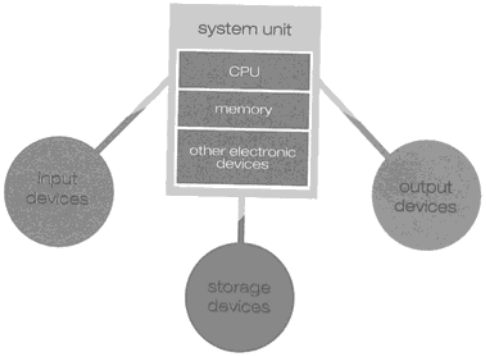
Chapter 2:
Computer Hardware and Technology Trends

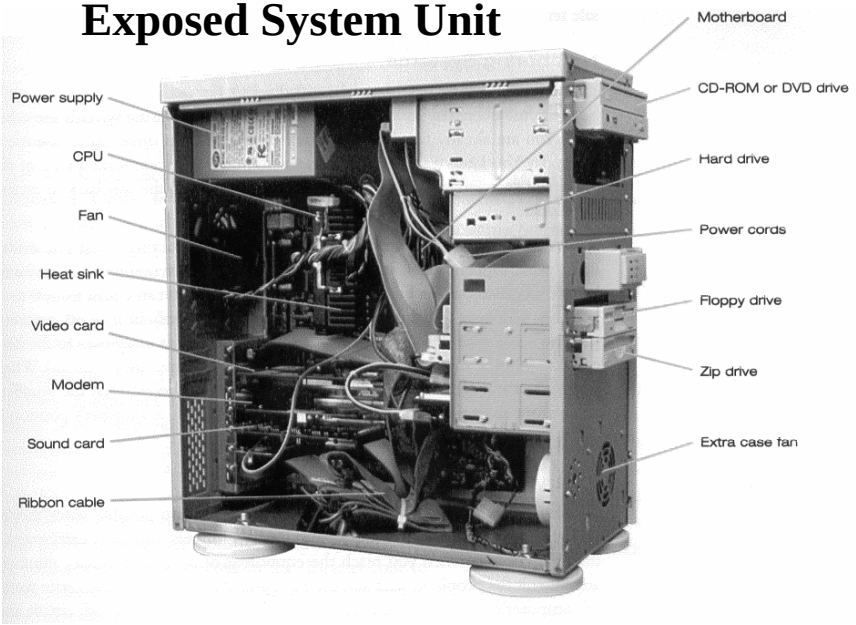
Inside the System Unit

Personal Computers

- The PC consists of 4 major components.
  - Input Device
  - Processor
  - Output Device
  - Storage Device

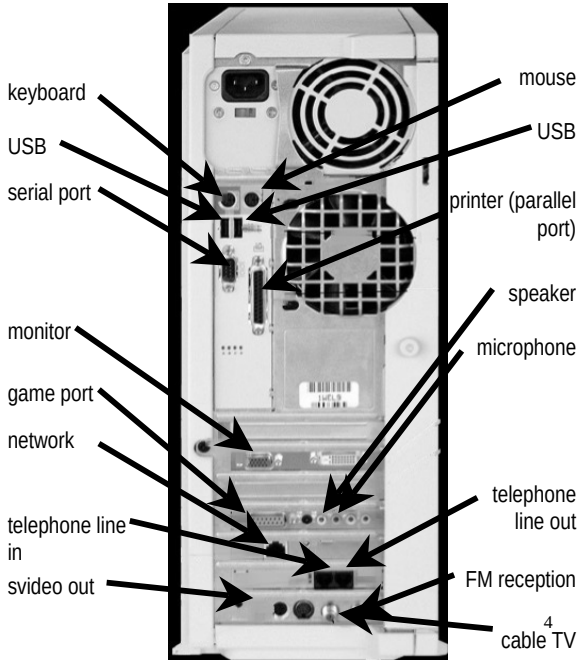


Exposed System Unit



Port

- Connects external devices to system unit



Why need Input and Output Device?

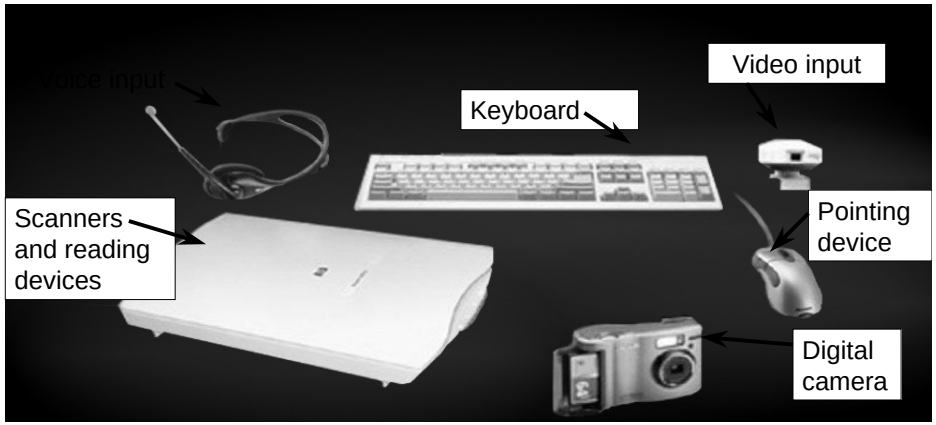
- Since computers are electronic devices which operate in a way not easily understood by humans, it is necessary for equipment to be used which will convert the signals used by computers into a form that can be used by humans and vice-versa.
- This is the role of input and output devices.

Computer Hardware and Technology Trends

Input Devices

What is an Input Device?

- Any hardware component used to enter data, programs, commands, and user responses into a computer



Input Device – Keyboard

- The most familiar of the input devices is the keyboard.
- Modeled after the typewriter keyboard.
- Generally this resembles the QWERTY type keyboard common on most typewriters.
- Unlike the typewriter keyboard, the computer is extended to contain up to 102 keys, which include a number pad, a series of special function keys and some keys to control the cursor on the screen.

Portable Keyboard

- Full-sized keyboard you conveniently can attach and remove from a handheld computer

Ergonomic Keyboard

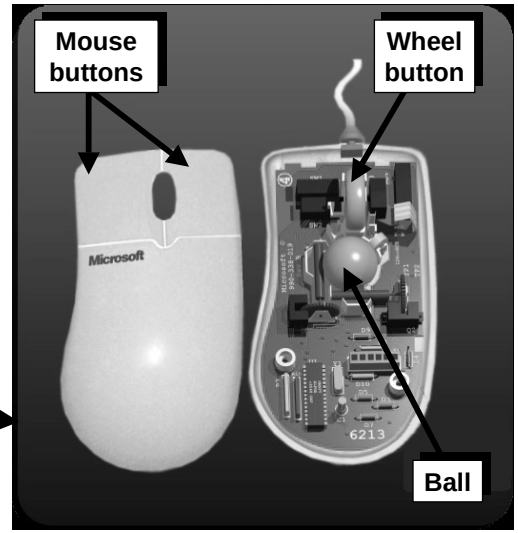
- Designed to minimize strain on hands and wrists
- Ergonomics incorporates comfort, efficiency, and safety into design of items in workplace

Input Device – Mouse

- The mouse is a small, plastic device which is connected to the computer by a small cable.
- It can be moved across a table top and the cursor will move across the screen in the same way.
- The cursor is a light square or line which appears on the screen to identify where the cursor is in the same position on the screen as the desired item, the item can be selected by pressing a button on the mouse.
- This saves the user having to type in the desired selection.

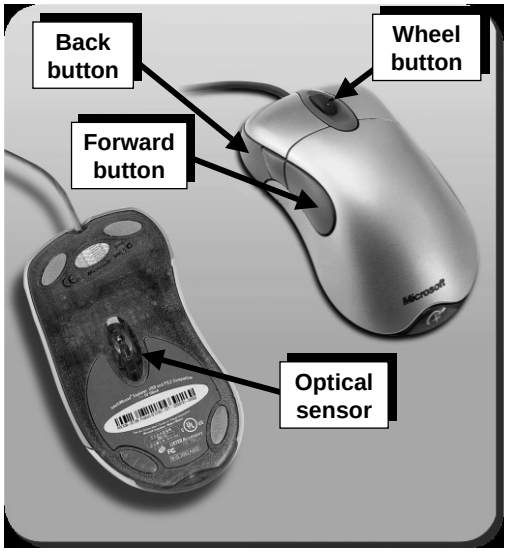
How does a Mechanical Mouse Work?

- Rubber or metal ball is on its underside
- Movement of mouse translates into signals computer understands



How does an Optical Mouse Work?

- Senses light to detect mouse's movement
- More precise than mechanical mouse
- Connect using a cable or wireless



Common Mouse Operations

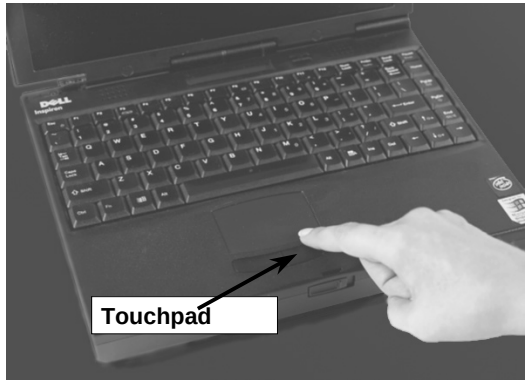
- Point
- Click
- Right-click
- Double-click
- Drag
- Right-drag
- Rotate wheel
- Press wheel

Trackball

- Stationary pointing device with a ball on its top
- To move pointer, rotate ball with thumb, fingers, or palm of hand

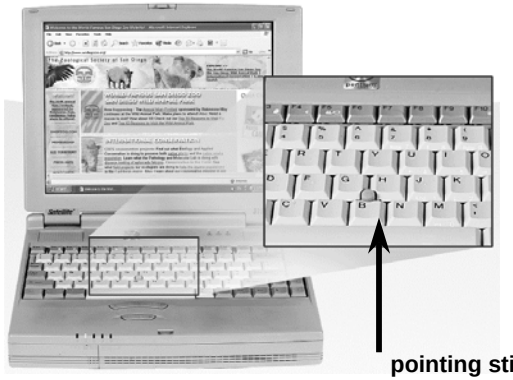
Touchpad

- Small, flat, rectangular pointing device sensitive to pressure and motion



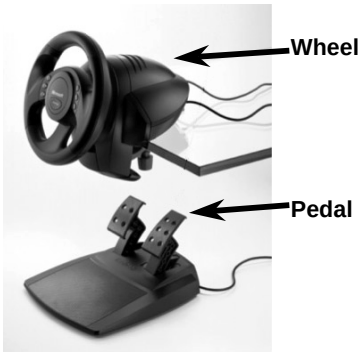
Pointing Stick

- Pointing device shaped like pencil eraser positioned between keys on keyboard



Joystick and Wheel

- Joystick is vertical lever mounted on a base
- Wheel is steering-wheel type input device
- Pedal simulates car brakes and accelerator



Light Pen

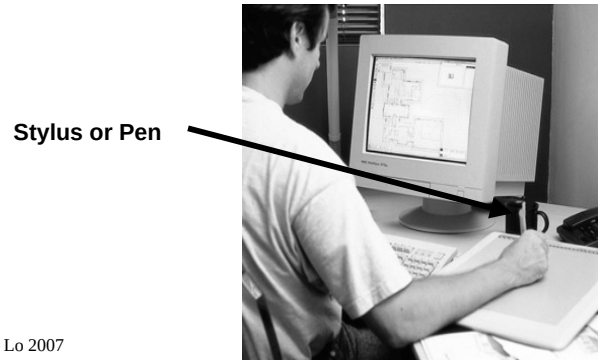
- Handheld input device that contains light source or can detect light
- Press light pen against screen surface and then press button on pen

Touch Screen

- Touch areas of screen with finger
- Often used with kiosks

Stylus

- Looks like a ballpoint pen, but uses pressure to write text and draw lines
- Used with graphics tablets and handheld computers



Input Device – Touch Panel

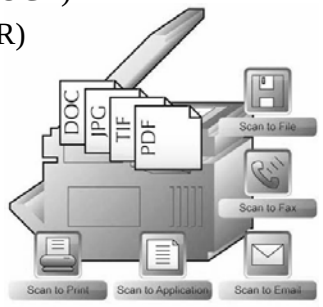
- The device which assists selection of items on a screen is the touch panel.
- This is a touch sensitive plastic sheet which is placed on the screen and again attached to the computer.
- The user can select items by touching the part of the touch pad at the location where the described item is on the screen.
- This will cause the touch pad to send an electrical signal to the computer and select the desired item.

