
- Some services provide storage for specific types of files.
- Many offer additional services such as encryption and passwords.
- Users subscribe to cloud storage to: access files on the Internet from any computer, store large files on the Internet, allow others to access their files, and store backups of data.

# Optical Discs

- An optical disc is a type of storage media that consists of a flat, round, portable disc made of metal, plastic, and lacquer that is written and read by a laser.
- Optical discs are 4.75 inches in diameter and less than one-twentieth of an inch thick.
- Smaller, 3 inch, mini discs exist for smaller computers and game consoles.

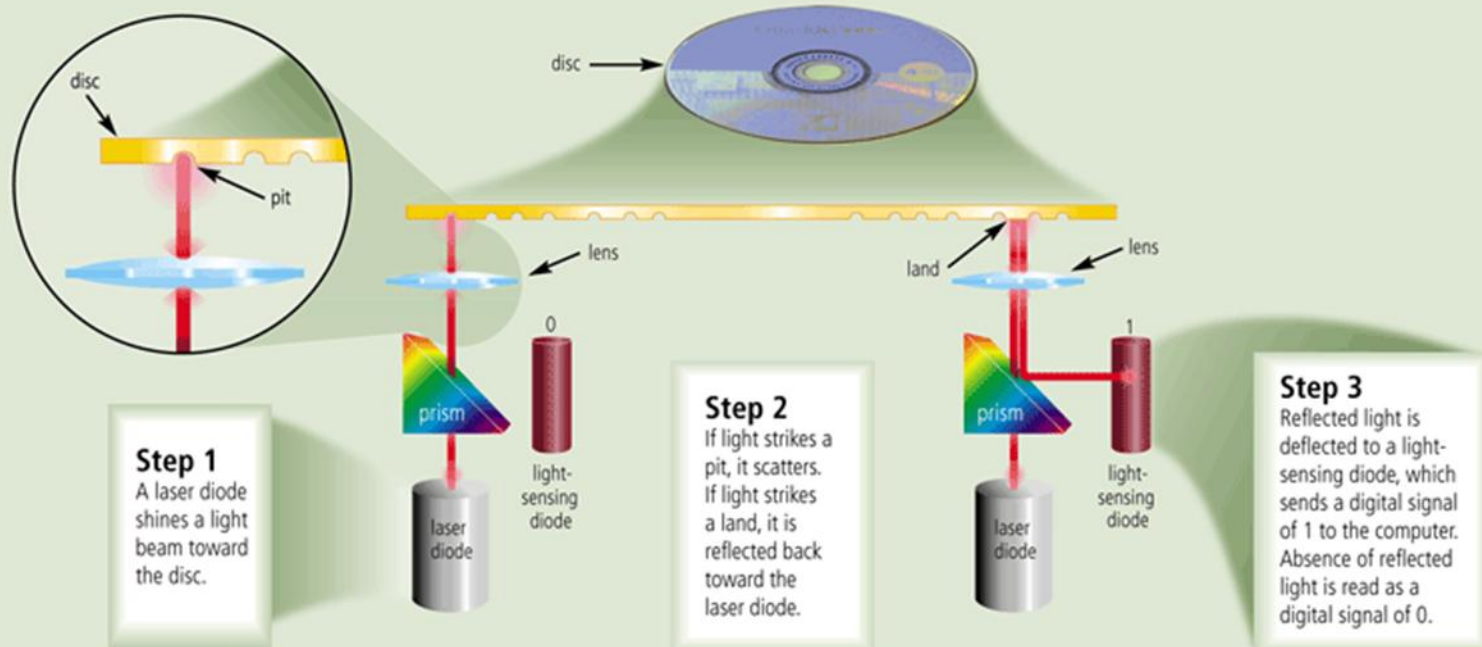
# Optical Discs

- They can be used to store software, data, photos, movies, and music.
- Some are read-only and some are read/write, which allows users to save.
- Nearly all personal computers have some sort of optical disc drive.

# Optical Discs

- Optical discs store items by using microscopic pits (indentations) and lands (flat areas) that are in the middle layer of the disc.

