

# المحاضرة الاولى

## Lecture1

### 1. History of Computers

The invention of numbers led to arithmetic and all kinds of calculating devices like "abacus". The abacus is an instrument used to perform arithmetic calculations, which has been used in orient for over 3000 years. The device still in use today in China, Japan, and Korea. See Figure 1.

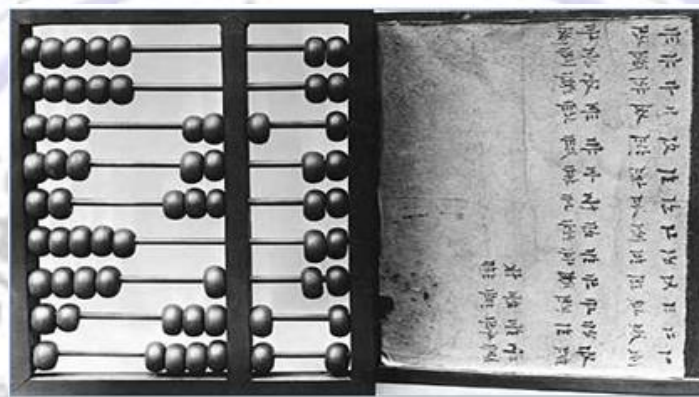


Figure 1 Abacas.

Abacus had little competition until the 1600's when **John Napier** used algorithms as the basis for a device which multiplied numbers. His work let to the invention of the "slide rule". See Figure 2.

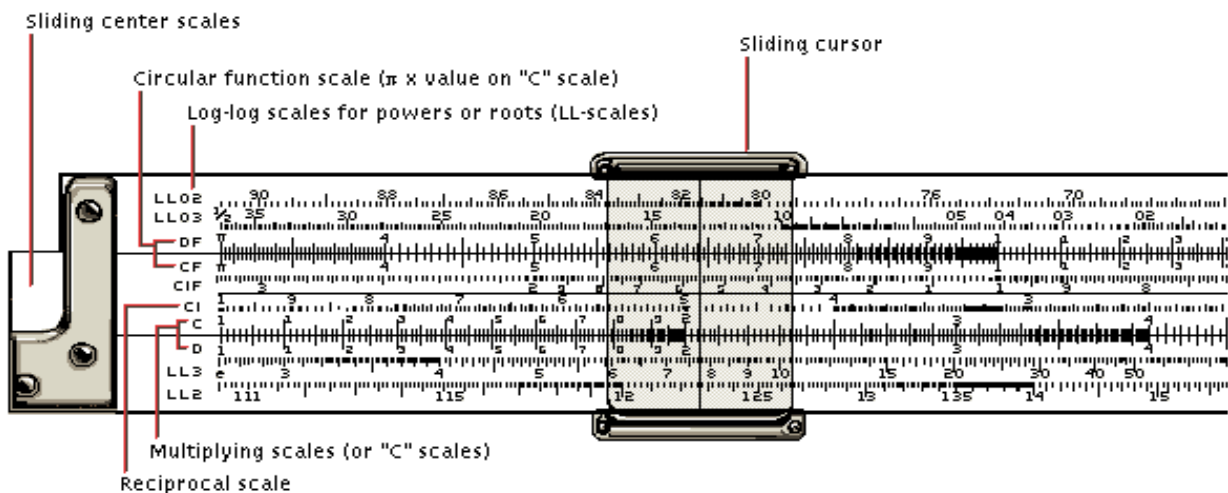


Figure 2 Slide Rule.

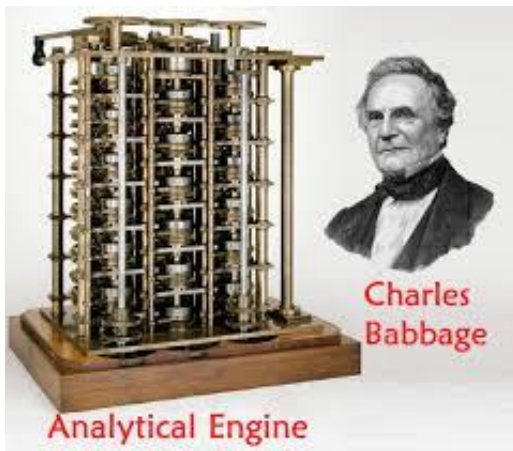
The history of computer dated back to the period of scientific revolution (1543 – 1678). French philosopher **Blaise Pascal** invented a machine in 1642 that added and subtracted, automatically carrying and borrowing digits from column to column see Figure 3. Pascal built 50 copies of his machine. Later in seventeenth century German mathematician **Gottfried Leibniz** designed a special system to enable multiplication on Pascal's machine. Both Pascal and Leibniz mac marked the genesis of the application of machine in industry.



Figure 3 The first mechanical computer by Pascal.

In the early of 1820's the British scientist **Charles Babbage** designed a mechanical computer was called *Difference Engine* (he never built it); it was intended to be a machine with a 20-decimal capacity that could solve mathematical problems. Babbage also made plans for another machine that called the *Analytical Engine* which considered the first programable computer that capable of performing all arithmetic operations efficiently. Babbage paved the way for modern digital computers as his *Analytical Engine* was built around the same five components (input, output, control, storage, memory, and ALU) used in modern digital computer. See Figure 4.

The punched card the used by *Analytical Engine* was firstly programmed by **Ada Lovelace** (English mathematician) who consider the first computer programmer (Figure 5). The early programming language **Ada** was named for her, and the second Tuesday in October has become Ada Lovelace Day, on which the contributions of women to science, technology, engineering, and mathematics are honored.

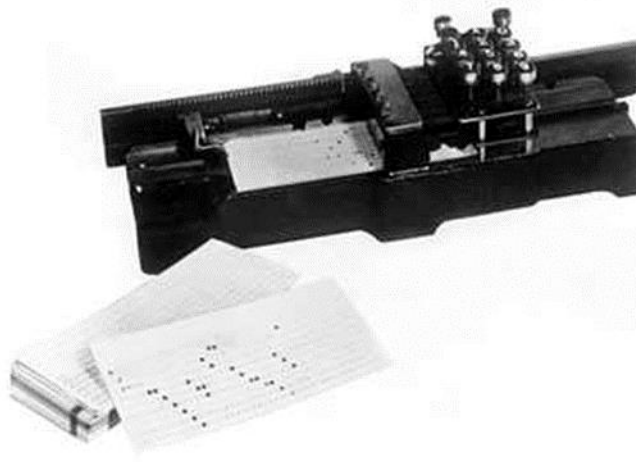


*Figure 4 Analytical Engine by Babbage*



*Figure 5 Ada Lovelace exhibition, with the Difference Engine in the foreground. Credit: Science Museum*

The first real progress toward computer come in the late of 1930's. American mathematician **Howard Aiken** introduced the first computer science program at Harvard University. His computer had to read instruction from punched cards<sup>1</sup> which could be stored away from the computer. See Figure 6.



*Figure 6 Punched card machine.*

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<sup>1</sup>"Punched card: about 3 inches high by 7 inches long, on which 80 columns of data could be entered in the form of holes punched with a keypunch machine. The punched holes corresponded to numbers, letters, and other characters and could be read by a computer that used a punched-card reader" 0



In 1936 British mathematician **Alan Turing** proposed the idea of a machine that could process equations without human direction. The machine (now known as a *Turing machine*) resembled an automatic typewriter that used symbols for math and logic instead of letters.

Between 1937 and 1939, American physicist **John Vincent Atanasoff** at Iowa State College built a computing device called the ABC (**A**tanassof **B**erry Computer) with the help of his assistant **Clifford Berry**. ABC used the binary arithmetic system of 1s and 0s commonly used in today's computers as well as a memory drum that stored data in a method similar to the storage technique used in modern memory chips.

Then in the early 1940's **John Mauchly** and **John Eckert** of the University of Pennsylvania designed a first general-purpose machine built using vacuum tubes<sup>2</sup> which they called "**ENIAC**" (**E**lectronic **N**umerical **I**ntegrator **A**nd **C**alculator). It was completed in 1945, used 18000 vacuum tubes, each the size of a small light bulb. It was composed of 30 separate units with additional power supplies and cooling units. It weighed more than 30 tons, occupied 1800 ft<sup>2</sup> room and consumed 175 kw of power. It used decimal arithmetic in its operations rather than the binary arithmetic. It was programmed through manual setting of switches and plugging of cables. ENIAC was very slow by today's standard, with limited amount of storage. See Figure 7.



*Figure 7 ENIAC the first electronic computer.*

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<sup>2</sup>Vacuum Tubes: electronic devices, consisting of a glass or steel vacuum envelope and two or more electrodes between which electrons can move freely.

In 1948 **Eckert** and **Mauchly** built an improved machine called the "**EDVAC**" (**E**lectronic **D**iscrete **V**ariable **A**utomatic **C**omputer), which incorporated some important design innovations by Hungarian American mathematician **John von Neumann**, which was an attempt to improve the way programs are entered and explore the concept of stored program.

In 1949 while the EDVAC project was in progress, a similar project was intended at Cambridge University. The project was to build a stored-program computer, known as "**EDSAC**" (**E**lectronic **D**elay **S**torage **A**utomatic **C**alculator). EDSAC became the world's full-scale, stored program, fully operational computer. Eckert and Mauchly eventually formed their own company; they produced the Universal Automatic Computer "**UNIVAC**", which was the first electronic computer designed to solve commercial problems, Figure 8. The UNIVAC contained about 5000 vacuum tubes, occupied 943 cubic feet, and weighed 8 tons. The first UNIVAC was delivered to the United States Census Bureau in 1951. The UNIVAC was a successor to the first general-purpose electronic computer ENIAC.



*Figure 8 UNIVAC computer system.*

ENIAC, EDSAC, EDVAC and other vacuum tube computer of 1940's have been labeled as the first generation of digital computer.

All these types of computer had the following disadvantages:

1. Limited amount of storage.
2. Unreliable because of using the vacuum tube.
3. Frequently burned out, and difficult to repair.
4. Difficult to programmed, for example ENIAC it is programmed by plugging wires into 3 walls of plug-boarder containing over 6000 switches.
5. Big size and weight.

In 1948, at **Bell** Telephone Laboratories, American physicists developed the *transistor*, a device that can act as an electric switch. The transistor had a tremendous impact on computer design, replacing costly, energy-inefficient, and unreliable vacuum tubes.