Input Device – Scanner

- A scanner can be used to capture an image of a document or a picture and store this in the computer.
- Both graphics and text can be stored and retrieved.
- It is an electronic device used in making color separations.
- Originals are placed on drums, which are rotated, reproduce the original via digital and electronic signals transferred to the finished film size through fiber optics.
- Scanners utilize electronic circuits to correct color, compress the tones and enhance the detail.

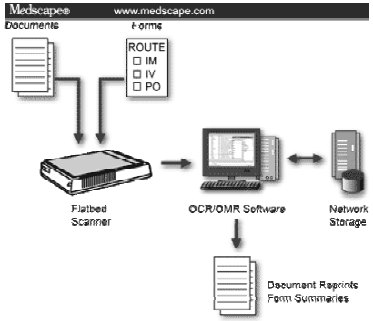
Recognition

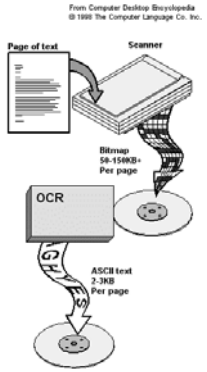
- Stored images can be used for a number of purposes.
- Scanned documents can be retrieved easily and reprinted, instead of having to search through the registry.
  - Magnetic Ink Character Recognition (MICR)
  - Optical Character Recognition (OCR)
  - Optical Mark Recognition (OMR)
  - Optical Bar Recognition (OBR)



Optical Character Recognition (OCR)

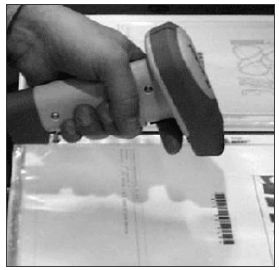
- When the scanner is used in conjunction with an Optical Character Recognition (OCR), we will be able to not only capture an image of a text, but also to decipher and recognize the individual characters, numbers or symbols.





Optical Bar Recognition (OBR)

- Another technique which is common today is bar coding.
- Bar code is a series of vertical stripes about one inch high.
- The stripes are of varying thickness and distances apart.
- The combination of stripes (bar code) actually represents a numerical code.
- This numerical code is the key field to a record containing data fields about the item.

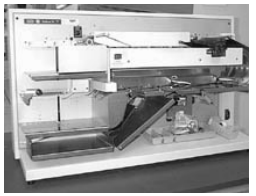


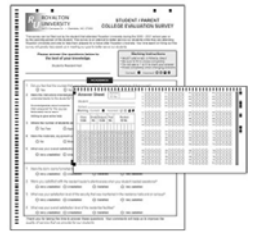
Bar Code

- Identification code that consists of a set of vertical lines and spaces of different widths
- Universal Product Code (UPC)

Optical Mark Recognition (OMR)

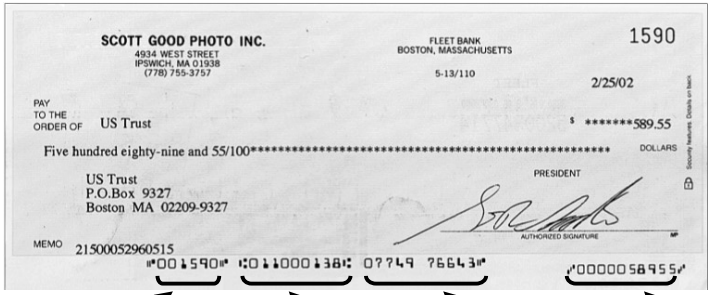
- Optical Mark Recognition is a method of computerized input from (usually) paper forms.
- It is generally distinguished from OCR by the fact that a recognition engine is not required.
- The marks are constructed in such a way that there is little chance of not reading the marks correctly.
- This requires the image to have high contrast and an easily-recognizable or irrelevant shape.





Magnetic Ink Character Recognition (MICR)

- Can read text printed with magnetized ink
- Banking industry almost exclusively uses MICR for check processing



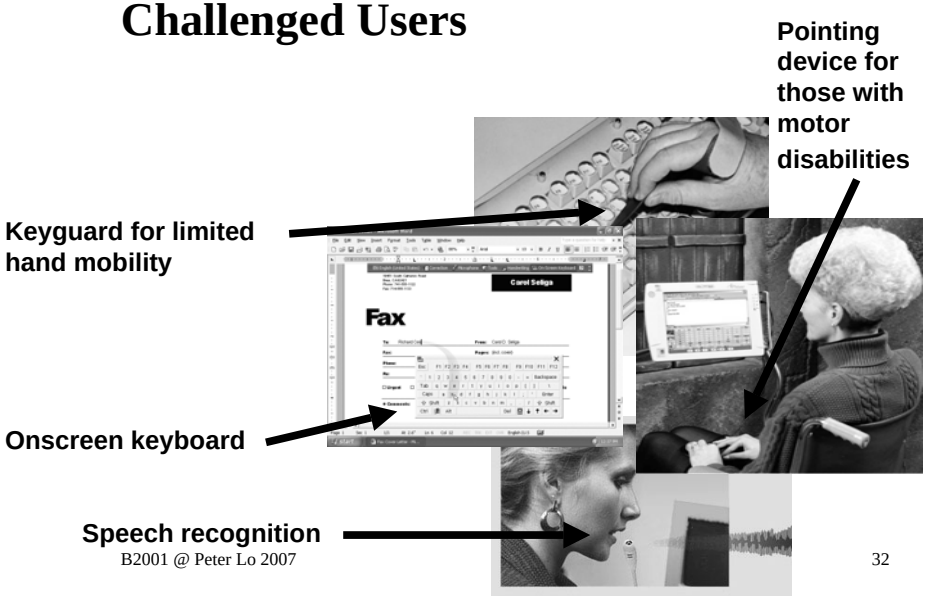
Handwriting Recognition

- Translates handwritten letters and symbols into characters that the computer can understand

Wireless Input

- Handheld computer or device used to collect data wirelessly at the location where transaction or event takes place
- Data transferred later to desktop computer through docking station

Input Devices for Physically Challenged Users

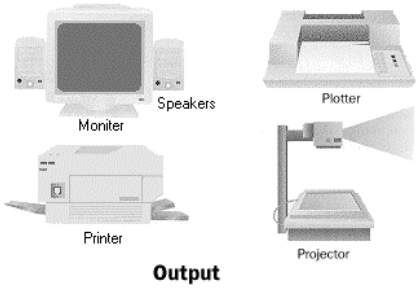


Computer Hardware and Technology Trends

Output Devices

Output Device

- Improvement in technology has resulted in the development of a variety of output devices which serve a variety of purposes.
- The quality of the output has improved at a continually reducing cost.

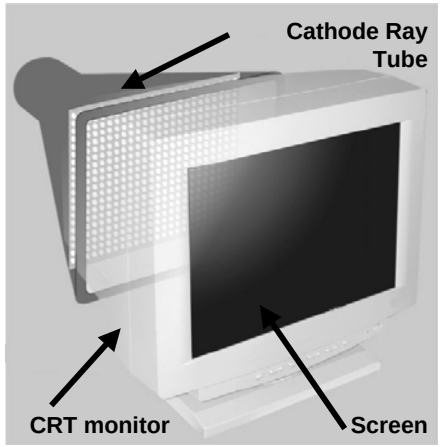


Display Device

- Television-like
- Information on a display device sometimes is called **Soft Copy**

Cathode Ray Tube (CRT) Monitor

- Large sealed, glass screen
- Screen coated with tiny dots of phosphor material
- Pixel, or picture element, is single point in electronic image
- Three dots (red, blue, and green) combine to make up each pixel



Liquid Crystal Display (LCD)

- Type of flat-panel display
- Uses liquid crystals between two sheets of material to present information on screen
- Electric current passes through crystals, which creates images on the screen

Some features of LCD screens

- Lightweight and compact
- Consumes less than one-third of the power than does a CRT monitor
- Ideal for notebook and handheld computers

Two Technologies Used for LCD Monitors

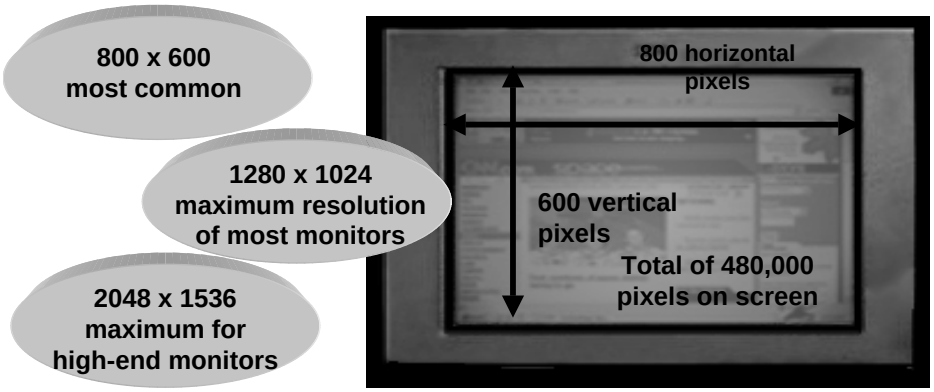
- Active-matrix display
  - Can display high-quality color viewable from all angles
- Passive-matrix display
  - Color often not as bright
  - Images best viewed when working directly in front of display

Gas Plasma Monitor

- Flat-panel display uses layer of gas plasma between two sheets of material
- Larger screen sizes and higher display quality than LCD, but much more expensive

Display Resolution

- Describes the sharpness and clarity of image
- The higher the resolution, the sharper the image and the more that can display on the monitor



Output Device – Printers

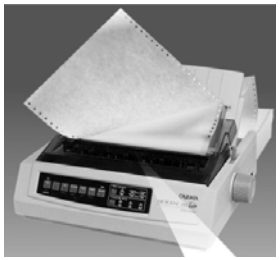
- A computer printer is a computer peripheral device that produces a hard copy (permanent human-readable text and/or graphics, usually on paper) from data stored in a computer connected to it.
- The world's first computer printer was a 19th century mechanically driven apparatus invented by Charles Babbage for his Difference Engine.

