

Computing A

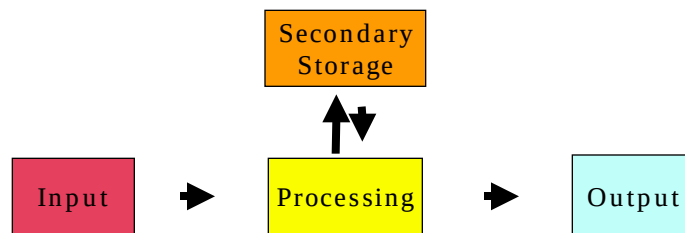
Week 3

CPU: Processing & Storage

Input & Output

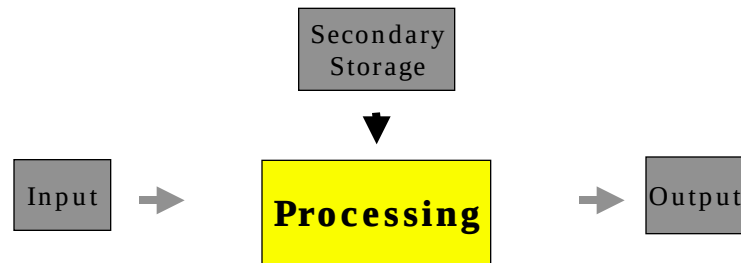
Functions of Computer Systems

Recall that there are four main functions of computer systems:



Processing

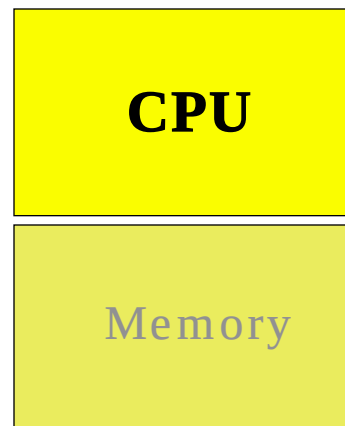
Today we will focus on the **central processing unit** (CPU) in more detail.



The CPU

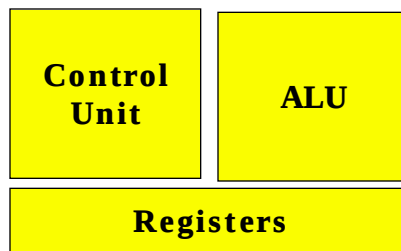
The **CPU** interacts closely with **memory** (primary storage).

Memory, however, is not part of the CPU.



Parts of the CPU

The CPU consists of a variety of parts including:



- Control unit
- Arithmetic/logic unit (ALU)
- Registers

The Control Unit...

directs the other parts of the computer system to execute stored program instructions.



The control unit communicates with the ALU and memory.

The Arithmetic/Logic Unit (ALU)...

performs **mathematical** operations as well as
logical operations.



Mathematical Operations

The ALU can perform four kinds of
mathematical calculations:

- **addition**
- **subtraction**
- **multiplication**
- **division**

Logical Operations

The ALU can perform logical operations.

Logical operations can test for these conditions:

- Equal-to (=)
- Less-than (<)
- Greater-than (>)

Registers...

are temporary storage areas for data or instructions.

Data held temporarily in registers can be accessed at greater speeds than data stored in memory.

Registers

Memory (Primary Storage)

Memory is the part of the computer that stores data and program instructions for processing.

CPU

Memory

Memory...

is also referred to as **RAM** (random-access memory).

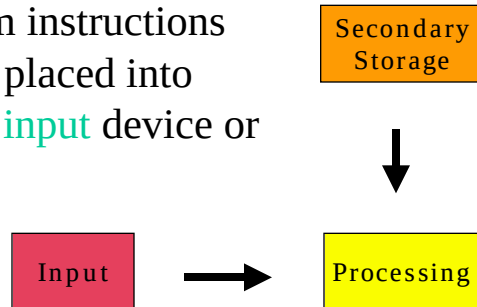
RAM is **temporary**, **finite**, and more **expensive** than secondary storage.

CPU

Memory

Executing Program Instructions

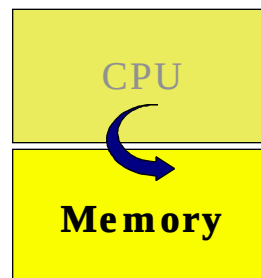
Before the CPU can execute a program, program instructions and data must be placed into memory from an **input** device or **storage** device.