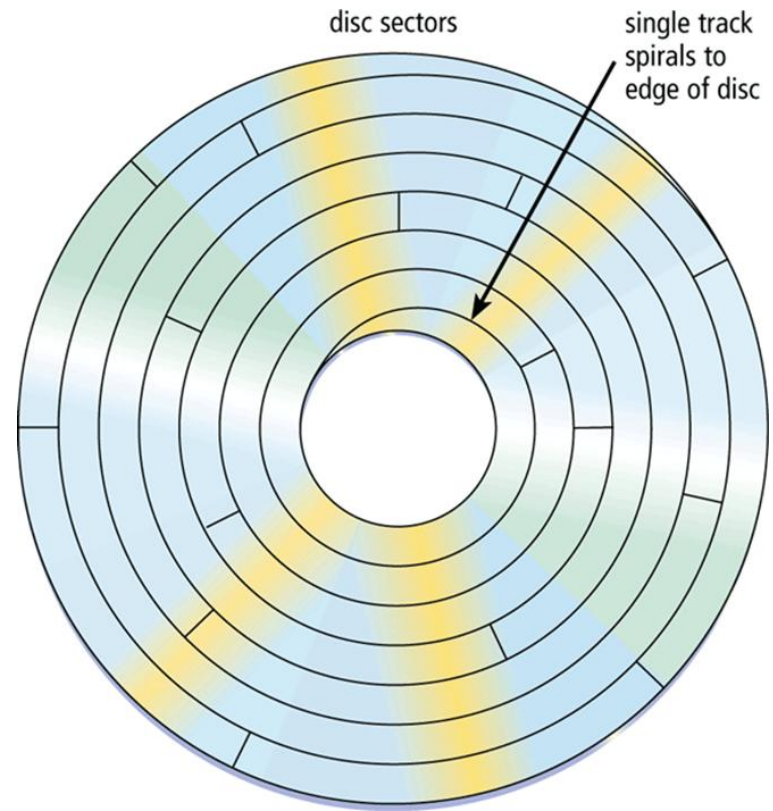
How a Laser Reads Data on an Optical Disc