In 1952 IBM\* announced its first computer, the IBM701. In 1964 IBM introduced a line of products under the name IBM360 series. This led Digital Equipment Corporation [DEC]\* to introduce PDP-8 the first *minicomputer* (Minicomputer: smaller size machine with lower cost, size and computing power). While in 1971 Intel\* introduced the first *microprocessor* Intel4004 for *microcomputer* (Microcomputer: very small computer, low in price).

In 1977 Apple\* introduced a series of first *personal computers* (PCs) by **Altair** (PCs: is a machine capable of performing calculations and instructions quickly and repetitively. It designed to be used by a single person at a time).

In the 1980's *workstations* are introduced. Workstations are similar to personal computers but have greater memory and more extensive mathematical abilities, and they are connected to other workstations or personal computers to exchange data. See Table 1.

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\*"IBM [International Business Machines], DEC, Intel, Apple"are Corporations names"p"roducing computers.



*Table 1 Summary of computer history.*

Machine name	Inventor/Place	Duration
Abacus	In orient	over 3000 years
Slide rule	J. Napier	1600's
Pascal machine	B. Pascal	1642
Leibniz machine	G. Leibniz	1700's
Difference Engine Analytical Engine	C. Babbage	1820's
Punched card machine	H. Aiken/ Harvard University	1930's
Turing machine	A. Turing	1936
ABC	Atanasoff & Berry/ Iowa State College	1937-1939
ENIAC	Mauchly & Eckert/ University of Pennsylvania	1940
EDVAC	Mauchly & Eckert & Neumann	1948
EDSAC	Cambridge University	1949
UNIVAC	Mauchly & Eckert/ United States Census Bureau	1951
IBM701.	IBM corporation	1952
IBM360 series	IBM corporation	1964
PDP-8 (minicomputer)	DEC corporation	1970's
Intel4004 (microcomputer)	Intel corporation	1971
PCs	Altair/ Apple corporation	1977
Workstation		1980's
Parallel computer		1990's



## 2. Computer Generations

### 1. The first generation (1951-1958): -

- First generation computers were **vacuum tube** to provide electronic circuits.
- For memory these computers used a magnetic drum (magnetic drum: a rotating cylinder whose outer surface could be magnetized).
- Punched cards were used for input for both data and programs.
- Programming instructions were given in machine language which is code composed entirely of 0's and 1's.
- These computers were slow, unreliable, expensive and tedious to program.

### 2. The second generation (1958-1964): -

- The second generation of computer began when **transistor** replaced vacuum tube. Transistors were 1/200th the size of vacuum tube, generated less heat, faster and failed less often.
- Internal memory was composed of tiny magnetic core strung on thin intersecting wires.
- Magnetic tape replaced punched cards for input and output.
- Printer will speed up to 600 lines per minute were developed for output results.
- Also, this generation brought improvement in software. One of the important developments was the invention of high-level programming languages like (FORTRAN, COBOL). Unlike machine language, the high-level programming language uses names and commands that resemble English.

### 3. The third generation (1964-1971): -

- **Integrated circuits** (IC) replaced transistors in third generation computer. IC is a complex electronic circuit etched on a tiny silicon chip about (1/4) inch square.
- Each IC (at that time) contains hundreds of transistors on a single chip; therefore, it is smaller, faster and more reliable than wiring together separate transistors.
- Improvement also occurred in the equipment attached to computers to handle input, output and storage. These are called peripheral devices.
- Magnetic disks replaced magnetic tape for storing information if rapid access of data was required.
- Printers were capable of printing nearly three thousand lines per minute.
- The television like cathode ray tube (CRT) was developed to display input and output.
- Operating system (OS) capable of time sharing began to appear during the third generation. Time sharing allows many users to use a single computer simultaneously.
- New programming language was developed that is called BASIC which is one early learned language initially designed for teaching students to program on time-shared computers.

- In the late 1960 another type of computer appears called minicomputer. These minicomputers which derive their name from their size and cost, they have been used in many applications.

#### 4. The fourth generation (1971- ....): -

- The beginning of forth generation computer comes with the development of *large-scale integration (LSI)* circuits.
- LSI circuits is a single chip that contains (at that time) thousands of transistors. LSI puts many more circuits on each silicon chip than was possible on earlier IC.
- Mainframe computer can support extensive time-sharing, that is, up to several hundred users may use the computer at the only one using it.
- Time-sharing is also possible on the smaller computer (minicomputer) but fewer than fifty users can use these computers simultaneously.
- In addition, programs and peripheral devices such as: disk, printer have growth in variety, capacity and sophistication.



# المحاضرة الثانية

## Lecture2

### 1. Computer Definition

A **Computer** is a fast electronic machine, which accept input data, processed it according to a program stored in its memory and produces the resultant output information. Alternatively, the **Computer** is a machine that performs tasks, such as calculations or electronic communication, under the control of a set of instructions called a program. **Programs** usually reside within the computer and are retrieved and processed by the computer's electronics. The program results are stored or routed to output devices, such as video display monitors or printers. Computers perform a wide variety of activities reliably, accurately, and quickly.

### 2. Purpose of a Computer

The purpose of a computer is to (turn) process **data** into **information** See Figure 1.

- **Data:** consist of the raw facts and figures that are processed into information (**datum** is a singular form of data). For example, the votes for different candidates being elected considered as data. Also, numbers, alphabets, text, photos, graphics, audio and video considered as data.
- **Information:** is data that has been summarized or otherwise manipulated for use in decision making. For example, the total votes for each candidate or the statistics result from election which are used to decide who won, considered as information.



Data	Information
Raw fact of things	Processed form of data
Input to any system is treated as data	Output from any system is treated as information
Just number and text	Processed data and organized context
May have no meaning alone	Always have meaning

Figure 1 Difference between Data and Information.



### 3. Parts of computers

Computer systems are made of two main parts: **hardware** and **software**.

- Hardware: (H/W) is the physical equipment you see and touch when using a computer system. So, the physical computer and its components are known as hardware. Computer hardware includes the **memory** that stores data and program instructions; the central processing unit (**CPU**) that carries out program instructions; the **input devices**, such as a keyboard or mouse, that allow the user to communicate with the computer; the **output devices**, such as printers and video display monitors, that enable the computer to present information to the user; and **buses** (hardware lines or wires) that connect these and other computer components. See Figure 2. However, H/W is useless without software.

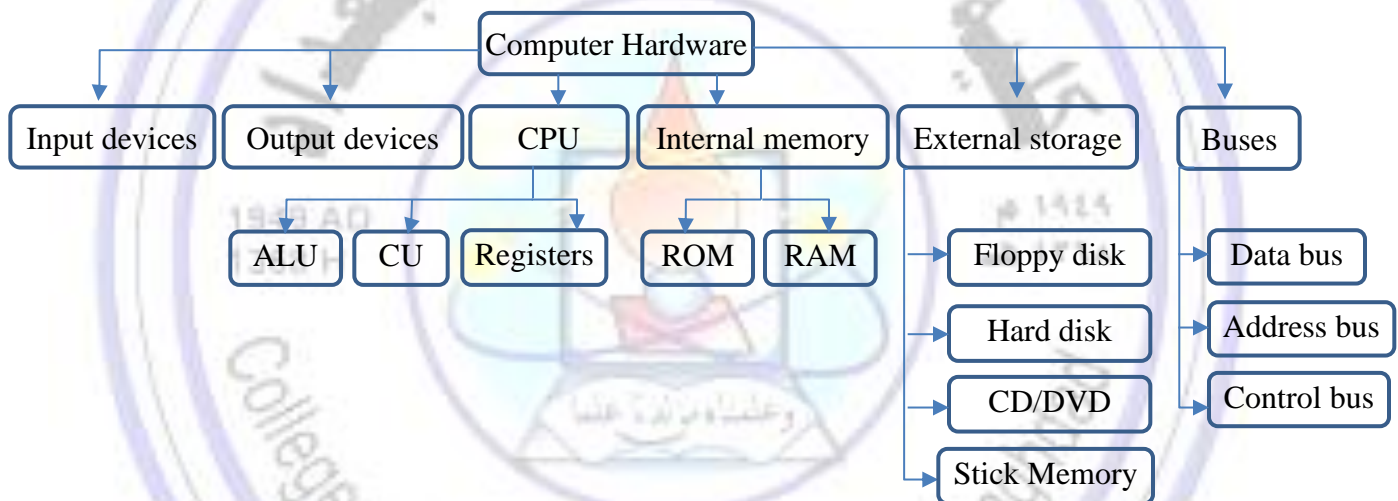


Figure 2 Computer Hardware Components.

- Software: (S/W) is the **programs** that run "control" the computer. Software generally is designed to perform a particular type of task, therefore; two types of computer software are classified into **application software** which include office application to manipulate texts, using Excel sheet or present slides. Application software also include program to display and modify a photograph or sound. While **systems software** includes programs like *operating systems* to direct the general operation in overall computer system, like DOS, Window, also include *programming languages* to write the computer programs, for example, BASIC, PASCAL, and *language processors* to translate the program that are written by the programmer into machine code that can be understood by the computer. See Figure 3.