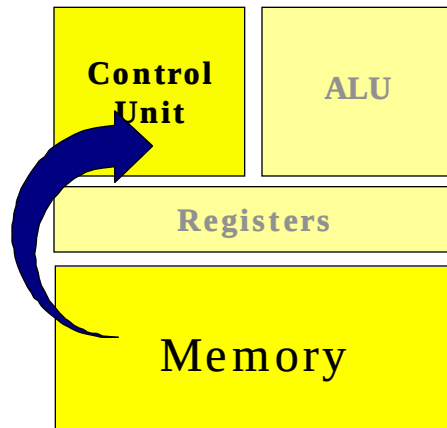
Executing Program Instructions

Once the necessary data and instructions are in memory, the CPU performs the following steps for each instruction:

- Fetching
- Decoding
- Executing
- Storing



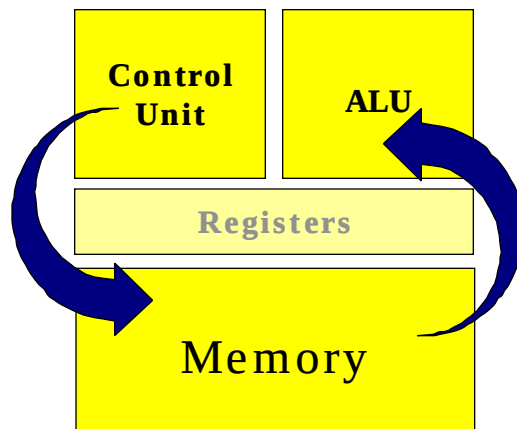
Fetching Instructions



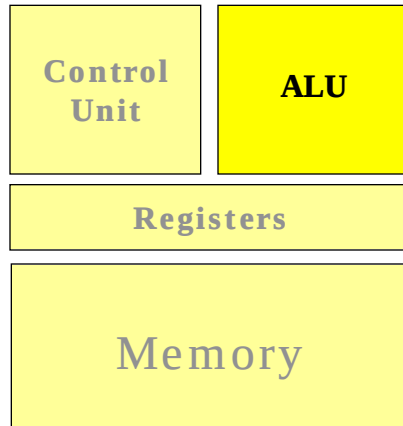
The control unit **fetches** (gets) the instruction from memory.

Decoding Instructions

The control unit decodes the instruction and directs that the necessary data be moved from memory to the ALU.



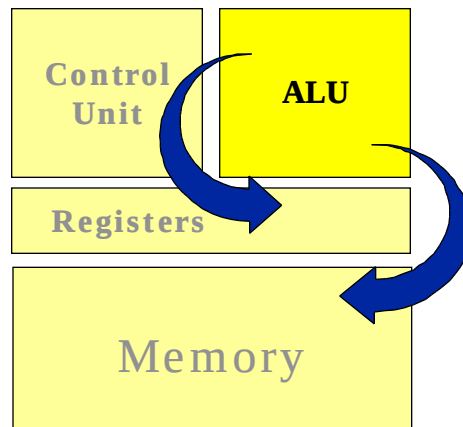
Arithmetic/Logic Operations



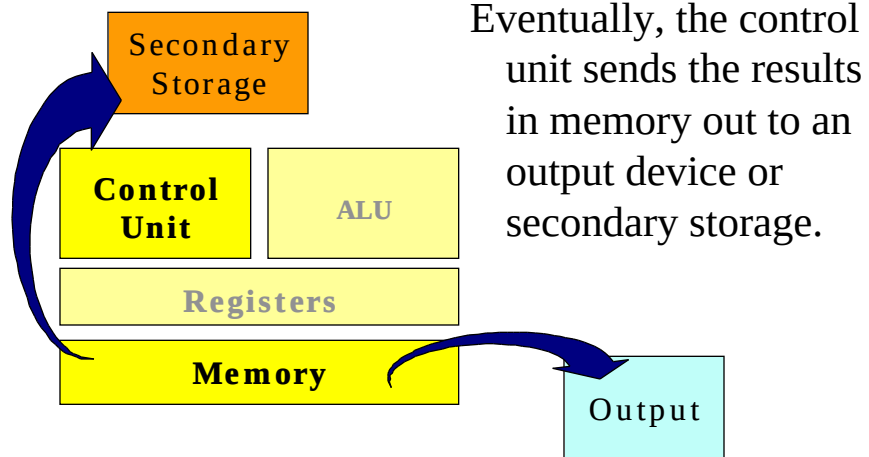
The ALU performs the arithmetic or logical operation on the data.