Categories of Printers

- There are two main categories of printer:
  - Impact Printer
    - Dot Matrix Printer
  - Non-impact Printer
    - Laser Printer
    - Ink-jet Printer

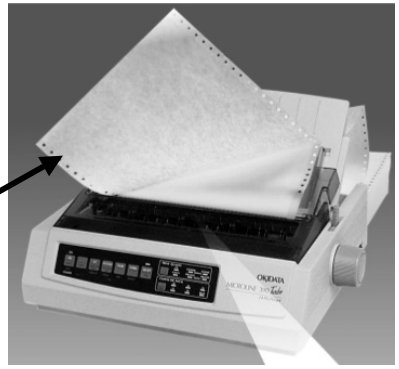
Impact Printer

- Forms characters by striking a mechanism against ink ribbon that physically contacts paper
- Ideal for printing multipart forms
- Can withstand dusty environments, vibrations, and extreme temperatures

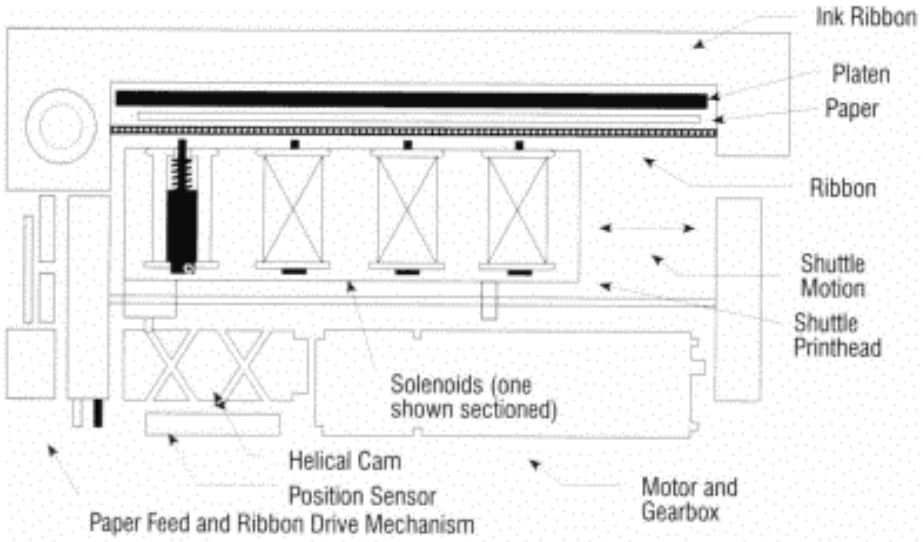


Dot-matrix Printer

- Impact printer that produces printed images when tiny wire pins on print head mechanism strike inked ribbon
- Most use continuous-form paper

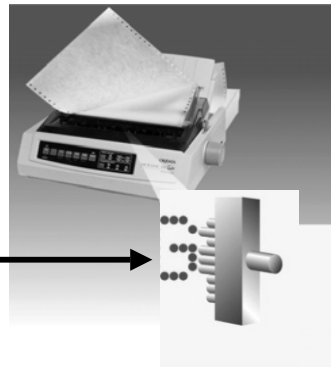


Inside Dot Matrix Printer



How does Dot Matrix Printer Work?

- When ribbon presses against paper, it creates dots that form characters and graphics
- A higher number of pins (9 to 24) means printer prints more dots per character, which results in higher print quality



Line Printer

- High-speed impact printer that prints entire line at a time
- Speed measured by number of lines per minute (lpm) it can print
- Band printer prints fully-formed characters using a hammer mechanism
- Shuttle-matrix printer is high-speed printer that works more like a dot-matrix printer

Non-impact Printer

- Forms characters and graphics on piece of paper without actually striking paper

Ink-jet printer

Laser printer

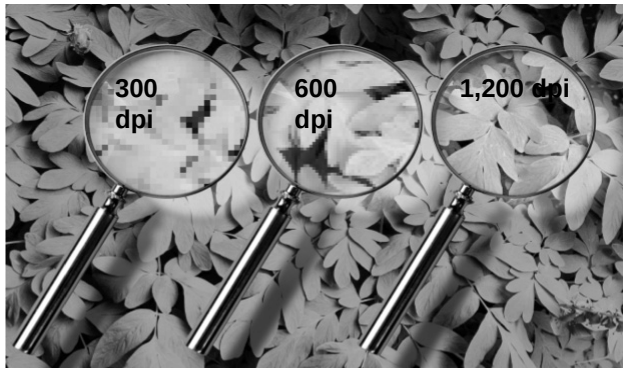
Thermal printer

Ink-jet Printer

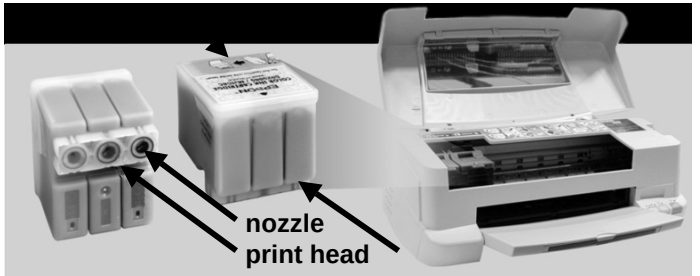
- Non-impact printer forms characters and graphics by spraying tiny drops of liquid ink onto piece of paper
- Most popular type of color printer for home use

Resolution of a Printer

- Sharpness and clarity of characters
- Measured by number of dots per inch (dpi) printer can output



How does an Ink-jet Printer Work?

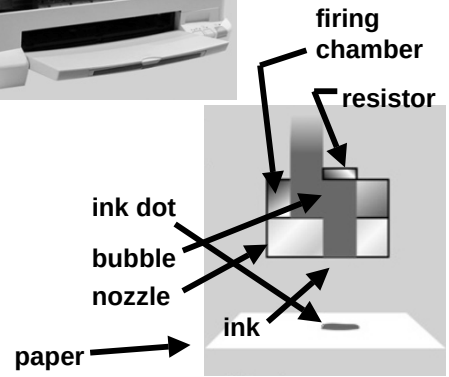


1: Small resistor heats ink, causing ink to boil and form vapor bubble

2: Vapor bubble forces ink through nozzle

3: Ink drops onto paper

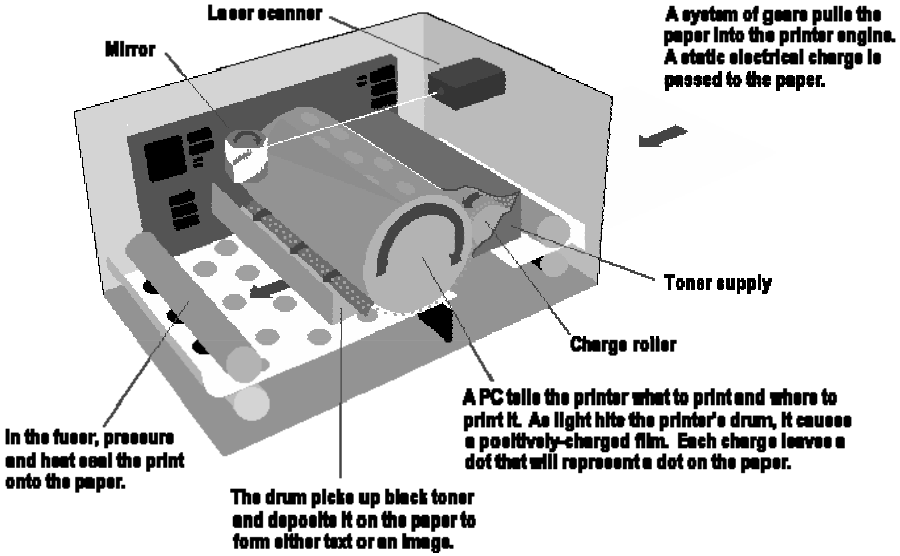
4: As vapor bubble collapses, fresh ink is drawn into firing chamber



Laser Printer

- High-speed, high-quality non-impact printer
- Prints text and graphics in very high-quality resolution, ranging from 600 to 1,200 dpi
- Typically costs more than ink-jet printer, but is much faster

Inside Laser Printer



How does a Laser Printer Work?

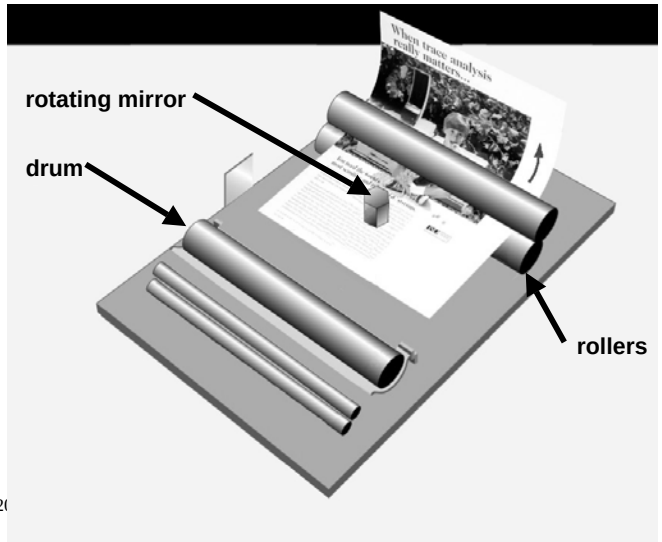
1: Drum rotates as paper is fed through

2: Mirror deflects laser beam across surface of drum

3: Laser beam creates charge that causes toner to stick to drum

4: As drum rotates, toner transfers from drum to paper

5: Rollers use heat and pressure to fuse toner to paper

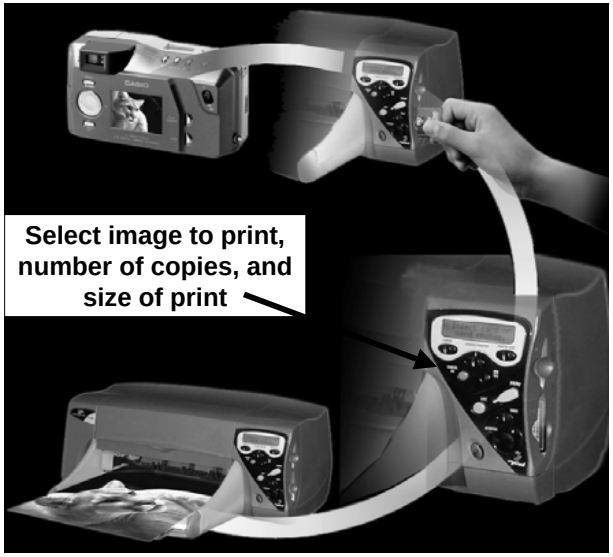


Thermal Printer

- Generates images by pushing electrically heated pins against heat-sensitive paper
- Ideal for small devices, such as adding machines