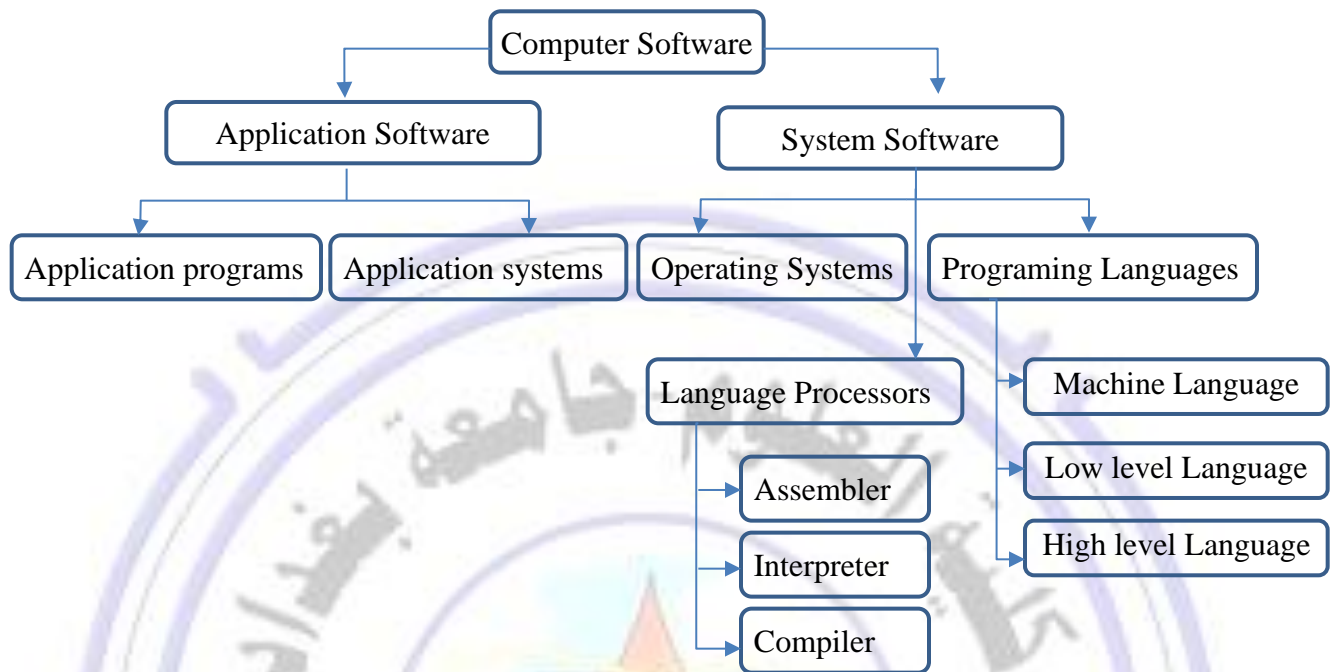


Figure 3 Computer Software Classification.

#### 4. Types of Computers:

Computers are classified into various types based on **purpose** (general or special purpose), **type of the processed data** (digital, analog, or hybrid). All modern computers are considered as digital computers which are also categorized according to their **size, storage capacity and speed**. See Figure 4.

##### 4.1 Computer types based on purpose

- **General purpose computer:** computers that follow instructions for general requirements, such as sale analysis, financial accounting, management information, etc. Almost all computers used in offices for education, commercial, and other applications are general purpose computers.
- **Special purpose computers:** computers designed from scratch to perform special tasks like scientific application and research, weather forecasting, space application, medical diagnostic are called special purpose computers.

#### 4.2 Computer types based on the processed data/technology used

- **Digital Computers:** operate on discrete data (0, 1). Digital refers to the processes in computers that manipulate binary numbers (0s or 1s), which represent switches that are turned on or off by electrical current. A bit can have the value 0 or the value 1, but nothing in between 0 and 1. Most modern computers are digital computers whose components have a finite number of states (0 or 1, or ON or OFF bits). These bits can be combined to denote information such as numbers, letters, graphics, sound, and program instructions.
- **Analog computers:** operate on continuous data range (0.5, 1.5, 2.25 ... etc.). Analog computers don't deal directly with numbers, so analog refers to circuits or numerical values that have a continuous range, such as current, voltage or frequency. They are programmed for measuring physical quantities like pressure, temperature, speed, and to perform computations on these measurements. Example of analog computer are thermometer and speedometer. Analog computers were the first type to be produced. A popular analog computer used in the 20th century was the slide rule. Because the sliding is continuous and there is no mechanism to stop at any exact values, the slide rule is analog.
- **Hybrid computers:** incorporate the technology of both analog and digital computers. These computers store and process analog signals that are converted into discrete numbers using analog-to-digital converters. They can also convert the digital numbers into analog signals using digital-to-analog converters. Hybrid computers are mainly used in artificial intelligence (robotics) and computer-aided manufacturing; for example, process control.

#### 4.3 Computer types based on size and storage capacity

- **Microcontrollers:** also called *embedded computers*, they are the tiny, specialized microprocessor installed in "smart" appliances and automobiles. These microcontrollers enable microwave ovens, for example, to store data about how long to cook your food and at what power setting. They are behind the new single-function products such as digital cameras, blood-pressure monitors, gas and chemical sensors for water and air and vibration sensors.
- **Microcomputers:** also called *personal computers (PCs)*, they can fit next to a desk or on a desktop or can be carried around. They either are stand-alone machines or connected to a computer network.



Microcomputers are several types: *desktop PCs*, *tower PCs*, *notebooks (laptops)*, and *personal digital assistants (PDAs)*.

**Desktop PCs:** are microcomputers whose case or main housing sits on a desk, with keyboard in front and monitor (screen) often on top.

**Tower PCs:** are microcomputers whose case sits as a "tower" often on the floor beside a desk, thus freeing up desk surface space.

\* Some desktop computers, such as Apple's 2004 iMac, no longer have a boxy housing; most of the actual computer components are built into the back of the flat-panel display screen.

**Notebooks:** also called *laptop computers* or *portable laptop*, they are light-weight portable computers with built-in monitor, keyboard, hard-disk drive, battery, and AC adapter that can be plugged into an electrical outlet. Laptop and notebook computers usually have hardware and software similar to PCs, but they are more compact and have flat, lightweight LCDs [liquid crystal display] instead of television-like video display monitors to display information.

**Personal digital assistants (PDAs):** also called *handheld computers* or *palmtops*, PDAs are small computers can be held in one hand they are used as notepads, scheduling systems, and address books; Some PDAs have touch sensitive screens allowing users to enter notes with a special pen like device rather than with a keyboard. Most PDAs can connect to other computers through a computer cable for sending or receiving information, they can connect to worldwide computer networks to exchange information regardless of location like send email and faxes.

- **Workstations:** workstations are similar to personal computers but have greater memory, fast computation power and more expensive. Usually used for complex scientific, mathematical, and engineering calculations. They also used to create movie special effects such as graphics capabilities and 3-dimentional life. They connected to other workstations or personal computers to exchange data.



- **Mainframe computers:** they have more memory, speed, and capabilities than workstations and are usually shared by multiple users through a series of interconnected computers (time sharing used). Often users access a mainframe by means of a terminal, which has a display screen and a keyboard and can input and output data but cannot by itself process data. Mainframe process billions of instructions per second, so they control business (in banks) and industrial facilities (in airlines) and are used for scientific research (in college). Mainframes vary in size from small, to medium, to large, depending on their use.
- **Supercomputers:** the most powerful mainframe computers, called supercomputers or "suppers", they are high-capacity machines, more expensive and faster computers with thousands of processors that can perform more than several trillion calculations per second because these computers break a task into small pieces, and each CPU (processor) processes a portion of the task to increase overall speed and efficiency. Such computers are called parallel processors. Supercomputers process complex and time-consuming calculations, such as those used to create weather predictions. Large businesses, scientific institutions, and the military use them.

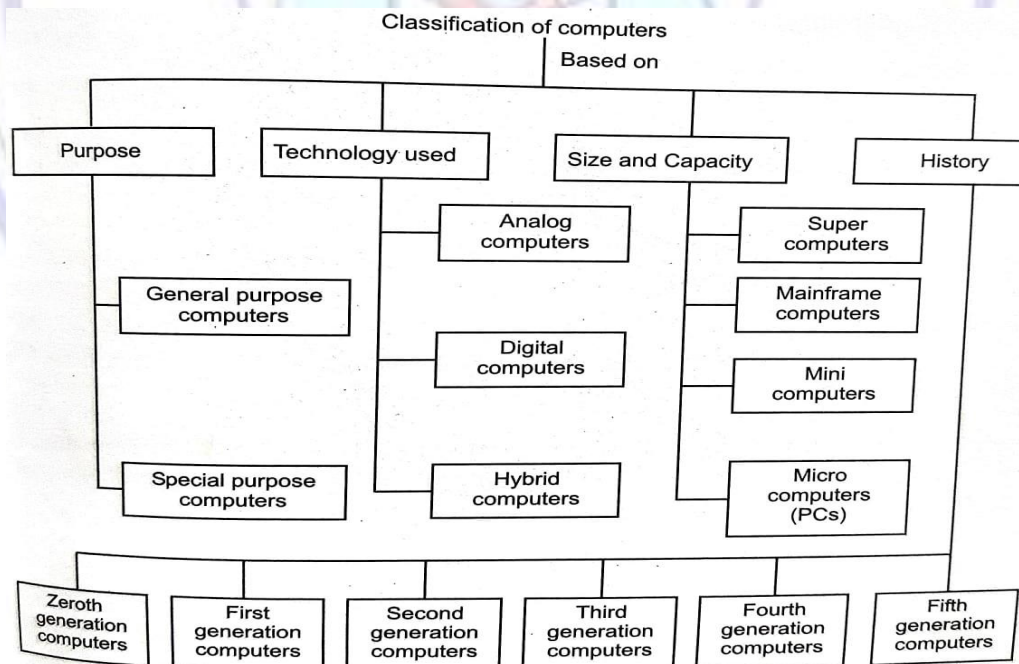


Figure 4 Computer Classification.

## 5. Uses of Computers:

1. ***In business***, computers track inventories with bar codes and scanners, check the credit status of customers, and transfer funds electronically.
2. ***In homes***, tiny computers embedded in the electronic circuitry of most appliances control the indoor temperature, operate home security systems, tell the time, and turn videocassette recorders (VCRs) on and off.
3. ***In automobiles***, regulate the flow of fuel, thereby increasing gas mileage. Computers
4. ***In entertainment***, creating digitized sound on stereo systems or computer-animated features from a digitally encoded laser disc.
5. ***In educations***, Computer programs, or applications, exist to aid every level of education, from programs that teach simple addition or sentence construction to programs that teach advanced calculus. Educators use computers to track grades and communicate with students, they can add graphics, sound, and animation to their communications
6. ***In scientific research***, Computers are used extensively in scientific research to solve mathematical problems, investigate complicated data, or model systems that are too costly or impractical to build, such as testing the air flow around the aircraft. The military employs computers in sophisticated communications to encode and unscramble messages, and to keep track of personnel and supplies.

# المحاضرة الثالثة

## Lecture3

### 1. Computer Hardware Units/ Input devices

Input hardware consists of devices that allow people to put data into the computer. I/P devices accepts data and converts the data into electrical pulses that are sent (with a special format) to the CPU, or to the internal memory. The input devices can be classified into:

- Direct input (on-line) devices: these devices include keyboard, mouse, light pen, touch screen and microphone.
- Indirect input (off-line) devices: these devices include punched card, magnetic tape, and magnetic disks.