Storing Results

The ALU stores the result of its operation on the data in memory or in a register.

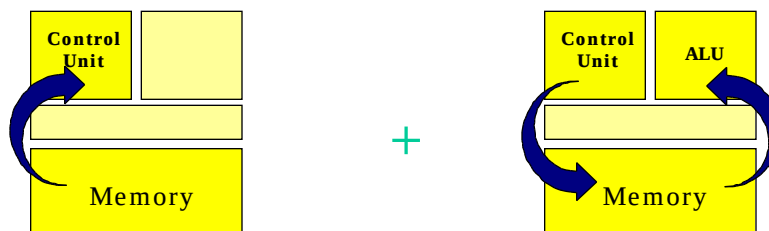


Executing Program Instructions



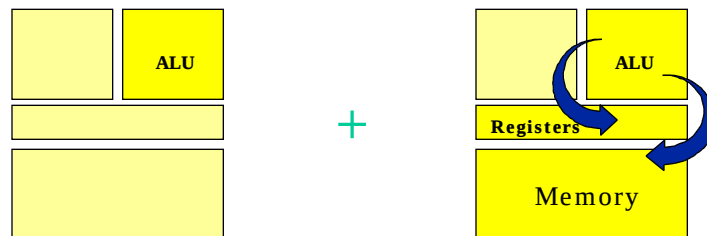
Instruction Time

The time it takes to fetch an instruction and decode it is called **instruction time**.



Execution Time

The time it takes to execute an ALU operation and then store the result is called **execution time**.



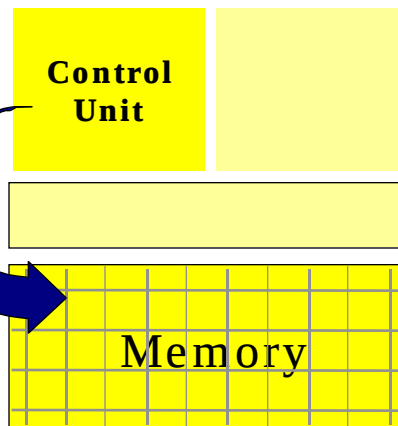
Machine Cycle

The combination of I-time and E-time is called the machine cycle.



Memory Locations and Addresses

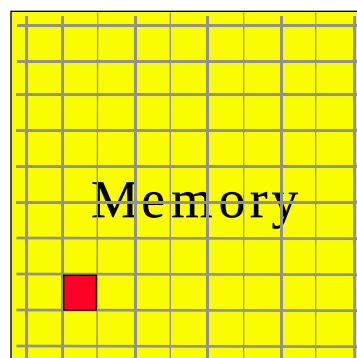
The control unit can find data and instructions because each location in memory has an **address**.



Storage Locations

Each location in memory is identified by an **address**.

Each location has a unique address.



Symbolic Addresses

The choice of the location in memory is arbitrary.

Addresses can only hold one **number** or **word**.

17		\$	
	%		Pat
Memory			364

Data Representation

The system in which all computer data is represented and manipulated is called the **binary system**.

Binary System

The binary system has only **two digits** to represent all values.

This corresponds to the **two states** of a computer's electrical system —on and off.

Off/On Switches

The computer can represent data by constructing combinations of **off** or **on** switches.

off



or



on

Zero or One

The binary system can also be represented by the digits **zero** and **one**.

0



or



1

Zero (off) and one (on) make up the two digits in the binary system.

The Bit

one bit



two bits



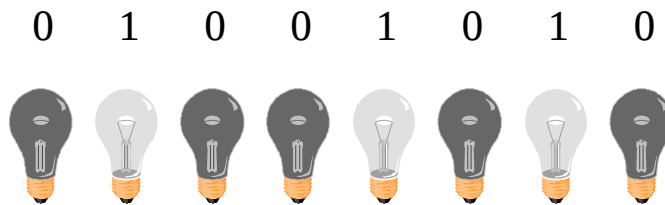
three bits



Each 0 or 1 in the binary system is called a **bit**.