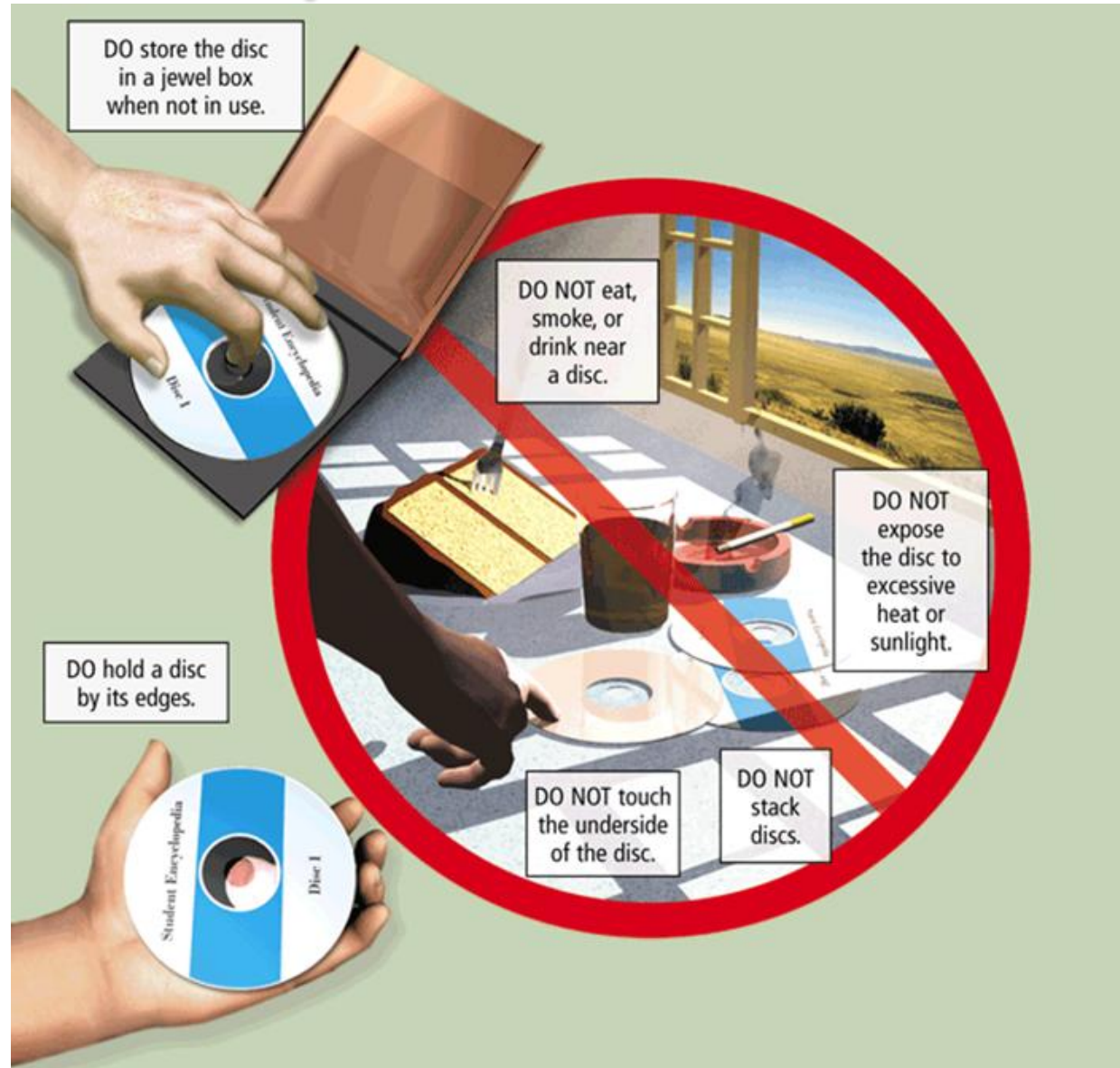


# Optical Discs

- Optical Discs commonly store items in a single track that spirals from the center of the disc and is divided into evenly sized sectors.



# Care of Optical Discs



# CDs

- A CD-ROM (compact disc read-only memory) is a type of optical disc that users can read but not write or erase.
- They typically hold from 650MB to 1GB of data.
- To read a CD-ROM, insert the disc in a CD-ROM drive
- They use an X to denote the original transfer rate of 150 KBps.
  - A 48X CD-ROM drive has a transfer rate of 7200 KBps.

# CD-Rs and CD-RWs

- A CD-R (compact disc-recordable) is a multisession optical disc on which users can write, but not erase, their own data.
  - Multisession means you can write on part of the disc at one time and another part later.
- A CD-RW (compact disc-rewritable) is an erasable multisession disc you can write on multiple times.
- A CD-RW drive is used to write to CD-RWs and CD-Rs.

# DVDs and Blu-ray Discs

- Although the size and shape are similar to a CDs, each store data in a different manner to achieve a higher capacity.
- A DVD-ROM (digital versatile disc-read-only memory) is a high-capacity optical disc on which users can read but not write or erase.
- Capable of storing 4.7-17GB of data.
- A DVD-ROM drive or DVD player is required to read a DVD-ROM.

# DVDs and Blu-ray Discs

- A Blu-ray Disc-ROM (BD-ROM) has storage capacities up to 100GB, as of today, and expecting up to 200GB.
- Blu-ray Disc (BD) drives and players are backward compatible with DVD and CD formats.

# Recordable and Rewritable DVDs

- DVD-R and DVD+R are competing DVD-recordable formats, storing up to 4.7GB.
- DVD-RW, DVD+RW, and DVD+RAM are three competing rewritable DVD formats, storing up to 4.7GB.
- Before investing in equipment, check to be sure it is compatible with the media on which you intend to record.