#### 1.1 Keyboard

Keyboard is an input device that converts letters, numbers, and other characters into electrical signals readable by the processor. The most common English-language key pattern for typewriters and keyboards is called **QWERTY** (Figure 1); refer to the layout of the first six letters in the top row of its keys (from left to right).

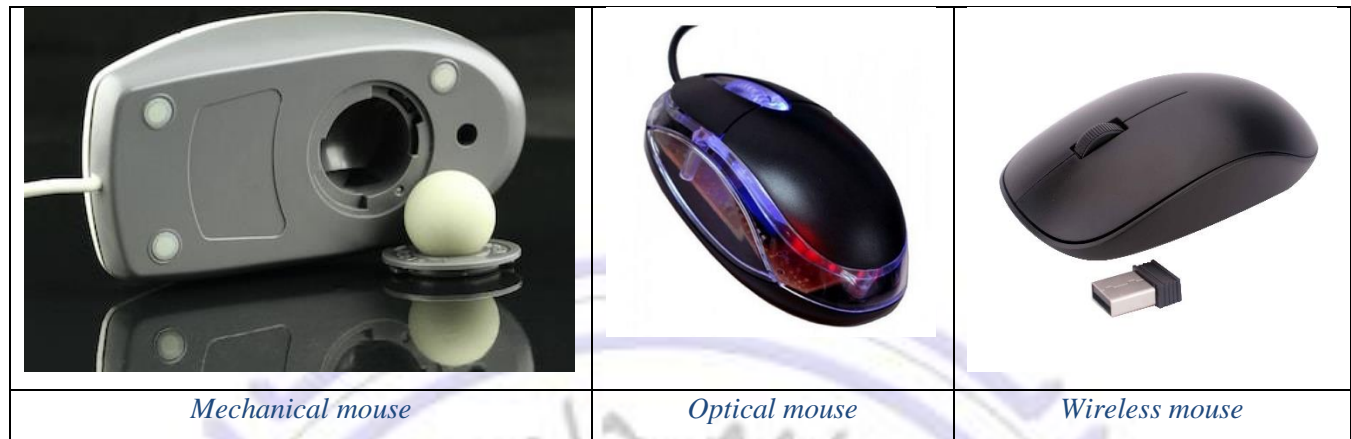


Figure 1 QWERTY keyboard.

#### 1.2 Mouse:

is a pointing device that is used to manipulate objects viewed on the computer display screen. It comes with **wired** and **wireless** versions. Wired mouse can be either **Mechanical Mouse**, where the motion of a ball on the bottom of the mouse is translated into directional signals, and the ball typically spins a pair of wheels inside the mouse; or an **Optical Mouse**, uses a pair of light-emitting diodes (LEDs) and a special reflective grid pad to detect motion. Wireless version of mouses require a battery and can be connected to the computer through a USB that emits radio frequencies. See Figure 2.





*Figure 2 Mouse types.*

### 1.3 Joystick

Joystick is an input device often used by people who play computer games. It consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling. It often used to control video games, and usually have one or more push-buttons whose state can also be read by the computer

Figure 3.



*Figure 3 Joystick.*

### 1.4 Scanner

Scanners are devices that optically scans images, printed text, handwriting or an object and converts it to a digital image that the computer can manipulate. See Figure 4.



*Figure 4 Computer scanners.*

### 1.5 Touch panel

which senses the placement of a user's finger and can be used to execute commands or access files.

### 1.6 Microphone

used to input sounds such as the human voice which can activate computer commands in conjunction with voice recognition software.

### 1.7 Light Pen

a pointing device in which the user holds a wand, which is attached to the computer, up to the screen and selects items or chooses commands on the screen (the equivalent of a mouse click) either by pressing a clip on the side of the light pen or by pressing the light pen against the surface of the screen.



*Figure 5 Input devices.*

Input data to the computer must be **encoded** in a suitable format. Since that most present day hardware employs digital circuits which have only two naturally stable states; namely ON and OFF, either 1 or 0, so **binary coding is used**, i.e. each number, character, text, image, or instruction is encoded as a string of **binary digits (bits)** each having one of two possible state (1 or 0). Alphanumeric characters are also expressed in terms of binary codes. There are several appropriate coding schemes have been developed.

➤ Two of the most widely codes are:

- **ASCII:** acronym for (**A**merican **S**tandard **C**ode for **I**nformation **I**nterchange).

A coding scheme that assigns numeric values to letters, numbers, punctuation marks, and certain other characters, by standardizing the values used for these characters, ASCII enables computers and computer programs to exchange information. ASCII provides for 256 codes divided into two sets: **standard** and **extended** of 128 each. These sets represent the total possible combinations of either 7 or 8 bits.

- The **basic, or standard ASCII** set uses 7 bits for each code, which produces 128-character codes ( $2^7$ ) from 0 through 127. In the standard ASCII character set, the first 32 values are assigned to communication and printer control codes nonprinting characters, such as backspace, carriage return, and tab that are used to control the way information is transferred from one computer to another or from a computer to a printer. The remaining 96 codes are assigned to common punctuation marks, the digits 0 through 9, and the uppercase and lowercase letters of the Roman alphabet. See Figure 6.
- The **extended ASCII** set uses 8 bits for each code, which produces an additional 128 codes numbered from 128 through 255. In the extended ASCII codes, 128 through 255, are assigned to variable sets of characters by computer manufacturers and software developers. These codes are not as interchangeable among different programs and computers as are the standard ASCII characters

- **EBCDIC:** acronym for (**E**xtended **B**inary **C**oded **D**ecimal **I**nterchange **C**ode)

A coding scheme developed by IBM to be used with its computers as a standard method of assigning binary (numeric) values to alphabetic, numeric, punctuation, and transmission-control characters. EBCDIC is similar to the ASCII coding scheme but, differs in using 8 bits for coding, thus allowing 256 ( $2^8$ ) possible characters (in contrast to the standard ASCII set). Although EBCDIC is not widely used with microcomputers, it is well known as an **IBM code** for the corporation's mainframes and minicomputers.



Binary	Oct	Dec	Hex	Glyph	Binary	Oct	Dec	Hex	Glyph	Binary	Oct	Dec	Hex	Glyph
010 0000	040	32	20	SP	100 0000	100	64	40	@	110 0000	140	96	60	`
010 0001	041	33	21	!	100 0001	101	65	41	A	110 0001	141	97	61	a
010 0010	042	34	22	"	100 0010	102	66	42	B	110 0010	142	98	62	b
010 0011	043	35	23	#	100 0011	103	67	43	C	110 0011	143	99	63	c
010 0100	044	36	24	\$	100 0100	104	68	44	D	110 0100	144	100	64	d
010 0101	045	37	25	%	100 0101	105	69	45	E	110 0101	145	101	65	e
010 0110	046	38	26	&	100 0110	106	70	46	F	110 0110	146	102	66	f
010 0111	047	39	27	'	100 0111	107	71	47	G	110 0111	147	103	67	g
010 1000	050	40	28	(	100 1000	110	72	48	H	110 1000	150	104	68	h
010 1001	051	41	29	)	100 1001	111	73	49	I	110 1001	151	105	69	i
010 1010	052	42	2A	*	100 1010	112	74	4A	J	110 1010	152	106	6A	j
010 1011	053	43	2B	+	100 1011	113	75	4B	K	110 1011	153	107	6B	k
010 1100	054	44	2C	,	100 1100	114	76	4C	L	110 1100	154	108	6C	l
010 1101	055	45	2D	-	100 1101	115	77	4D	M	110 1101	155	109	6D	m
010 1110	056	46	2E	.	100 1110	116	78	4E	N	110 1110	156	110	6E	n
010 1111	057	47	2F	/	100 1111	117	79	4F	O	110 1111	157	111	6F	o
011 0000	060	48	30	0	101 0000	120	80	50	P	111 0000	160	112	70	p
011 0001	061	49	31	1	101 0001	121	81	51	Q	111 0001	161	113	71	q
011 0010	062	50	32	2	101 0010	122	82	52	R	111 0010	162	114	72	r
011 0011	063	51	33	3	101 0011	123	83	53	S	111 0011	163	115	73	s
011 0100	064	52	34	4	101 0100	124	84	54	T	111 0100	164	116	74	t
011 0101	065	53	35	5	101 0101	125	85	55	U	111 0101	165	117	75	u
011 0110	066	54	36	6	101 0110	126	86	56	V	111 0110	166	118	76	v
011 0111	067	55	37	7	101 0111	127	87	57	W	111 0111	167	119	77	w
011 1000	070	56	38	8	101 1000	130	88	58	X	111 1000	170	120	78	x
011 1001	071	57	39	9	101 1001	131	89	59	Y	111 1001	171	121	79	y
011 1010	072	58	3A	:	101 1010	132	90	5A	Z	111 1010	172	122	7A	z
011 1011	073	59	3B	;	101 1011	133	91	5B	[	111 1011	173	123	7B	{
011 1100	074	60	3C	<	101 1100	134	92	5C	\	111 1100	174	124	7C	
011 1101	075	61	3D	=	101 1101	135	93	5D	]	111 1101	175	125	7D	}
011 1110	076	62	3E	>	101 1110	136	94	5E	^	111 1110	176	126	7E	~
011 1111	077	63	3F	?	101 1111	137	95	5F	_					

Figure 6 ASCII printable character table.



## 2. Computer Hardware Units/ Output devices

Output hardware consists of devices that translate information processed by the computer into a form that humans can understand, for example print, sound, graphics, or video.

### 2.1 Monitors

The monitor is the display device that takes the electrical signals from the video card and forms an image using points of the colored light on the screen. All monitor can be categorized by the **way they display color**:

1. **Monochrome Monitors:** display only one color (such as green, white) against a contrasting background, which is usually black. These monitors are used for text-only displays where the user does not need to see color graphics.
2. **Grayscale Monitor:** display varying intensities of gray (from a very light gray to black) against a white or off-white background.
3. **Color Monitors:** can display anywhere from 16 colors to 16 million colors.

➤ **Two basic types of monitors are:**

1. **Cathode Ray Tube (CRT):** is typical monitor that you see on a desktop computer; it looks like a television screen and works the same way. This type of monitor uses a large vacuum tube called a cathode ray tube.