Photo Printer

- Color printer that produces photo lab quality pictures and prints everyday documents



Label Printer

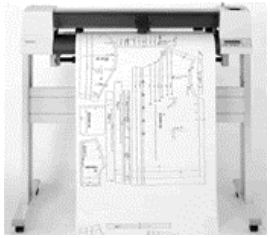
- Small printer that prints on adhesive type material that can be placed on a variety of items
- Most also print bar codes and e-stamps

Portable Printer

- Small, lightweight ink-jet or thermal printer that allows mobile user to print from notebook or handheld computer while traveling

Plotter

- Plotters are sophisticated printer used to produce high-quality graphs or diagrams
- Large-format printer similar to plotter and is used to print quality color prints
- There are two types of plotters:
  - Pen Plotters
  - Electrostatic Plotters

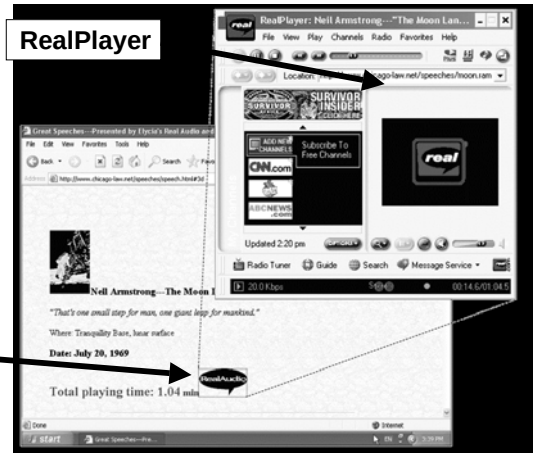


Audio Output Device

- Computer component that produces music, speech, and other sounds
- Speakers and headsets are common devices

Voice Output

- Computer talks to you through speakers on computer

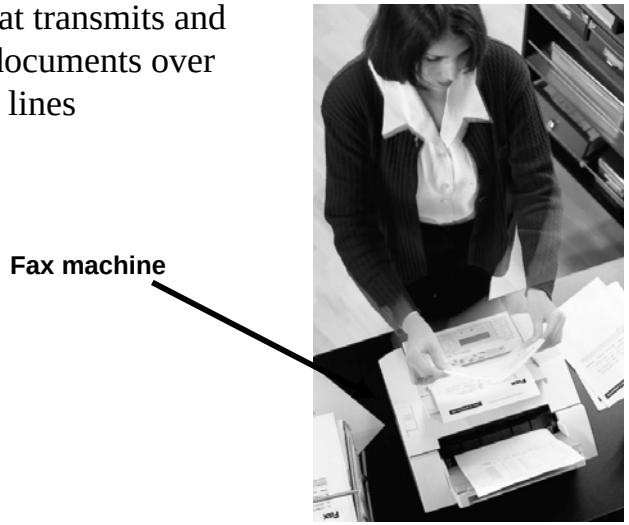


Data Projector

- Device that takes image from a computer screen and projects it onto a larger screen

Facsimile (FAX) Machine

- Device that transmits and receives documents over telephone lines



Fax Modem

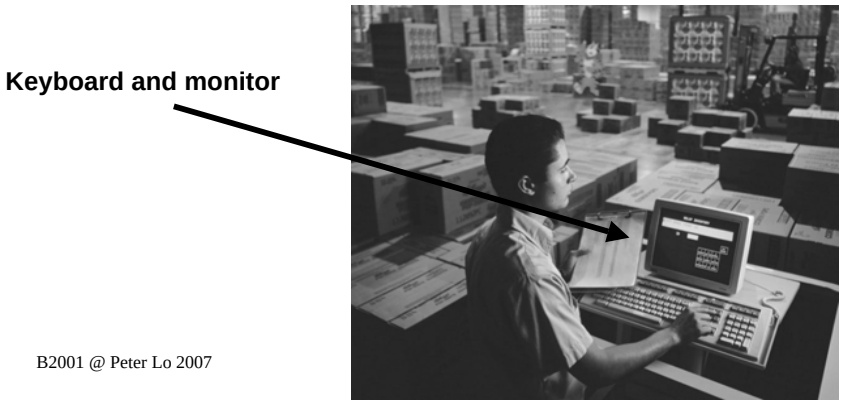
- Modem that allows you to send and receive electronic documents as faxes

Terminal

- Terminals are devices for translating and/or receiving data over a communication channel.
- They are connected to a computer, which controls the transmission of data over cables or over telephone lines.
- The most well known of all output devices is the Visual Display Unit (VDU)
- Device that performs both input and output, examples of terminal are:
  - Dumb Terminals
  - Intelligent Terminals
  - Special-purpose Terminals

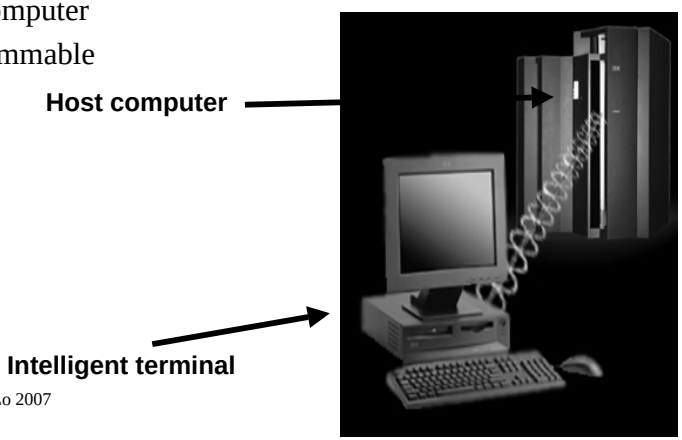
Dumb Terminal

- Has a keyboard and monitor, but no processor or memory
- Connects to host computer that performs processing and then sends output back



Intelligent Terminal

- Has monitor, keyboard, memory and processor
- Similar to a PC in that it can perform tasks independent of host computer
- Programmable



Point-of-Sale (POS) Terminal

- Records purchases at point where purchase is made
- Output from POS terminals serves as input to host computer

POS terminal in a grocery store

Scanner and keyboard are input

Automated Teller Machine (ATM)

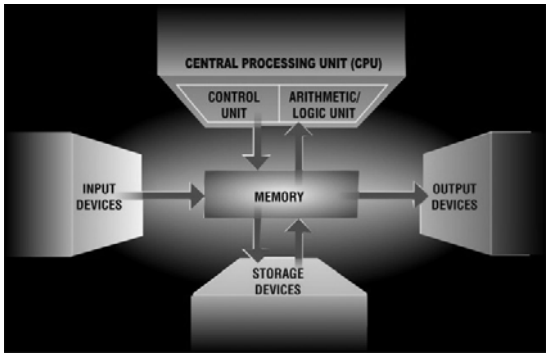
- Self-service banking machine that connects to host computer through telephone network

Computer Hardware and Technology Trends

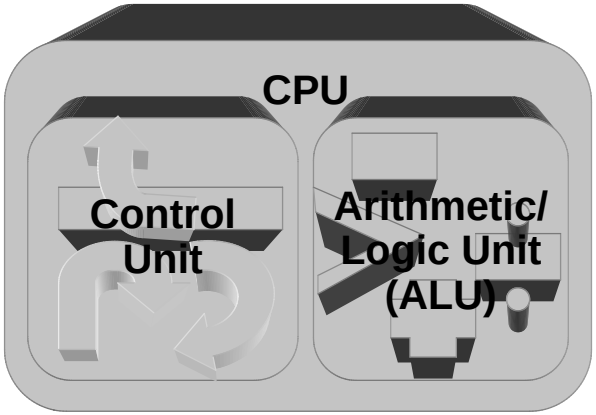
Processor

Central Processing Unit (CPU) ?

- Interprets and carries out basic instructions that operate a computer
- Also called the **Processor**



Components of the CPU



Control Unit

- The control unit receives program instructions, one at a time, from the computer's memory. It supervises the execution of these instructions and sends out control signals to peripheral devices, coordinated by a clock.
- Control unit repeats four basic operations:
  - **Fetch** – Obtain program instruction or data item from memory
  - **Decode** – Translate instruction into commands
  - **Execute** – Carry out command
  - **Store** – Write result to memory

Machine Cycle?

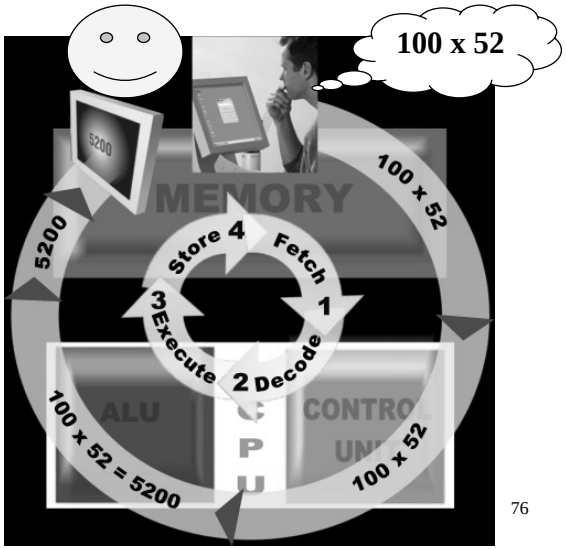
- **Four operations of the CPU comprise a machine cycle**
- **Also called instruction cycle**

- **Instruction time (i-time) - time taken to fetch and decode**
- **Execution time (e-time) - time taken to execute and store**

Example of a Machine Cycle

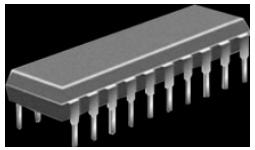
Student enters math problem (100 x 52) into computer's memory

Result in memory displays on monitor's screen

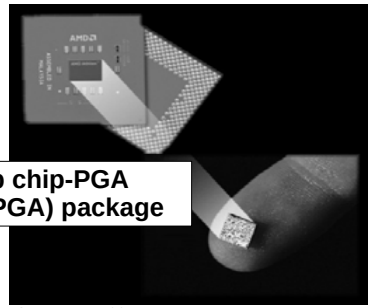


Available CPU Packages

single edge contact (SEC) cartridge



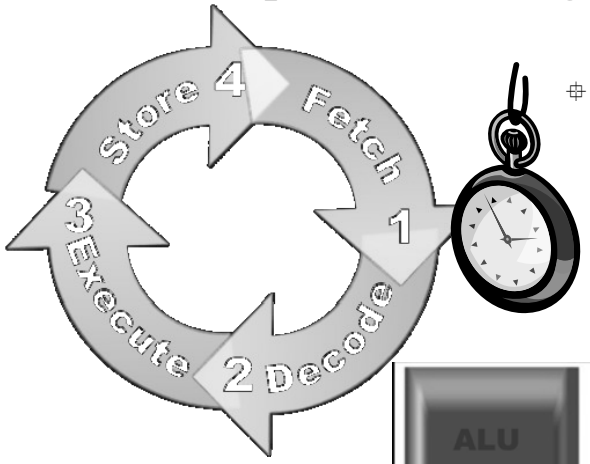
dual inline package (DIP)