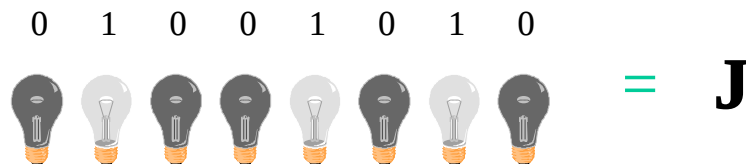
The Byte

A group of 8 bits is called a **byte**.



One Character of Data

Each byte represents **one character of data** (a letter, digit, or special character).



Storing Bytes

Storage and memory capacity is expressed in the **number of bytes** they can hold:

1 **kilo**byte = 2^{10} or 1024 bytes

1 **mega**byte = 2^{20} or 1,048,576 bytes

1 **giga**byte = 2^{30} or 1,073,741,824 bytes

Computer Word

A computer word is defined as the number of bits that constitute a common unit of data.

Computer Word Length

Word length varies by computer. For example:

8 bits = 1 byte = one word length

64 bits = 8 bytes = one word length

Coding the Computer

A code for determining which group of bits represent which characters on a keyboard is called ASCII.

ASCII

ASCII has been adopted, as the standard, by the U.S. government and is found in a variety of computers.

0 1 0 0 1 0 1 0 = **J**

ASCII-8 code

Keyboard character

Computer Speed and Power

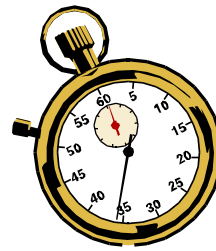
Speed and power are determined by:

- Microprocessor speed
- Bus lines
- Cache
- Flash memory
- RISC
- Parallel processing

Microprocessor Speeds

Microprocessor speeds can be measured in a variety of ways:

- Megahertz
- MIPS
- Megaflops



Megahertz

One measure of microprocessor speed is **megahertz** (MHz) which is one million machine cycles per second.

MIPS

Another measure of microprocessor speed is **MIPS** which is one million instructions per second.

Megaflops

Megaflops, or one million floating-point operations per second, is still another measure of microprocessor speed.

Bus Lines

A bus line is a set of parallel electrical paths.
A bus is like a mode of transportation for data.

Bus Width

The amount of data that can be carried at one time is bus width (wider = more data).



Cache

Cache is a relatively small block of very fast memory.

The data and instructions stored in cache are those that are **most recently or most frequently used**.

Cache speeds up the internal transfer of data and software instructions.

Flash Memory

Accessing data and instructions from within the CPU is fast but not when it comes from a secondary storage device.

Flash memory is **nonvolatile** (like secondary storage) but allows **fast access** (like RAM).

RISC

New RISC computers have chips with fewer instructions as a means of making them run faster.

Older, slower machines have chips (called CISC) with instructions that are seldom or never used.

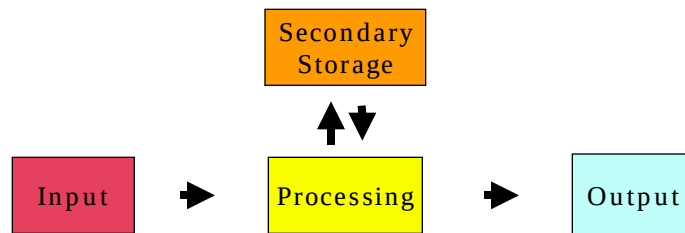
Parallel Processing

Using several processors at the same time (in parallel) greatly increases processing speed.

When parallel processing, the computer can be starting other tasks before the sequence of fetch-decode-execute-store is complete.

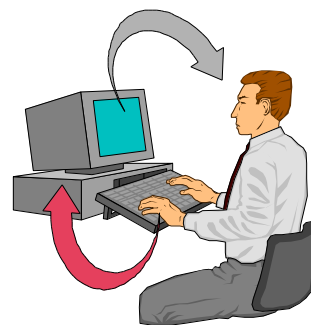
Functions of Computer Systems

Recall that there are four main functions of computer systems.



Input and Output

The computer user is very aware of inputting **data** and the output (processed information) that is the result.



Inputting Data

- Keyboard
- Mouse
- Trackball
- Magnetic-ink character recognition
- Scanner
- Optical mark recognition
- Optical character recognition
- Bar codes
- Handwritten characters
- Voice input
- Touch screens
- Looking

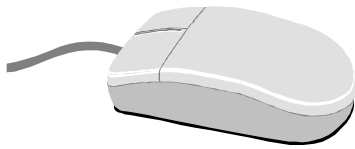
Keyboard

A keyboard is similar to a typewriter keyboard. Not all keyboards are traditional. Customized keyboards can be found in business, schools, and homes.