CRT Advantages	CRT disadvantages
- Used with desktop computers, because they provide the <i>brightness</i> and <i>clearest picture</i> for relatively <i>low cost</i> .	- CRT monitors are <i>big</i> , so they take up desktop space and can be difficult to move. By contrast, flat-panel monitors which have light weight. - It requires <i>a lot of power</i> to run; therefore, they are not particular for use with notebook computers for example.

- 2- **Flat-Panel Display:** is used primary with portable computer, but it is becoming an increasingly popular feature with desktop computers. There are several types of Flat-Panel monitors, the common one is the **Liquid Crystal Display (LCD)** monitors.

LCD Advantages	LCD disadvantages
<ul style="list-style-type: none"><li>- LCD monitors take up less desk space than CRT.</li><li>- Run cooler than CRT.</li></ul>	<ul style="list-style-type: none"><li>- LCD images can be difficult to see in bright light.</li><li>- Limited viewing angle, the user must face the screen nearly straight on to see the image clearly.</li><li>- More expensive than CRT.</li></ul>



Figure 7 Types of Monitors.

## 2.2 Digital Light Projectors (DLP)

This device is replaced by old fashion slide projectors and over-head projectors as the source of presentations. Instead of using 35- millimeter photographic slides or 8.5 by 11-inch overhead transparencies. When using digital light projectors, the image can be shown directly from the computer's disk on a wall or large screen. DLP is a small device weight only a few pounds and can display more than 16 million colors at resolutions up to 1024×768. See Figure 8.



Figure 8 Digital Light Projector DLP vs Over-head projector

## 2.3 Printers

Printers give documents and reports that can you carry or share with others. This type of output information is called a **hard copy output** (unlike the output on monitor which called **soft copy output**).

➤ Four criteria evaluate the printer functionality:

1. **Image Quality:** also known as print resolution usually is measured in dots per inch (**dpi**). The more dots per inch a printer can produce, the higher its image quality.
2. **Speed:** printer speed is measured in the number of pages per minute (**ppm**) the device can print.
3. **Initial Cost.**
4. **Cost of Operation:** the cost of ink and the type of printer paper, for *example low-quality recycled paper* is fine for printing draft quality documents and costs less, while *Glossy*, thick photo-quality used for printing photographs, can cost more depending on size.

➤ Three most popular types of printers are:

1. **Dot Matrix Printers:** are used in workplaces where physical impact with the paper is important, such as when the user is printing to carbon-copy. This printer creates an image by using a mechanism called a *print head*, which contains a matrix of short pins arranged in one or more columns, the printer can push any of the pins out in any combination to create an alphanumeric character. The highest resolution printers have 24 pins. The speed of dot matrix printer is measured in character per second (**cps**), the faster one print more than 500 cps. See Figure 9.

Note: a special type of impact printer is Line Printer work like a dot matrix printer but uses a special wide print head that can print an entire line of text at one time, 3000 lines of text per minute.

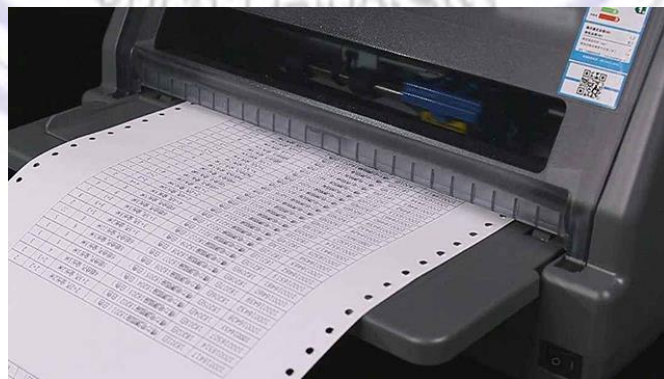


Figure 9 Dot Matrix Printer.



2. **Ink jet printers:** create an image directly on the paper by spraying ink through tiny nozzles. The resolution of this printers at least 360 dpi. They can print 2 or 4 pages per minutes. The operation cost of ink jet printer is relatively low compared with laser printer, the only part that needs replacement is the ink cartridge. See Figure 10.



Figure 10 Ink Jet Printer.

3. **Laser Printers:** are more *expensive* than ink jet printers, their print quality are *higher*, and most are *faster*. The laser is at the heart of these printers. There is a memory is built into the printer to interpret the data that it receives from the computer and control the laser. The amount of memory that laser printers contain determines the speed at which documents are printed. The resolutions of laser printer 300-600 dpi both horizontally and vertically.



Figure 11 Laser Printer.



➤ **Other types of printers are:**

- *Thermal-Wax printers*: they create bold colors and have a low per-page cost. They are used primary for presentation graphics.
- *Dye-Sub Printer*: used to print all kinds of high-resolution color documents, such as photographs and posters. They create extremely sharp images, but they are slow and costly.
- *Photo Printers*: make it easy to print hard copy of images taken on a digital camera. Photo printers work slowly; some can take 2 to 4 minutes to create a printout.

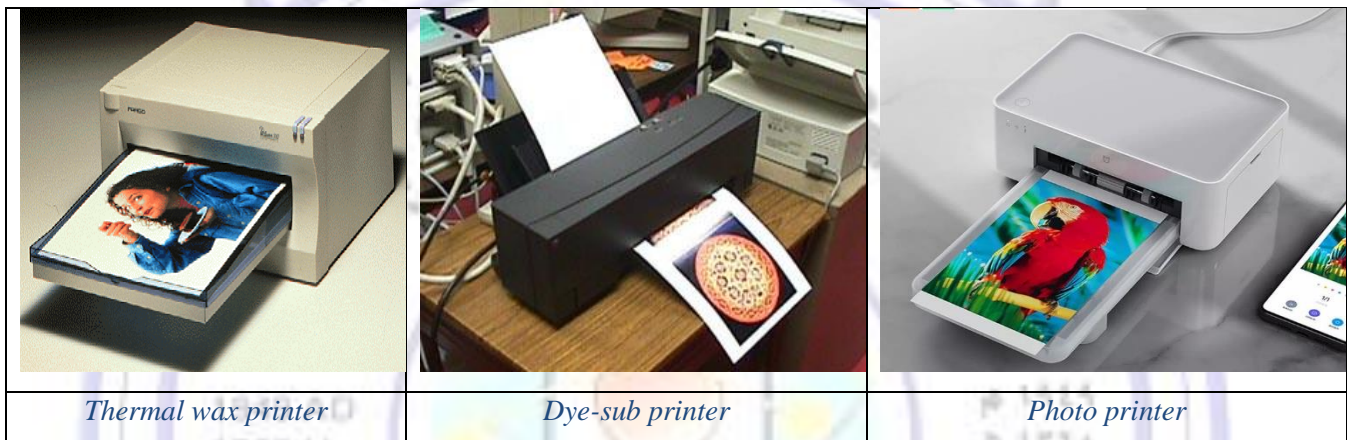


Figure 12 Other types of printers.

## 2.4 Plotters

A plotter is a special kind of output device. It is like a printer because it produces images on paper, but the plotter typically is used to print large-format images, such as construction or engineering drawings.



Figure 13 Plotters.

# المحاضرة الرابعة

## Lecture4

### 3. Central Processing Unit (CPU)

CPU is the main component or 'brain' of a computer, which performs all the input data. The CPU is sometimes called the **processor** or in the microcomputer is called **microprocessor**, where it is built on a single chip or integrated circuit IC. A single chip or (ICs) of the CPU is made from a semiconducting material (usually silicon) with millions of electrical components on its surface, actually the CPU is a number of interconnected processing units that are each responsible for one aspect of the CPU's function.

#### 3.1 CPU Components

The CPU is **physically** implemented as single silicon "Chip" Figure 1. Although physically a single component, the CPU is **logically** made up from a number of subparts Figure 2.

The three most important, which will be present in every CPU are: (1) arithmetic logic unit (ALU), (2) control unit (CU), and (3) register set.



Figure 1 CPU chip.

#### 3.1.1 Arithmetic Logic Unit (ALU)

ALU is responsible for all arithmetic operations like addition, subtraction, multiplication, and division as well as logical operations such as comparison (less than, equal to, and greater than). ALU contains circuits for each arithmetic and logical operations to manipulate data, these circuits differ from one processor to another depend on its version. Often there will be different versions of such circuits, one for integer numbers, one for real numbers, or other circuits implement comparison operations. In addition, there is "logic" circuits that directly manipulate bit pattern data (0 or 1).

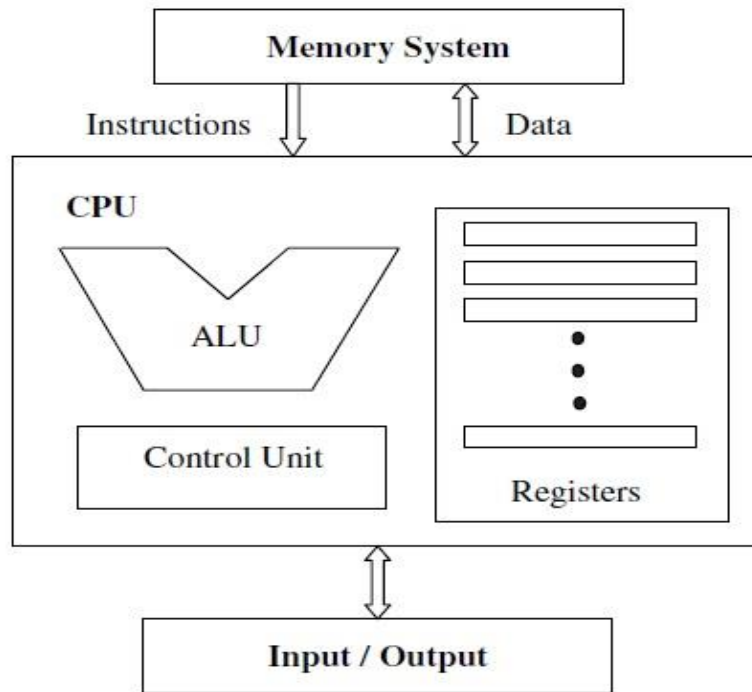


Figure 2 CPU component and interactions with the memory and I/O.