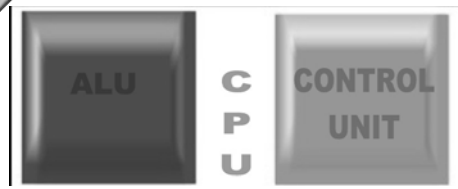
flip chip-PGA (FC-PGA) package

pin grid array (PGA)

CPU's Speed Measuring

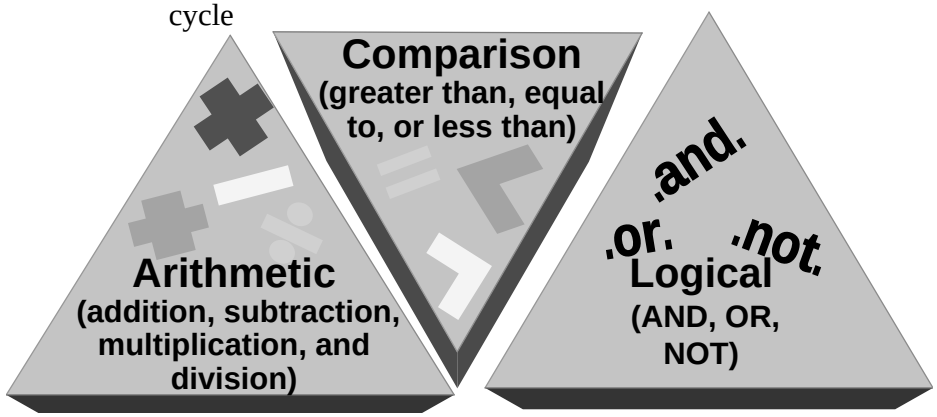


- According to how many millions of instructions per second (MIPS) it can process



Arithmetic/Logic Unit (ALU)

- This is the part of the processor where the arithmetical, logical and other operations are carried out. This is the component that performs execution part of the machine cycle

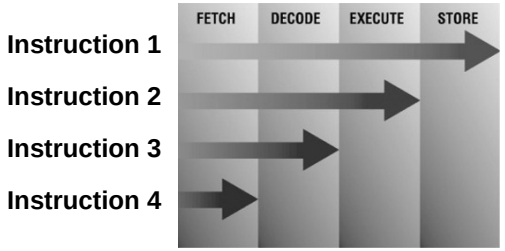


Pipelining

- CPU begins executing second instruction before completing first instruction. Results in faster processing

Machine Cycle (without pipelining)

Machine Cycle (with pipelining)

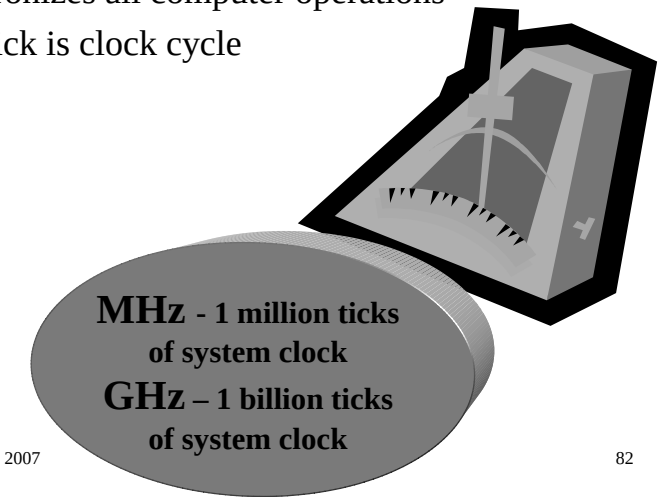


Register

- Temporary storage area that holds data and instructions
  - Stores location from where instruction was fetched
  - Stores instruction while it is being decoded
  - Stores results of calculation
  - Stores data while ALU processes it

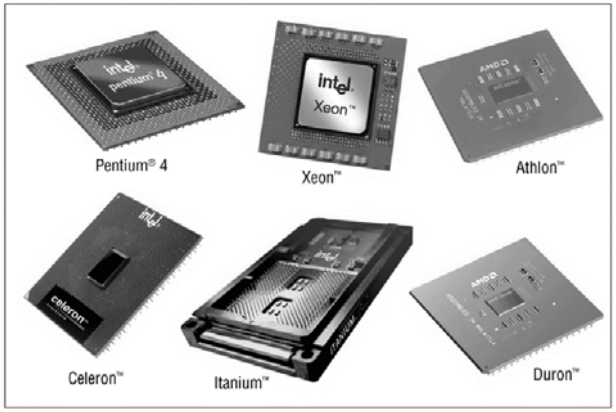
System Clock

- Synchronizes all computer operations
- Each tick is clock cycle



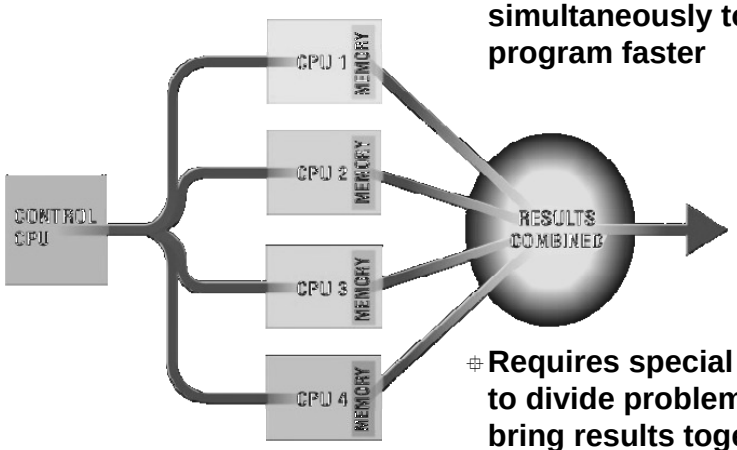
Microprocessor

- Single processor chip found in personal computers



Parallel Processing

- **Using multiple processors simultaneously to execute program faster**



- **Requires special software to divide problem and bring results together**

Memory: The CPU's Electronic Scratchpad

- Memory is the temporary storage area for operating system, application programs, and data
- It consists of one or more chips on motherboard
- Each byte stored in unique address
- This is circuitry used to store data within the processor while the computer is operating.
- A personal computer has two types of memory.
  - **Volatile Memory** – Loses its contents when computer's power is turned off
  - **Nonvolatile Memory** – Does not lose its contents when computer's power is turned off

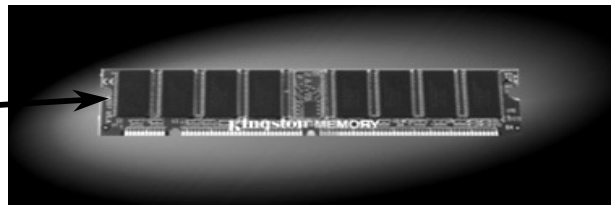
How is Memory Measured?

- Memory is measured by number of bytes available

Term	Abbreviation	Approximate Memory Size	Exact Memory Amount	Approximate Number of Pages of Text
Kilobyte	KB or K	1 thousand bytes	1,024 bytes	1/2
Megabyte	MB	1 million bytes	1,048,576 bytes	500
Gigabyte	GB	1 billion bytes	1,073,741,824 bytes	500,000
Terabyte	TB	1 trillion bytes	1,099,511,627,776 bytes	500,000,000

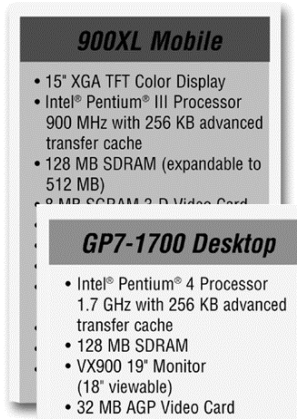
Random Access Memory (RAM)

- Memory chips that can be read from and written to by processor
- Most RAM is volatile
- The more RAM a computer has, the faster it operates



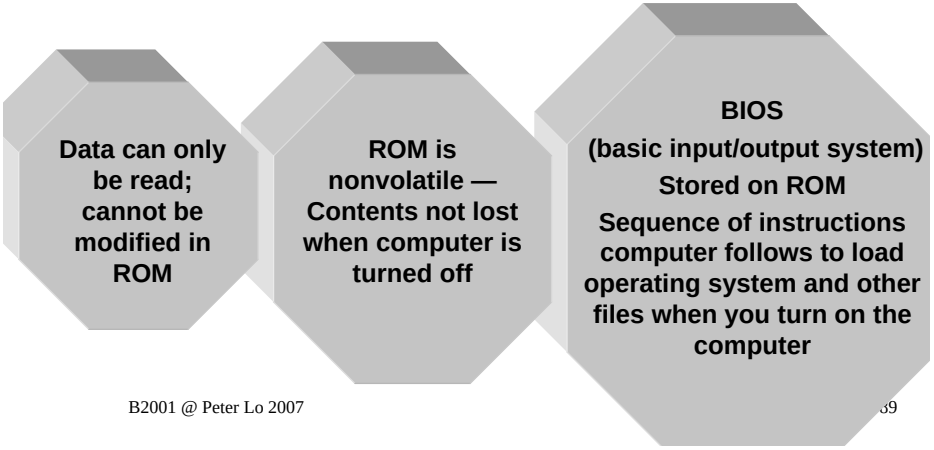
Cache

- Helps speed computer processes by storing frequently used instructions and data
- Also called **Memory Cache**, **Cache Store**, or **RAM Cache**
- L1 cache built in processor
- L2 and L3 cache not built in processor
- L2 advanced transfer cache most common



Read-Only Memory (ROM)

- Memory chips that contain data, instructions, or information that is recorded permanently

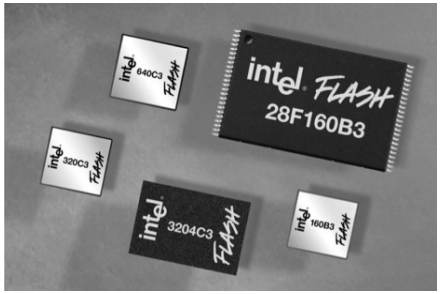


Types of ROM

- Firmware
  - ROM chips manufactured with permanently written data, instructions, or information
- PROM (Programmable Read-Only Memory)
  - Blank ROM on which you can place items permanently
- EEPROM (Electrically Erasable Programmable Read-Only Memory)
  - Type of PROM containing microcode programmer can erase

Flash Memory

- Nonvolatile memory that can be erased electronically and reprogrammed
- Used with handheld computers and digital cameras, cellular phones, and automobiles



CMOS

- CMOS stand for **Complementary Metal-Oxide Semiconductor** memory
- Stores information about the computer
  - Type of disk drives
  - Keyboard
  - Monitor
  - Current time and date
- Uses battery to retain information when computer is turned off