Mouse

The mouse movement corresponds to movement of the **pointer** (cursor) on the screen.

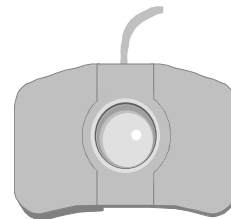


A mouse also has one or more **buttons** which allow selection of items on a screen.

Trackball

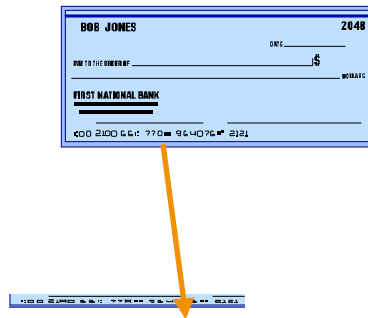
The trackball stays in one place while the user rolls the ball directly with their hand.

Trackballs are ideal when a flat surface does not exist.



Magnetic-ink Recognition

The most common example of characters made of magnetic particles can be seen on personal checks.



Scanner

A scanner is an **optical recognition** system that uses light to scan an image and convert it into electrical signals.



The signals are then processed so that the image appears on the computer monitor.

Optical Mark Recognition

This technique uses a machine to sense marks on a piece of paper.

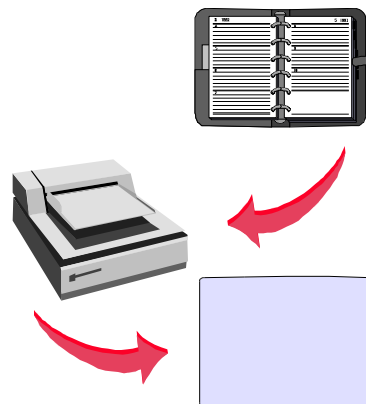
Computer-graded answer sheets rely on optical mark recognition (OMR) to score tests.

Exam				
	a	b	c	d
1.	☒	☐	☐	☐
2.	☐	☐	☒	☐
3.	☐	☒	☐	☐
4.	☒	☐	☐	☐
5.	☐	☐	☐	☒

Optical Character Recognition (OCR)

OCR devices use a light source to read special characters or printed text.

OCR devices can “read” pages in a book or sale tags on store merchandise.



Bar Codes

Bar codes appear on the product as a series of zebra-like stripes.

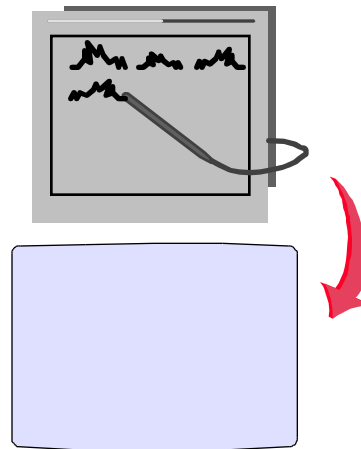
Bar codes are used to identify a product when read by a device called a **bar code reader**.



Handwritten Characters

Machines can read handwritten characters.

However, the size, completeness, and legibility of the handwriting must follow rigid rules.



Voice Input

Speaking to a computer requires **speech recognition** devices.

The computer processes the sounds into binary code and can “learn” what the code means.



Touch Screens

Touch screens are designed so that if touched, the computer knows what the person has selected.



Looking

In the future, input might be gathered from our eye movements, and watching images that appear on our retina.

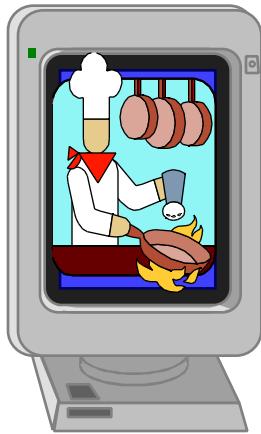


Output of Information

Useful information for the user can take on a variety of forms:

- Computer screens
- Printers
- Voice output
- Music and sound

Computer Screens



Screen output is known as **soft copy** because it is intangible and temporary.