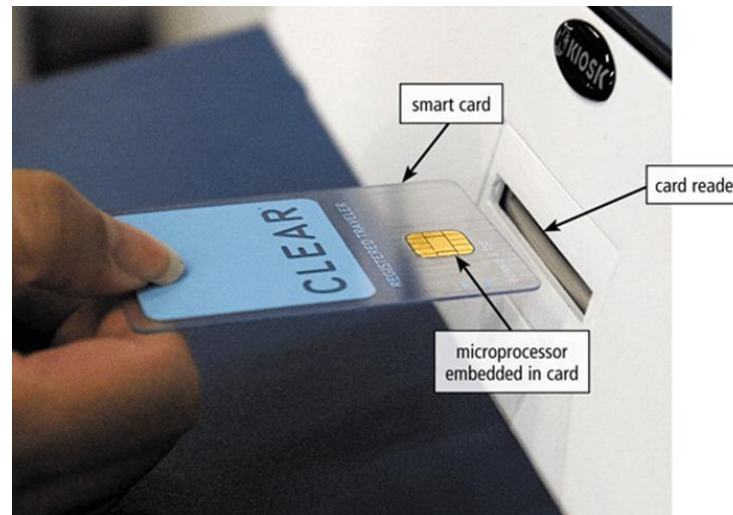
# Tape

- Tape, one of the first storage media used, is a magnetically coated ribbon of plastic capable of storing large amounts of data and information at a low cost.
- A tape drive reads and writes data on a tape.
- Tape is no longer used as a primary method of storage.
- Tape uses sequential access, which means reading or writing data consecutively.
  - As opposed to random access, which is used by hard disks and flash memory, since they can both locate a particular data item immediately.



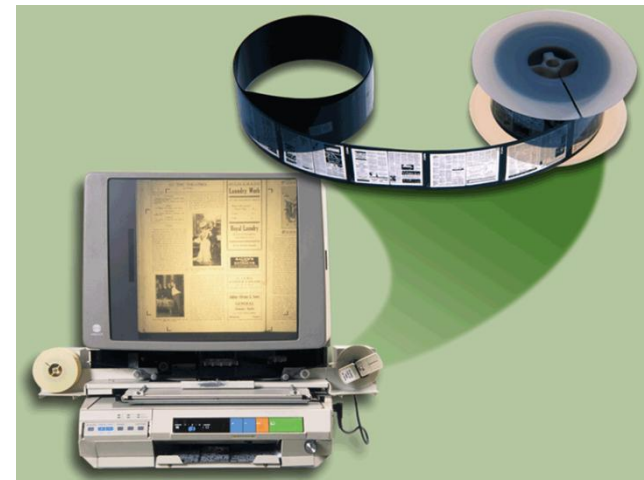
# Magnetic Stripe Cards and Smart Cards

- A magnetic stripe card is a credit card, entertainment card, bank card, or other similar card, with a stripe that contains information identifying you and the card.
- A smart card is similar in size to a credit card or ATM card and stores data on a tiny microprocessor embedded in the card.



# Microfilm and Microfiche

- Both store microscopic images of documents on roll or sheet film.
- Microfilm is a 100 to 215 foot roll of film.
- Microfiche is a small sheet of film, usually about 4x6 inches.
- They are used mainly for archiving purposes.
- They are inexpensive and have the longest life of any storage media.



# Enterprise Storage

- To meet their large-scale needs, enterprises use special hardware geared for heavy use, maximum availability, and maximum efficiency.
- One or more servers on the network have the sole purpose of providing storage to connected users.
- In an enterprise, some storage systems can provide more than 185TB of storage capacity.

# Enterprise Storage

- Server Count
  - Intel: 100,000
  - Facebook: 60,000
  - Verizon: 25,788
  - Time Warner Cable: 24,817
  - AT&T: 20,268
- Estimated Server Count
  - Google: 450,000
  - Microsoft: 218,000
  - Amazon: 40,000 just for web services
  - eBay: 50,000
  - Yahoo: 50,000
    - Source: <http://www.datacenterknowledge.com/archives/2009/05/14/whos-got-the-most-web-servers/>