### 3.1.2 Control Unit (CU)

The CU is responsible for controlling the transfer of data and instruction among other units of the computer. The CU does not perform any actual processing on the data; it acts as a central nervous system which send control signals, manages and coordinates all other units of the computer device. The CU performs **fetching** the instruction from the main memory, and **decoding** the instruction, and then **executing** it in the CPU.

### 3.1.3 Registers Set

It is a collection of registers that are contained within the microprocessor, which are essentially extremely fast temporary memory locations used to create and store the results of CPU operations and other calculations. While most data are kept in the memory during the program execution, the CPU registers are designed to hold a small amount of data in the CPU to make the program run more quickly and efficiently.

Registers are different from one computer to another according to its **number**, the **types** of register, **register size** which means the **length of each register** (word size), and also differ in the **usage** of each register.



CPU start with 8-bit register like 8080/8085 MP, while 8086/8088 MP comes with 16-bit registers set. Most of the current microprocessors comes with 32-bit or 64- bit processor. The higher register length, the most speed the computer is.

**1- General-purpose registers (GPR):** can be used for multiple purposes and assigned to a variety of functions by the programmer. Like accumulator register (register A), in addition there are other types of registers such as (B, C, D, E, F, G, H) can provide a wide variety of functions or such as storing data value or storing intermediate results in arithmetic operations. Some machines allow two contiguous registers to hold double-length values like AX register which hold 16-bit register, while AH and AL hold 8-bit data.

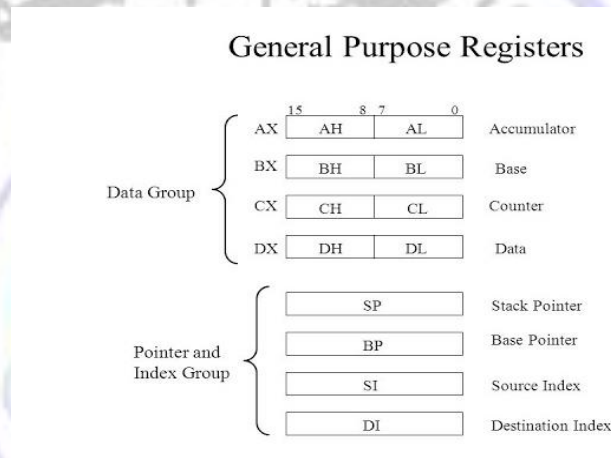


Figure 3 GPR for 8086/8088 MP.

**2- Special-purpose registers (SPR):** are restricted to only specific functions, they can't be used as GPR by the data user. SPR include:

**2.1 Memory Access Registers:** two registers are essential in memory write and read operations: the *memory data register (MDR)* and *memory address register (MAR)*. The MDR and MAR are used exclusively by the CPU and are not directly accessible to programmers.

- **MDR:** this register will contain the data to be written into (or read from) an address location. Sometimes this register is known as *memory buffer register (MBR)*.
- **MAR:** this register is used to hold the address of the location to (or from) which the data is to be transferred.

- In order to **perform a write operation** into a specified memory location, the MDR and MAR are used as follows:

1. The word to be stored into the memory location is first loaded by the CPU into MDR.
2. The address of the location into which the word is to be stored is loaded by the CPU into a MAR.
3. A write signal is issued by the CPU.

- Similarly, to perform a **memory read operation**, the MDR and MAR are used as follows:

1. The address of the location from which the word is to be read is loaded into the MAR.
2. A read signal is issued by the CPU.
3. The required word will be loaded by the memory into the MDR ready for use by the CPU.

**2.2 Instruction Fetching Registers:** Two main registers are involved in fetching an instruction for execution: the *program counter (PC)* and the *instruction register (IR)*.

- **PC:** is the register that contains the address of the next instruction to be fetched (or keeps track of the executions). It holds the memory address of instruction currently being executed. During the execution of the current instruction, the contents of the PC register are updated to the address of the next instruction to be executed. In the case of a branch operation, the PC register is updated to point to the branch target instruction after the branch is resolved.
- **IR:** receive the instruction as it is brought in (fetched) from main memory and holds it while it is decoded and executed, it's output is available to the control unit CU which generate the timing signals to control the actual processing circuits needed to execute the instruction.

**2.3 Condition registers or flags.** are used to hold processor status bits, or flags. These bits are set by the CPU as the result of the execution of an operation. The status bits can be tested at a later time as part of another operation. The individual bits in this register record various status data. For example, one bit is used to indicate whether the CPU is executing code from an ordinary program or code that from part of the controlling Operating Systems (OS) program. Another group of bits in the flags register will be used to record the result of comparison instructions performed by the ALU. One bit in the flags register would be set if the performing of an arithmetic operation results two equal values.

### 3.2 Microprocessor busses

Data is stored in a register as a unit of 8 bits. Each bit is transferred from one register to another by mean of separate wire. So, the group of eight wires, that is used as a common way to transfer data between registers is known as a **bus**. The bus is the connection between two hardware components to transmit signals between them. The three major types of buses for a microprocessor are *data*, *address* and *control* bus. See Figure 4 .

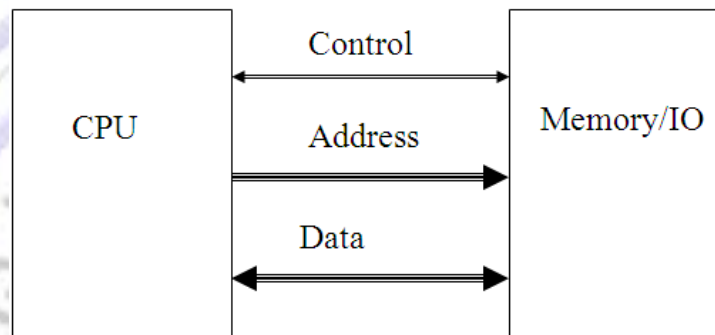


Figure 4 MP buses.

- 1- **The data bus:** It is a *bi-directional* bus that connects the CPU, memory, and the other hardware devices on the motherboard. The number of wires in the bus affects the speed at which data can travel between hardware components.
- 2- **The address bus:** It is a *one-directional* bus that connects only the CPU and RAM and carries only *memory address*. The address bus used by the MP to specify the number of locations (words) in memory.
- 3- **The control bus:** It is a *bi-directional* bus used by MP to coordinates its operations and carrying *control signal* (either write signal or read signal). Also control bus can carrying timing signals.

### 3.3 How CPU works:

The CPU is controlled by a list of software instructions, called a *computer program*. Software instructions entering the CPU originate in some form of memory storage device such as a hard disk, floppy disk, CD-ROM, or magnetic tape. These instructions then pass into the computer's main memory (RAM), where each instruction is given a unique address, or memory location. The CPU can access specific pieces of data in RAM by specifying the address of the data that it wants.



As a program is executed, data flow from RAM through an interface unit of wires called the *bus*, which connects the CPU to RAM. The data are then *decoded* by a processing unit called the *instruction decoder* that implements software instructions. From the instruction decoder the data pass to the arithmetic/logic unit (ALU), which performs calculations and comparisons. Data may be stored by the ALU in temporary memory locations (in registers) where it may be retrieved quickly. The ALU performs specific operations such as addition, multiplication, and conditional tests on the data in its registers, sending the resulting data back to RAM or storing it in another register for further use. During this process, the program counter (PC) keeps track of each successive instruction to make sure that the program instructions are followed by the CPU in the correct order.

### 3.4 CPU Clock:

*CPU clock* is an important component within the CPU, which measures and allocates a fixed time slot for processing each and every micro-operation (smallest functional operation). CPU allocates one or more cycles to complete a micro-operation.

*Clock pulses* are a measure of the speed of a processor. Clock pulses are measured in *Hertz*, or number of pulses per second. For instance, a 100-megahertz (100-MHz) processor has 100 million clock pulses passing through it per second, or gigahertz (GHz) processor has billions of processing cycles per second.

### 3.5 CPU Basic Operations (Summary):

A microprocessor executes a program by repeatedly cycling through following three basic steps, see Figure 5:

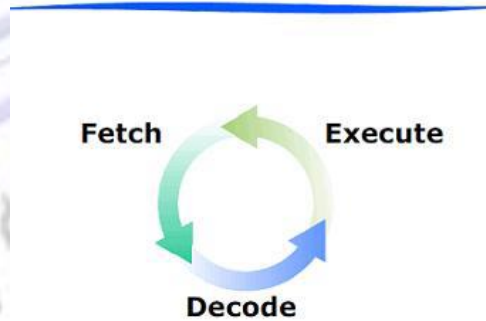
- 1- Fetch an instruction from main memory and place it in the CPU
  - The contents of the PC are transferred to MAR.
  - The main memory is accessed and the current instruction is fetched into MDR.
  - The operation code is transferred from MDR to IR where it is decoded.
- 2- Decodes the instruction; if other information is required by the instruction, fetch the other information.
  - Op-code (operation code) of the instruction is decoded.
  - Contents of PC are incremented by 1(in case of 1 byte instruction or equal to the no. of bytes of the instruction currently being executed.)



**3-** Execute the instruction and store the results.

- Execute the instruction
- Store the results in the proper place (go to the fetch phase to begin executing the next instruction).

**Fetch-Execute Cycle**



*Figure 5 MP basic operation.*

**NOTE:**

**Single core processors**, meaning they had only one microprocessor in an IC chip, they run multiple programs (*Multi-tasking*) to increase the processing speed like Intel MPs (8080, 8086, 8088, 80286, 80386, 80486 until Pentium).

*Multi-Tasking* is a technique that capable of running many tasks (programs) at the same time. By dividing the time of MP between all of the tasks, the MP switches from one task to another so quickly that it gives the appearance of executing all of them simultaneously.

**NOTE:**

**multi-core processors** have more than one core on a single IC each one with its own cache memory. They operate in *parallel* and can run programs much faster than a single core chip; this process is also called *multiprocessing*. The multi-core processors system can work on multi-tasking technique (but only one processor is involved at a time).

# المحاضرة الخامسة

## Lecture5

### 4. Internal Memory/ Main Memory Unit

Internal memory is located inside the system unit (system cabinet on motherboard). Internal memory operates at the highest speed and can be accessed directly by the central processing unit (CPU). It contained on computer chips and uses electronic circuits to store information. There are two type of internal memory *random access memory (RAM)* and *read-only memory (ROM)*. Information stored in RAM can be accessed in any order, and may be erased or written over. Information stored in ROM may also be random-access, in that it may be accessed in any order, but the information recorded on ROM is usually permanent and cannot be erased or written over.