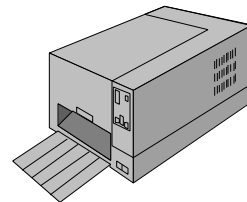
Most computer screens are of the **cathode ray** variety.

Printers

A printer is an output device that produces a **hard copy** of your work (a printout on paper).

There are two ways to print onto paper:

- **Impact**
- **Non-impact**



Music and Sound Output

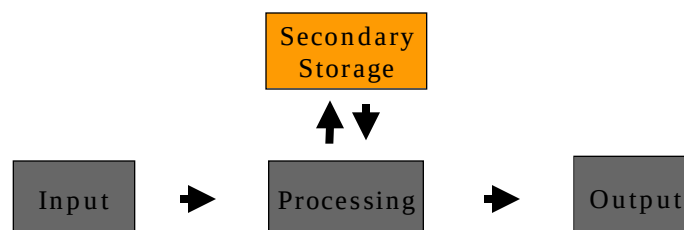
This can be as simple as attaching speakers to the computer to improve the quality of sound output.

For more serious output, sound chips can be added that simulate different instruments or sound effects.



Secondary Storage

Secondary Storage allows for semi-permanent storage of information.



Benefits of Secondary Storage

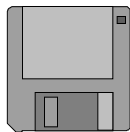
By separating storage from the computer, a number of benefits can be derived:

- Space
- Reliability
- Convenience
- Economy

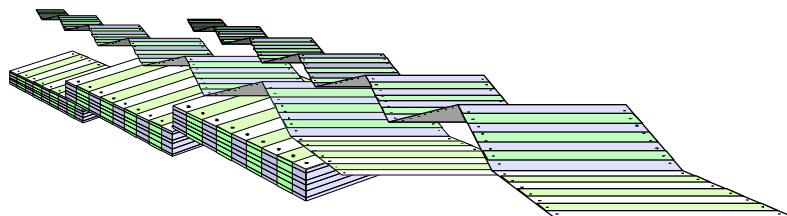
Secondary
Storage



Space



A diskette can hold the equivalent of 500 printed pages.



Reliability



Data in secondary storage is basically safe.

Sometimes, however, disks do fail.

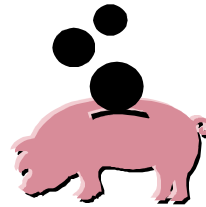
Convenience



Locating and accessing electronic data is much easier and faster than non-electronic means of storing information.

Economy

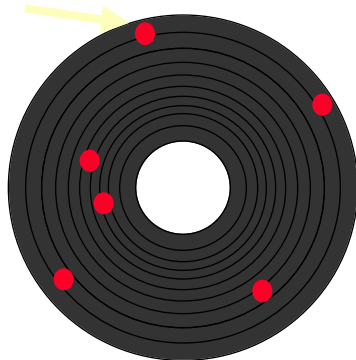
Together, space-saving,
reliability, and convenience
lead to cost savings for
businesses.



These savings are then passed on to
customers.

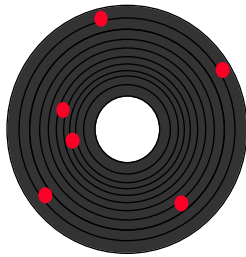
Magnetic Storage of Data

data



Data is represented as
magnetized spots
on a disk.

Bits on a Disk



A magnetized spot represents a **1** (bit).

The absence of a magnetized spot represents a **0** (bit).

Reading Data from Disk

Secondary
Storage



Processing

Reading data on a magnetic disk means converting the magnetized data into **electrical impulses** and sending them to the processor.

Writing Data to Disk

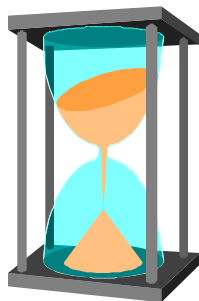
Secondary
Storage



Processing

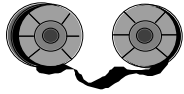
Writing data onto a magnetic disk means to convert electrical impulses from the processor into **magnetic spots** on the disk.

Longevity of Digital Documents



Although digitized information is theoretically invulnerable, the physical media on which it is stored has a **limited physical lifetime**.

Limited Lifetimes



Magnetic tape 1 yr.



Videotape 1–2 yrs.



Magnetic disk 5–10 yrs.



Optical disk 30 yrs.