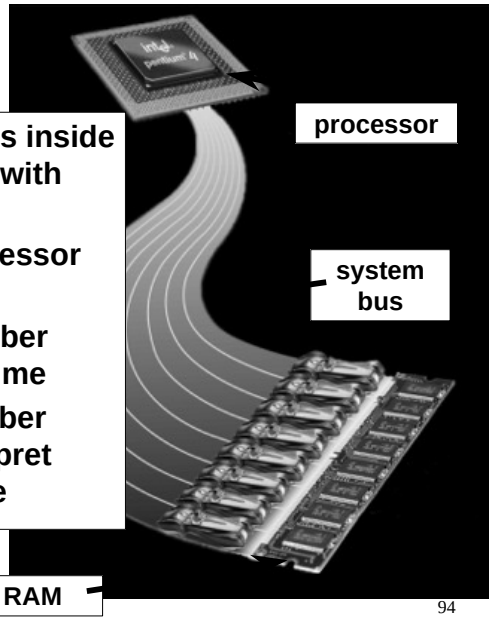
Memory Access Time

- Speed at which processor can access data from memory directly
- Measured in nanoseconds (ns), which is one billionth of a second
- It takes 1/10 of a second to blink your eye; a computer can perform up to 10 million operations in same amount of time

TERM	ABBREVIATION	SPEED
Millisecond	ms	One-thousandth of a second
Microsecond	µs	One-millionth of a second
Nanosecond	ns	One-billionth of a second
Picosecond	ps	One-trillionth of a second

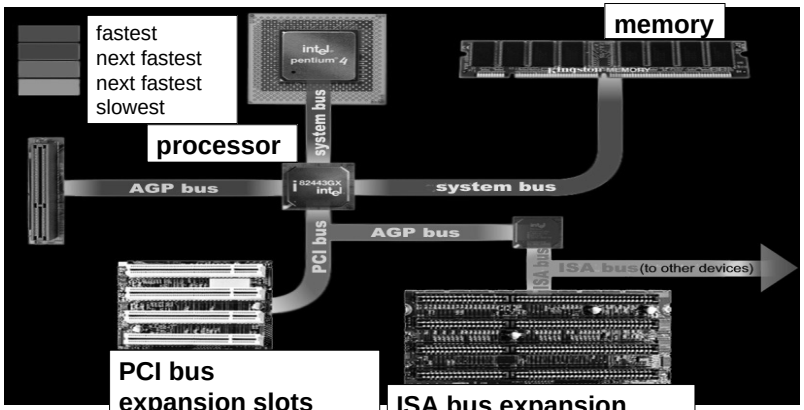
BUS

- **Channel that allows devices inside computer to communicate with each other**
- **System bus connects processor and RAM**
- **Bus width determines number of bits transmitted at one time**
- **Word size determines number of bits processor can interpret and execute at a given time**



Expansion Bus

- Allows processor to communicate with peripherals



Computer Hardware and Technology Trends

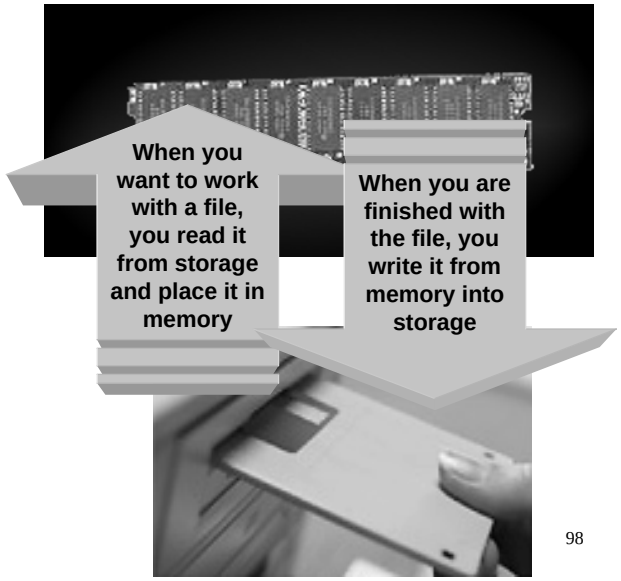
Storage

What is Storage?

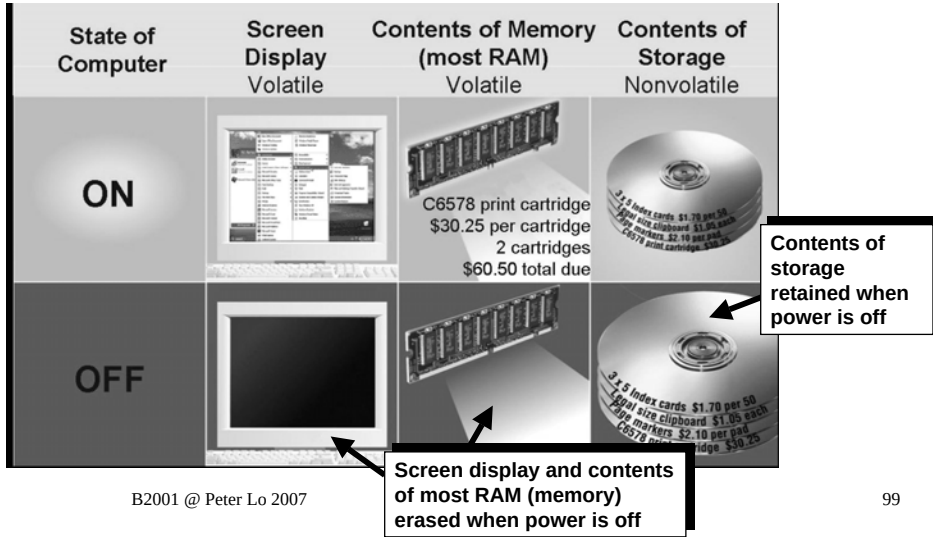
- Media and devices used to store and retrieve data, instructions, and information

How does storage differ from memory?

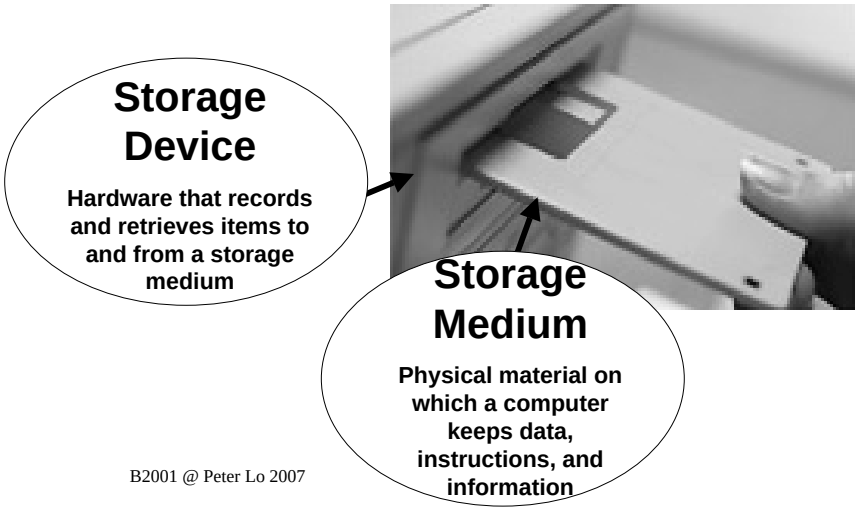
- Stores items for future use, rather than temporarily
- Storage is nonvolatile, rather than volatile



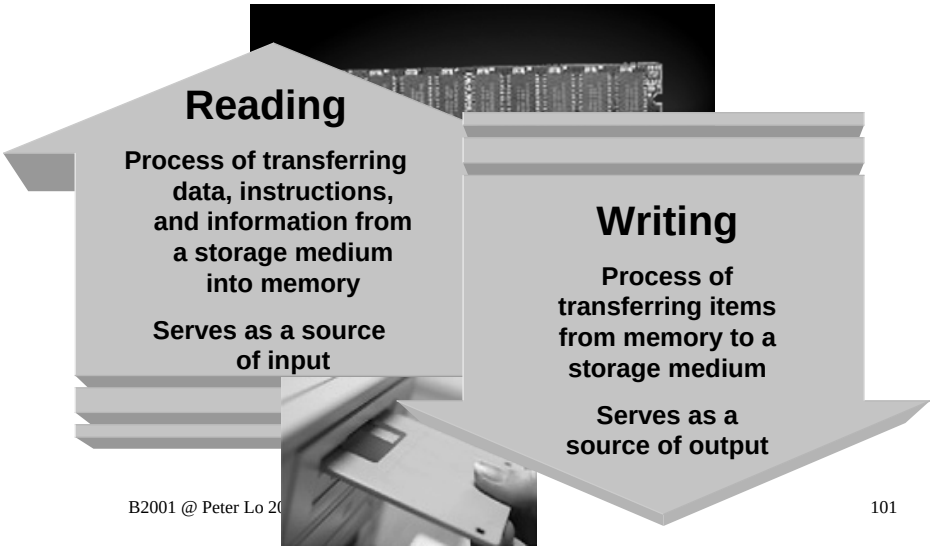
How does Volatility Compare?



What is a Storage Device and a Storage Medium?



Reading and Writing

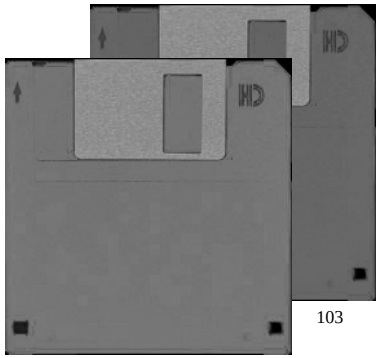


Memory vs. Storage (Summary)

	Device	Access Speed	Cost per MB
Memory	Cache Memory	Fastest	Highest
	RAM	Fast	High
Storage	Hard disk	Medium	Medium
	CD-ROM Disc	Slow	Low
	Backup Tape	Very Slow	Lowest

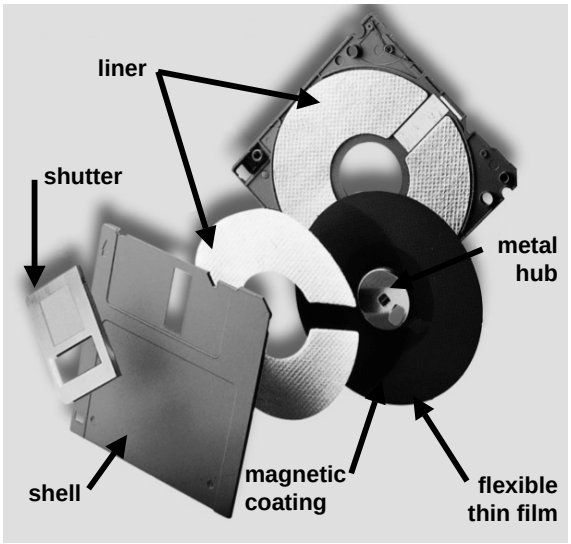
Floppy Disk

- Portable, inexpensive storage medium
- Today's standard disk is 3.5" wide



What are the parts of a floppy disk?

- Thin, circular, flexible film enclosed between two liners



How does a floppy disk drive work?