#### 4.1 ROM

ROM memory is generally used to hold parts of the code of the computer's *operating system*. Some computers have small ROM memories that contain only a minimal amount of code just sufficient to load the *operating system* from a disk storage unit. Other machines have larger ROM memories that store *substantial parts of the operating system* code along with other code, such as code for generating graphics displays Figure 1 .

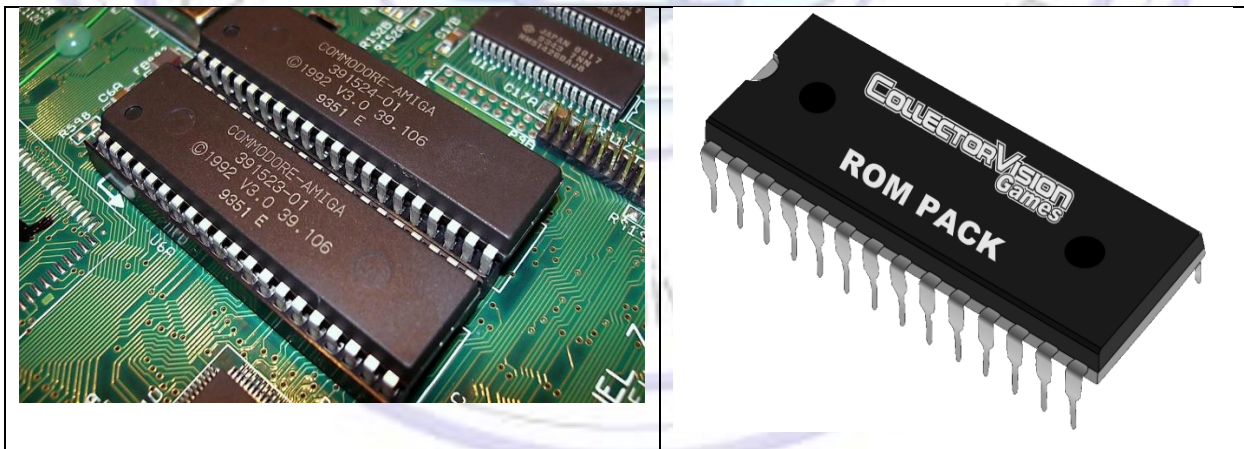


Figure 1 Internal Memory (ROM).

That's mean ROM memory is used to store items that the computer needs to execute when it is first turned on. For example, the ROM memory on a PC contains a basic set of instructions, called the *basic input-output system (BIOS)*.

- **BIOS** is the *program* that starts a computer up. The PC uses BIOS to start up the operating system. BIOS is stored on computer chips and keep the information even the power turn off. BIOS responsible for **POST** [power on self-test] check the peripheral device connectivity, **booting process** [loading the operating system from disk to main memory] and **basic input/output operations**. The BIOS is *firmware*, and thus cannot store variable data.
- **CMOS** is a type of memory technology where the BIOS stores the date, time, and system configuration details it needs to start the computer, but most people use the term to refer to the chip that stores variable data for startup. A computer's BIOS initialize and control components like the floppy and hard drive controllers and the computer's hardware clock, but the specific parameters for startup and initializing components are stored in the CMOS.  
Many people use the terms **BIOS** (basic input/output system) and **CMOS** (complementary metal oxide semiconductor) interchangeably, but in actuality, they are distinct, though related, components of a computer Figure 2.

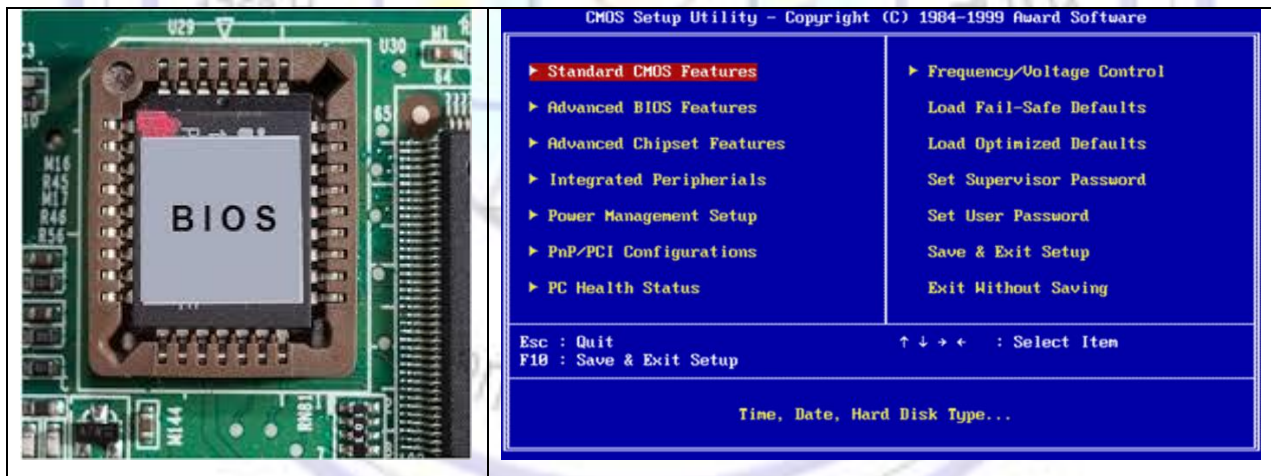


Figure 2 BIOS & CMOS.

A ROM is permanent if the information stored in it cannot be changed. Newer technologies allow ROMs to be semi-permanent—that is, the information can be changed, but it takes several seconds to make the change. For example, a *FLASH BIOS* which is a BIOS developed chip can be programmed to enable the user to change BIOS program without changing a BIOS chip.



### **ROM can be divided as:**

- **PROM** [*Programmable ROM*]: is a ROM that can be electrically programmed by the user. It cannot be erased and programmed again.
- **EPROM** [*Erasable Programmable ROM*]: is a ROM that can be electrically programmed by the user. It can be erased (usually with ultraviolet light) and programmed as often as desired. EPROMs are more expensive than PROMs.
- **EEPROM** [*Electrically Erasable Programmable ROM*]: The entire chip does not have to be completely erased to change a specific portion of it. Instead of using UV light, the electrons in the cells of an EEPROM could be returned to normal with the localized application of an electric field to each cell. This erases the targeted *cells* of the EEPROM instead of, removing the entire chip to be rewritten.

## 4.2 RAM

RAM is the acronym instead of RWM is standard. It actually standards for "Random Access Memory". Its origin is very old, it was used to distinguish main memory (where data values can be accessed in any order – hence "randomly") from secondary storage like tapes (where data can only be accessed in sequential order). RAM memory is used to hold the rest of the code and data for the operating system, and the *code and data for the program(s)* being run at the moment by the computer.

RAM is made in electronic chips made of so called [semiconductor](#) material, just like processors and many other types of chips. In RAM, transistors make up the individual storage cells which can each “remember” an amount of data. Physically, RAM consists of small electronic chips which are mounted in modules (small printed circuit boards). The modules are installed in the PC’s motherboard using sockets Figure 3.



*Figure 3 RAM Slots.*

**RAM can be divided as:**

- **SRAM** [Static RAM] does not need to be periodically refreshed. *Memory refreshing* is common to other types of RAM and is basically the act of reading information from a specific area of memory and immediately rewriting that information back to the same area without modifying it. Static RAM's are costlier and consume more power. They have higher speed than D-RAMs. The **advantages** of using SRAM (vs. DRAM) are *lower power consumption* and *faster access speeds*. The disadvantages of using SRAM (vs. DRAM) are *lesser memory capacities* and *higher costs of manufacturing*.
- **DRAM** [Dynamic RAM] loses its stored information in a very short time (for milli sec.) even when power supply is on. So, constant change or action (e.g., refreshing) is needed to keep data intact. The **advantages** of using DRAM (vs. SRAM) are *lower costs of manufacturing* and *greater memory capacities*. The **disadvantages** of using DRAM (vs. SRAM) are *slower access speeds* and *higher power consumption*.

SRAM	DRAM
Do not need refreshing periodically	Need constant refreshing to keep the data stored
lower power consumption	higher power consumption
faster access speeds	slower access speeds
lesser memory capacities	greater memory capacities
higher costs of manufacturing	lower costs of manufacturing

RAM	ROM
Random Access Memory	Read only Memory
Volatile (maintains its data while the device is powered)	Non-Volatile (does not lose content when power is lost)
Store information temporary	Stores information permanently
Large size with higher capacity	Small size with less capacity
Read data quickly to run application, it allows both read and write	Stores the program required to initially boot the computer Used only for reading
Cost more than ROM	Cheaper than RAM
Very Fast and use a lot of power	Fast and uses very little power
Used as primary memory	Used in firmware and microcontroller
Types: SRAM, DRAM	Types: PROM, EPROM, EEPROM

### 4.3 Memory Location and Addresses

Most memories represent data with the binary number system [sequences of the two binary digits 0 and 1] which are called bits. In a computer, the two possible values of a bit correspond to the on and off states of the computer's electronic circuitry.

In memory, bits are grouped together so they can represent larger values. A group of eight bits is called a byte and can represent decimal numbers ranging from 0 to 255 ( $2^8$ ). The particular sequence of bits in the byte encodes a unit of information, such as a keyboard character. One byte typically represents a single character such as a number, letter, or symbol.

**Memory capacity** is usually quantified in terms of *kilobytes*, *megabytes*, and *gigabytes*. The prefixes are measured as powers of two, with kilo- meaning 2 raised to the 10<sup>th</sup> power ( $2^{10}$ ), or 1,024; mega- meaning 2 raised to the 20<sup>th</sup> power ( $2^{20}$ ), or 1,048,576; and giga- meaning 2 raised to the 30<sup>th</sup> power ( $2^{30}$ ), or 1,073,741,824. See the following table

Unit	Power of 2	Description
Bit	$2^0$	1 binary digit (0 or 1)
nibble	$2^2$	4 bits
byte	$2^3$	8 bits
kilobyte	$2^{10}$	1024
megabyte	$2^{20}$	1,048,576 bytes
gigabyte	$2^{30}$	1,073,741,824 bytes
terabyte	$2^{40}$	1,099,511,627,776 bytes
petabyte	$2^{50}$	1.125899906843 e+15 bytes
exabyte	$2^{60}$	1.152921504607 e+18 bytes
zettabyte	$2^{70}$	1.180591620717 e+21 bytes
yottabyte	$2^{80}$	1.208925819615 e+24 bytes

the memory is organized so that a group of  $n$  bits can be *stored* or *retrieved* in a single, basic operation. Each group of  $n$  bits is referred to as a **word of information**, and  $n$  is called the word length. **Word**: is the entity consisting of  $n$  bits that can be stored and retrieved in and out of the memory using one basic



memory operation (read or write), i.e., **word** is the width of the primary data paths between memory and the CPU. Word is (the smallest addressable entity), word sizes vary between machines. See Figure 4 which illustrate a memory of a machine with 16-bit 2-byte word size.