Types of Magnetic Storage Media

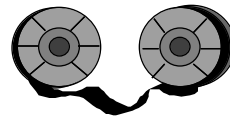
There are various types of magnetic storage media:

- Magnetic tape
- Diskettes
- Hard disks
- Optical disks

Magnetic Tape

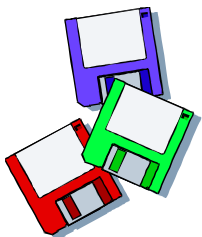
Tape density refers to the stored number of characters (or bytes) per inch.

In businesses, magnetic tape is usually reserved for **backup** purposes.



Diskettes

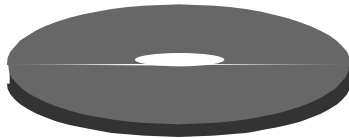
Diskettes are made of a flexible mylar disk enclosed in a hard casing.



Advantages of diskettes:

- **portability**
- **easy backup of files**
- **new software releases**

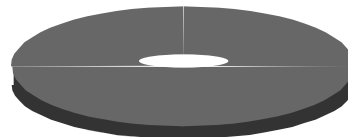
Hard Disks



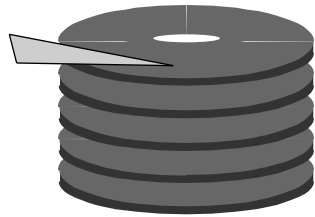
A hard disk is a **metal platter** coated with magnetic oxide that can be magnetized to represent data.

Benefits of Hard Disks

- **Size**—more data can be stored on a hard disk than on a diskette.
- **Necessary for graphics**—larger storage capacity is required for audio, graphic, and video files.
- **Faster access**



Disk Packs

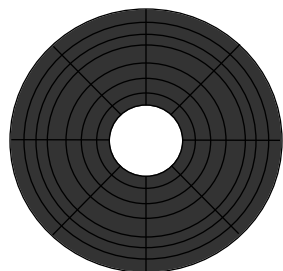


Several hard disks can be assembled into a **disk pack**.

An **access arm** moves the read/write head over the tracks on a hard disk.

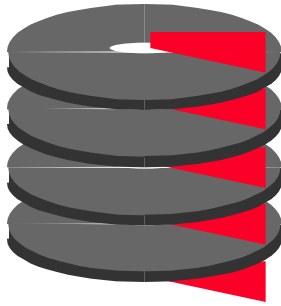
Sector Method

In the sector method, each **track** on a disk ...



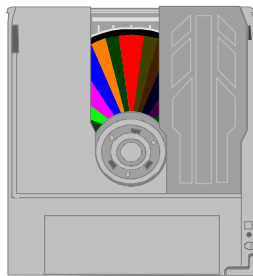
is divided into **sectors** that hold a specific number of characters.

Cylinder Method



Using the cylinder method to organize data on a hard disk, the data is stored **vertically** within the disk pack.

Optical Disks



An optical disk consists of a disk with a metallic layer.

A laser is used to read/write to an optical disk.

Types of Optical Storage Media

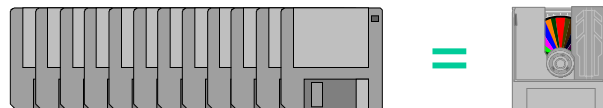
The various types of optical storage media include:

- Read-only
- Write-once/read-many
- Magneto-optical
- CD-ROM
- DVD-ROM

Read-Only

These disks can **only be read** from, not written to.

The information stored on dozens of diskettes can be stored on one optical disk.



Write-once/Read-many

Often referred to as WORM, after data is written on them, these disks become a read-only medium.

WORM disks are ideal for securing original versions of valuable documents and data.

Magneto-optical

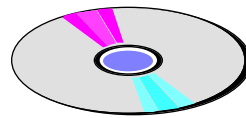
A magneto-optical disk combines the **ability to write to disk** [magnetic disk feature] with a **high volume of storage** capacity [optical disk feature].

CD-ROM

CD-ROM stands for **compact disk, read-only memory**.

A CD-ROM is identical to audio compact disks.

Up to 660 MB of storage space is available per disk.



DVD-ROM

DVD stands for digital video disk.

A DVD-ROM can store from 4.7 GB (more than seven times that of a CD-ROM) to 17 GB.

Such storage capacity is needed for files containing both text, audio, graphics, and video—in other words, **multimedia**.