1: Shutter moves to expose recording surface on disk

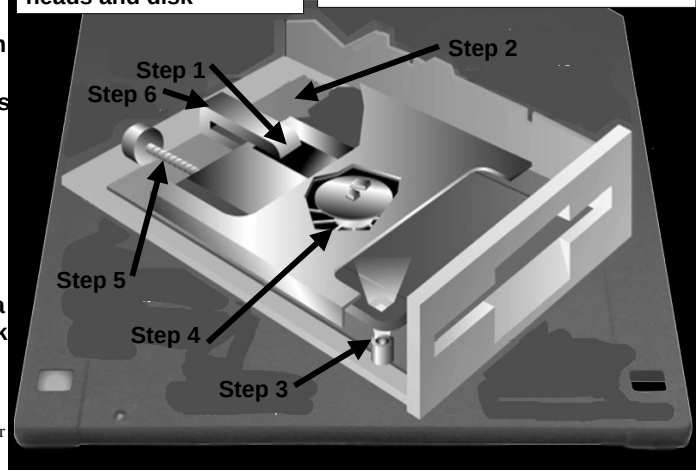
4: Motor causes floppy disk to spin

5: Motor positions read/write heads over correct location on disk

6: Read/write heads read data from or write data on the floppy disk

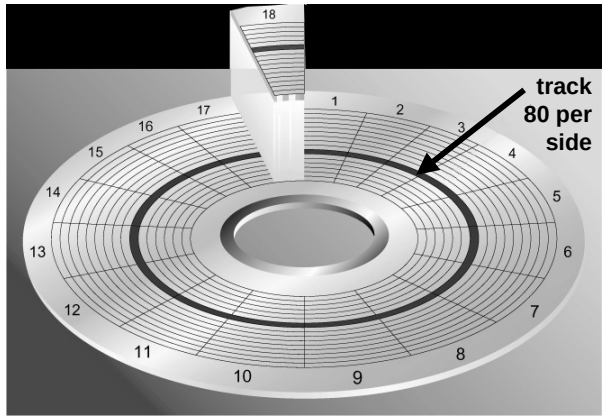
2: Signal sent to control movement of read/write heads and disk

3: If write instruction, circuit board verifies whether disk can be written to



Tracks and Sectors

- Track is narrow recording band that forms full circle on disk surface
- Sector can store up to 512 bytes of data



80 tracks per side x 18 sectors per track x 2 sides per disk x 512 bytes per sector = 1,474,560 bytes

How to Take Care a Floppy?

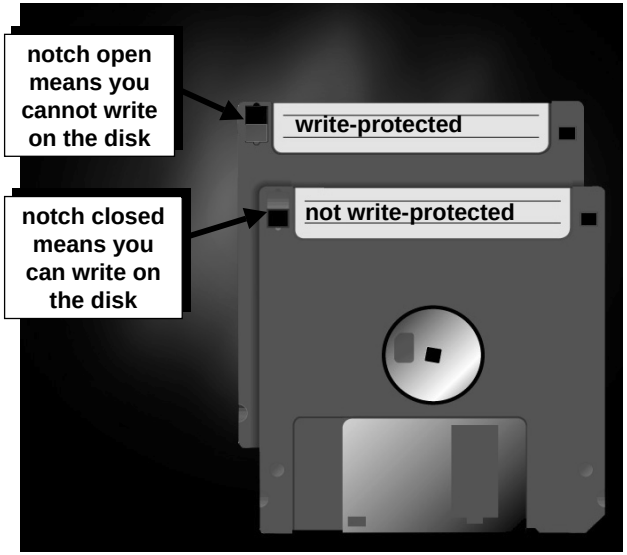
- Proper care helps maximize disk's life
- Floppy disk can last at least seven years

What is a Write-protect Notch?

- Small opening with a cover that you slide
- Protects floppy disks from being erased accidentally

notch open means you cannot write on the disk

notch closed means you can write on the disk

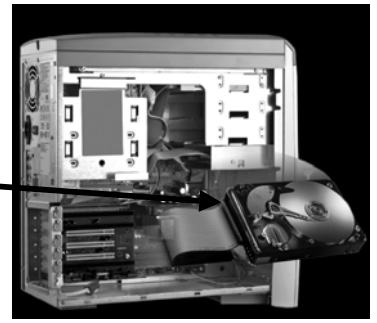


High-capacity Disk Drive

- Uses disks with capacities of 100 MB and greater
- Primarily used to backup files and transfer files

Hard Disk

- High-capacity storage
- Consists of several inflexible, circular platters that store items electronically
- Components enclosed in airtight, sealed case for protection



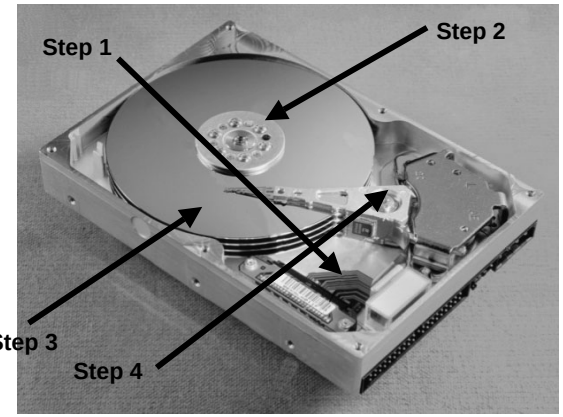
How does a Hard Disk Work?

1: Circuit board controls movement of head activator and small motor

2: Small motor spins platters

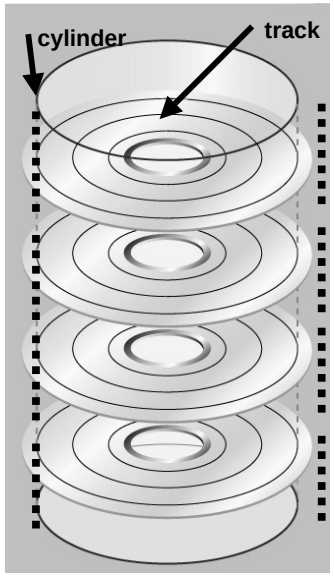
3: When software requests disk access, read/write heads determine location of data

4: Head actuator positions read/write head arms over correct location on platters to read or write data



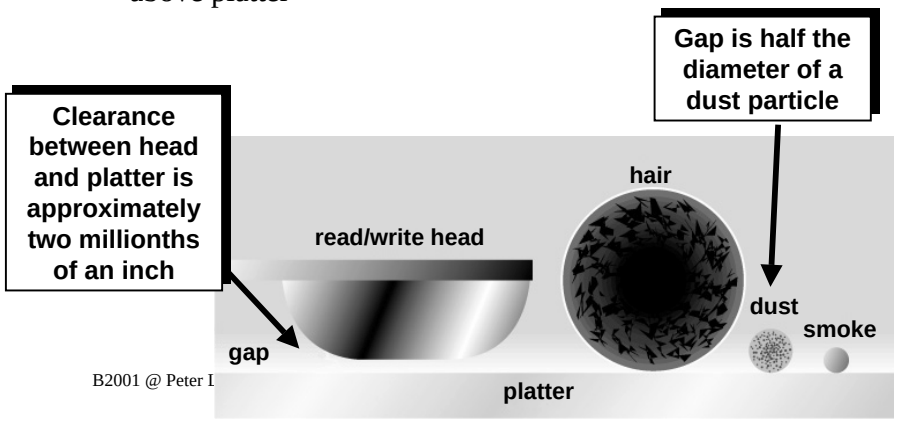
What is a Cylinder?

- Location of a single track through all platters
- Single movement of read/write head arms can read same track on all platters



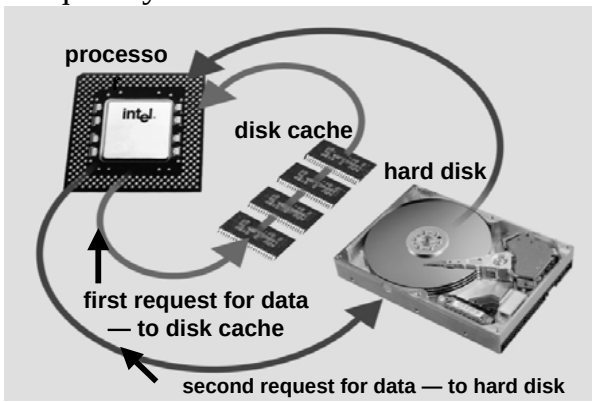
A Head Crash!

- Occurs when read/write head touches platter surface
- Spinning creates cushion of air that floats read/write head above platter



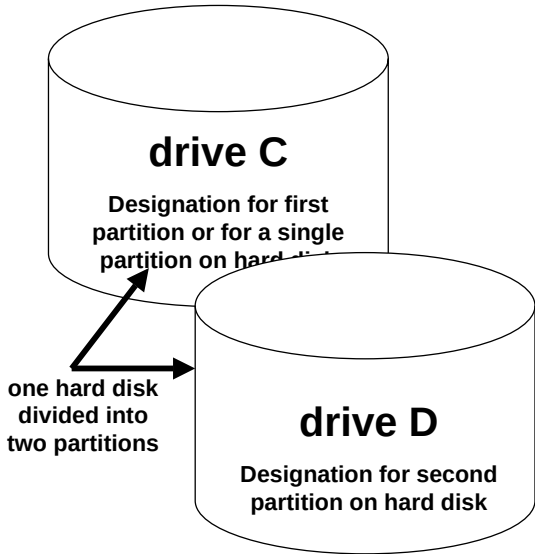
Disk Cache

- Portion of memory processor uses to store frequently accessed items



What is a Partition?

- Formatted hard disk divided into separate areas called partitions
- Each partition functions as if it were a separate hard disk drive



Removable Hard Disk

- Disk drive in which a plastic or metal case surrounds the hard disk so you can remove it from the drive
- Used for backup or to transfer files

ZIP Drive

- A high-capacity floppy disk drive developed by Iomega Corporation.
- Zip disks are slightly larger than conventional floppy disks, and about twice as thick.
- They can hold 100 or 250 MB of data.
- Because they're relatively inexpensive and durable, they have become a popular media for backing up hard disks and for transporting large files.

Compact Disc (CD)

CD-ROM

CD-R

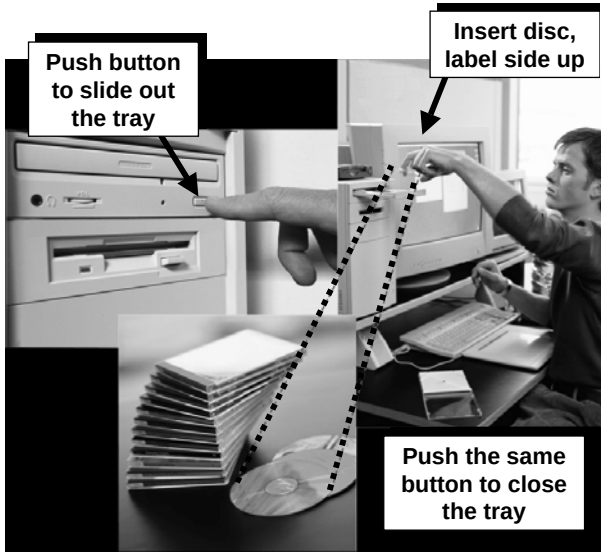
- Storage medium
- Most PCs include some type of compact disc drive
- Available in variety of formats

CD-RW

DVD+RW

How do you Use a Compact Disc?

- CD drives can read compact discs, including audio discs

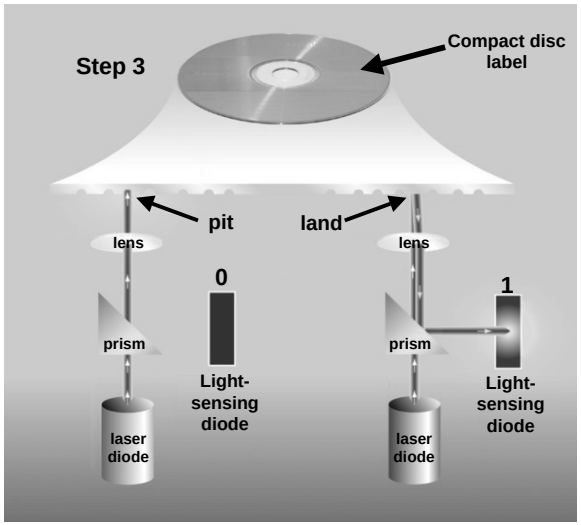


How does a Laser Read Data on a Compact Disc?

1: Laser diode shines light beam toward compact disc

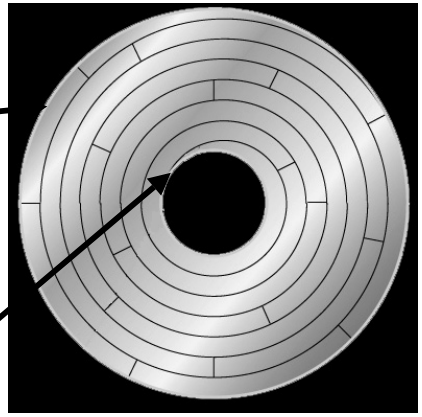
2: If light strikes pit, it scatters. If light strikes land, it is reflected back toward laser diode.

3: Reflected light deflected to light-sensing diode, which sends digital signal of 1. Absence of reflected light read as digital signal of 0.



How Data Stored on a Compact Disc?

- Typically stores items in single track
- Track divided into evenly sized sectors that store items



How should you Care for a Compact Disc?

1: Do not expose to excessive heat or sunlight
2: Do not eat, smoke, or drink near a disc
3: Do not stack
4: Do not touch underside
5: Store in jewel box when not in use
6: Hold disc by its edges

What is a CD-ROM?

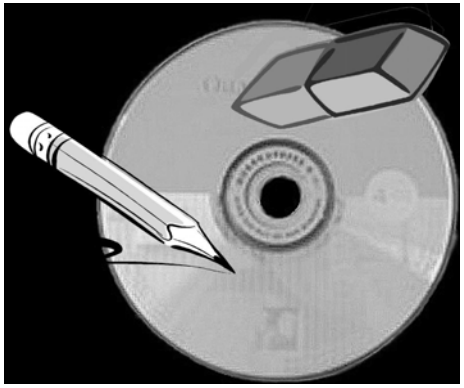
- Compact disc that uses same laser technology as audio CDs for recording music
- Cannot erase or modify contents
- Typical CD-ROM holds about 650 MB
- Commonly used to distribute software and games

CD-R (Compact Disc-Recordable)

- Compact disc onto which you can record text, graphics, and audio
- Write on CD-R using CD burner (recorder) or CD-R drive and special software
- CD-R drive can read and write both audio CDs and standard CD-ROMs
- Cannot erase disc's contents

CD-RW (Compact Disc-ReWritable)

- Erasable disc you can write on **Multiple Times**
- Must have a CD-RW disc, CD-RW software, and CD-RW drive



How to Create Audio CD?

Step 1: Artist composes song and creates CD

Step 2a: Song stored on audio CD and purchased by user

OR

Step 2b: Song compressed and stored on Internet

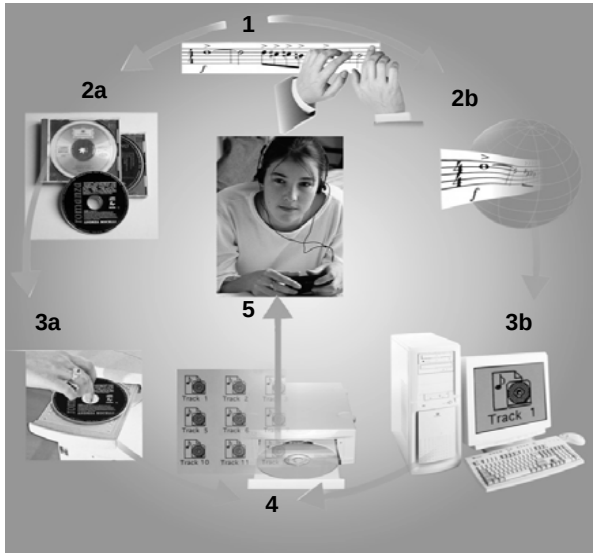
Step 3a: User inserts audio CD into CD-ROM drive, plays song, and copies it to hard disk

OR

Step 3b: User downloads song as audio file to hard disk

Step 4: User copies file to CD-RW disc

Step 5: User listens to song on personal computer or removes CD and listens to song on portable CD player



DVD-ROM (Digital Video Disc-ROM)

- High capacity compact disc capable of storing from 4.7 GB to 17 GB
- Must have DVD-ROM drive or DVD player to read DVD-ROM
- Primarily used for movies
- Next-generation software will be delivered on DVD

How does a DVD-ROM store data?

- Two layers of pits are used, where lower layer is semitransparent
- Laser can read through it to upper layer
- DVD+RW is a rewritable DVD

Sides	Layers	Storage Capacity
1	1	4.7 GB
1	2	8.5 GB
2	1	9.4 GB
2	2	17 GB

Tape

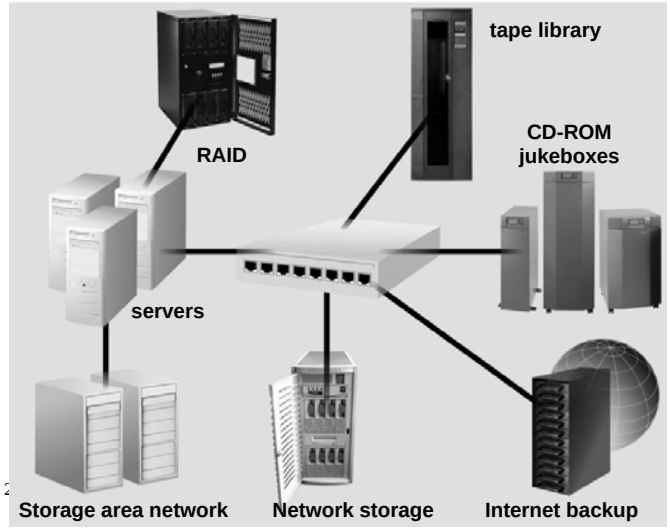
- Magnetically coated ribbon of plastic capable of storing large amounts of data and information at a low cost
- Primarily used for backup

Sequential Access vs. Direct Access

- Sequential Access
  - Reading and writing data consecutively
  - Method used for tape
- Direct Access
  - Can locate a particular data item or file immediately
  - Method used for floppy disks, hard disks, and compact discs
  - Also called Random Access

Enterprise Storage System

- Strategy that focuses on availability, protection , organization, and backup of storage in a company

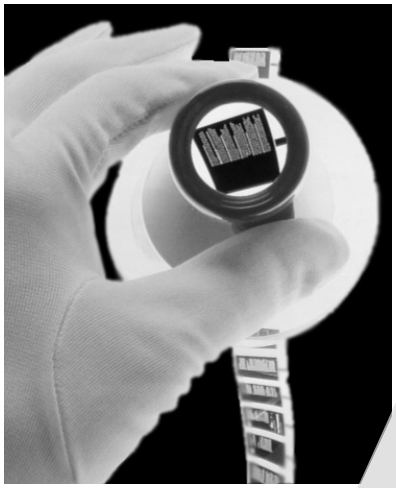


Miniature Mobile Storage Media

- Handheld devices use to augment internal storage

Device Name	Storage Capacity	Type, Use
CompactFlash	4 GB	Cartridge Digital cameras, notebook computers
Memory Stick	2 GB	Memory Card Digital cameras, handheld computers, notebook computers, printers, cellular telephones
Microdrive	6 GB	Memory Card Digital cameras, handheld computers, music players, video cameras
SmartMedia	2 GB	Memory Card Digital cameras, handheld computers, photo printers, cellular telephones

Microfilm and Microfiche



- Store microscopic images of documents on a roll or a sheet of film
- Images recorded using a **Computer Output Microfilm (COM) Recorder**

Microfilm

Uses a 100- to 215-foot roll of film

Microfiche

Uses a small sheet of film, usually 4" x 6"

Life Expectancies of Various Media

Media Type	Guaranteed Life Expectancy	Potential Life Expectancy
Tape	2 to 5 years	20 years
Compact Disc	5 years	50 to 100 years
Microfilm	100 years	200 years

Computer Hardware and Technology Trends

Technology Trends

Technology Trends – General

- Cost performance advantage of computers over manual labor
- The dominance of the GUI concept
- Dramatic increases to storage
- The use of intelligent agents to make computers appear 'smarter'
- Computers will become to be increasingly smaller in size and more portable
- Wearable computers: A consequence of nanotechnology
- An increasing importance in artificial intelligence and expert systems

Technology Trends – Hardware

- **Lower Cost and Greater Capability** – Advances in materials science, manufacturing, and concepts of computing promise to maintain the historic growth pattern in hardware power. Hardware prices have dropped while their capacity has increased. The improved capabilities of the computer include higher speed and larger storage capacity.
- **Better Reliability** – As hardware becomes cheaper, it is easier to justify hardware redundancy, which means having standby or duplicate hardware to act as a fallback in cases of hardware failure.
- **Portability** – Computers are becoming smaller and more portable. This can be seen in the notebook and palmtop computers.

Technology Trends – Networked Computing

- Mobile and wireless applications will take on increasing importance
- Home computing will be integrated with various electronic services to create smart appliances
- E-commerce will grow at an exponential rate
- The Internet will continue to penetrate every level of society
- Business to Business commerce will be increasingly done electronically

Technology Trends – Implications of Increased Computerization

- The hardware trends have resulted, and will continue to result in greater usage of computers and information processing. Many or all aspects of a business organization will be touched by the use of computers.
- The increased presence of computers brings with it a number of issues and risks.
  - **Security** – There will be greater concern for security, especially in view of the fact that all documents could be accessed by a hacker using a telephone line.
  - **Connectivity** – Differences in hardware and software purchased by different parts of an organization could result in problems in networking three computers, integrating the applications and sharing data.

Technology Trends – Convergence of Technologies

- Historically, data processing, telecommunications and office services have evolved separately.
  - Office services or systems include many equipment found in the office and which we take for granted today.
  - Data processing involves computers and software.
  - The telephone was not related to either technology.
- In the last few decades, we have seen a gradual merger of these technologies.
  - It would not be possible to have the international computer networks we know without using the telephone network for data transmission.
  - Similarly, the telephone systems are now managed using computers.

Intelligent Building

- Many end-user computing tools help to automate the office and therefore, these concepts overlap.
- Types of Telecommunication Services
  - The services to be considered include computer data, telephones and faxes, videoconferencing and so on. The media used is usually the telephone network but there are different options which must be considered to meet the traffic requirements.
- Transportation
  - The lifts, escalators and other transportation means must be carefully integrated. An intelligent building will ensure that lifts are sent to the floors which need them most.