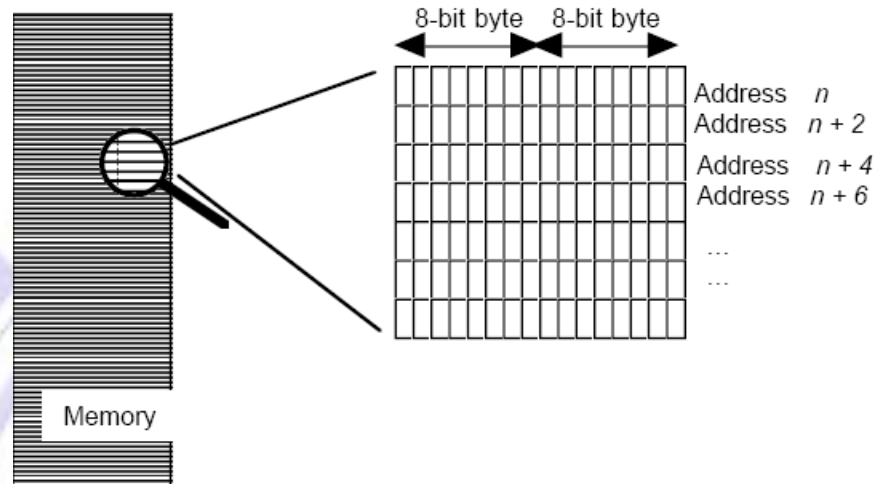


Figure 4 Memory organized in words with integer address.

Memory can be viewed as a vector (one dimensional array) of **words**. Each word consists of adjacent cells grouped together each cell capable of storing a binary digit (bit) having value 1 or 0, so the main memory can be modeled as an array of millions of adjacent cells. See Figure 5. The words can be identified by their positions (**index number**) in this vector – the integer index of a word is its "**address**". Most computers are designed to allow addressing of individual bytes. (If a request is made for a specific byte, the memory unit may return the entire word, leaving it to the CPU circuits to select the required byte). Because the individual bytes are addressable, word addresses increase in 2s (or in 4s if it is a machine with 4-byte words).

$$\text{Memory size (M) in bits} = 2^{\text{address-index}} \times \text{word length}$$

For example, the size of a typical memory of a personal computer is 256 Mbytes, that is,  $256 \times 2^{20} = 2^{28}$  bytes. Then it has 28 address-index.



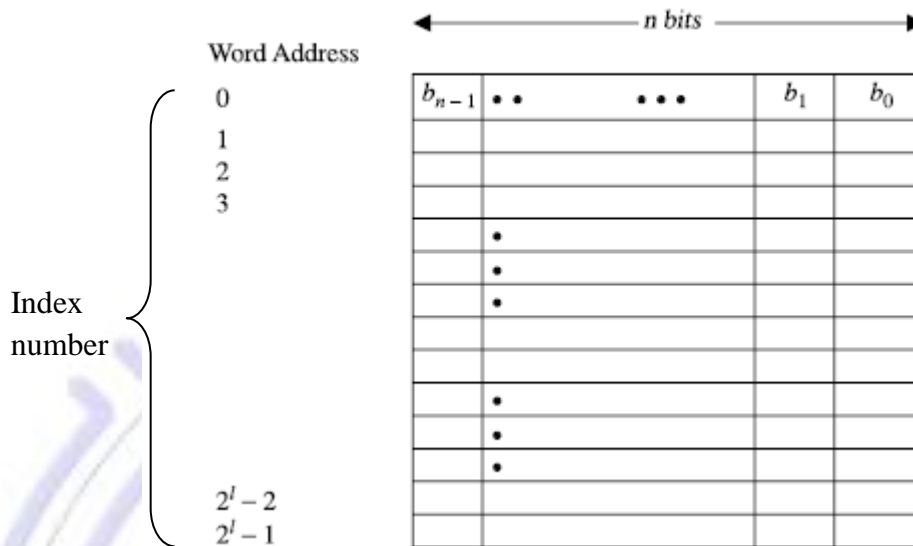


Figure 5 main memory addressing.

In order to be able to move a word in and out of the memory, a distinct address has to be assigned to each word. This address will be used to determine the location in the memory in which a given word is to be stored. This is called a memory *write* operation. Similarly, the address will be used to determine the memory location from which a word is to be retrieved from the memory. This is called a memory *read* operation.

The number of bits,  $n$ , needed to distinctly address  $M$  words in a memory is given by

$$n = \log_2 M$$

$M$  is the memory size,  $n$  is the number of address-index

Example: Suppose you have memory size 64 M (read as 64 mega words), then what is the number of address?

Sol:

The number of bits in the address is

$$n = \log_2 M.$$

$$n = \log_2 (64 \times 2^{20}) = \log_2 (2^{26}) \text{ then } n = 26 \text{ bits.}$$

# المحاضرة السادسة

## Lecture6

### Memory Chip Capacity Calculations with Examples

As mentioned in the previous lecture that the internal main memory structure consisting of rows and columns of basic cells. Each cell is capable of storing one bit of information (0, 1) as shown in Figure 1. Cells belonging to a given row can be assumed to form the bits of a given memory **word**.

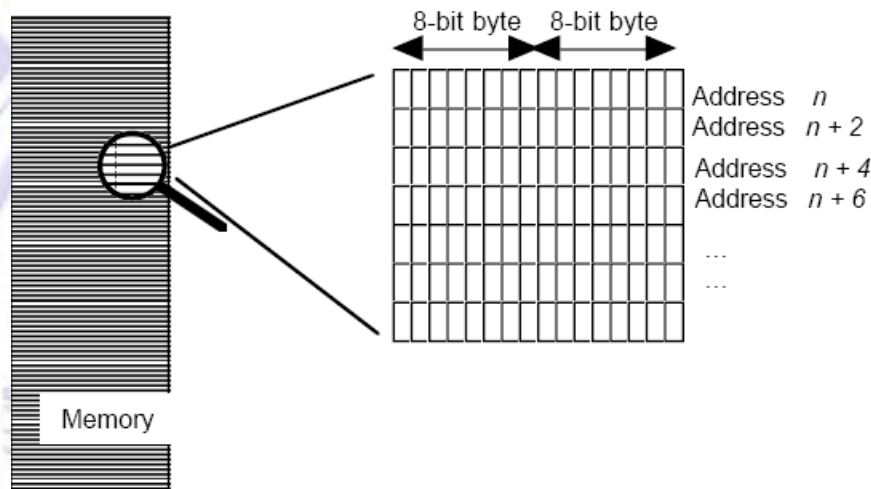


Figure 1 Memory organized in words with integer address.

The address lines  $A_0 \dots A_{n-1}$  in the memory chip contain an address, which is decoded from an  **$n$ -bit** address into one of  **$2^n$  locations** (*The number of locations may be obtained from the address width of the chip*) within the chip, each of which has a  **$w$ -bit** word associated with it. The storage capacity of a memory chip is the product of the number of locations and the word width. The chip thus contains  $2^n \times w$  bits.

The computer's **word size** can be the size of the data bus which carries data between the CPU and memory and the CPU and I/O devices. To access the memory, to store or retrieve a single word of information, it is necessary to have a unique address. The **word address** is the number that identifies the **location** of a word in a memory.

$$\text{Memory size (M) in bits} = 2^n \times w$$

- $n$  = address-index = number of address buses
- $w$  = word length = word size in bit = register size = data width
- Memory size = number of cells in a chip

**Example1:** A memory chip has 10 address lines, and 8-bit data width

- How many memory locations can be addressed?
- How many bus lines are used to hold the data?
- What is the number of memory chip cells?
- What is the memory chip size?

**Solution1:**

- $2^{10} = 1024$  locations
- 8 buses
- $M = 1024 \times 8 = 8192$  cells
- $M = 1024 \times 8 = 2^{10} \text{ (Kbyte)} \times 1 \text{ byte} = 1 \text{ Kbyte}$

**Example2:** A certain memory chip is specified as 4K byte  $\times$  8

- How many words can be stored on this chip?
- What is the word size?
- How many total bits can this chip store?

**Solution2:**

- 4K byte =  $4 \times 1024 = 4096$  words (locations)
- Word size = 8 bit = 1 byte
- Total bits = memory capacity =  $4096 \times 8 = 32768$  bits

**Example3** Suppose a memory system has a 16M  $\times$  32,

- How many address lines?
- How many data lines?



- What is the register length?

**Solution3:**

- The number of locations in memory that can be addressed are  $16M = 2^4 \times 2^{20} = 2^{24}$ , so the number of address are 24
- While the word length is 32 bits, so the data lines will be also 32 lines.
- Register length = 32 bits

**HW1:** Suppose you have a 2K x 16 memory system

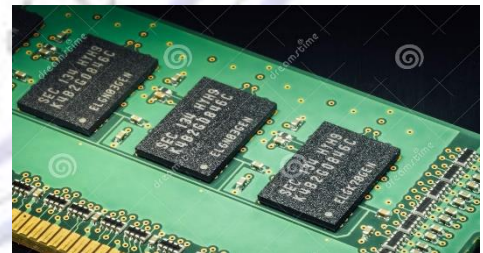
- 1- What is the word length?
- 2- How many lines for the address and data?
- 3- How many memory locations that can be addressed?
- 4- What is the register size?
- 5- How many cells this memory system can hold?

**HW2:** A system with memory capacity with 1Gbyte  $\times$  1, organized as 1Gbyte row and 1Kbyte column

- 1- What is the number of address required to select a row of data?
- 2- What is the register width?
- 3- What is the memory capacity in bits?

**HW3:** A memory board with 3 chips on it. Each chip has 32 address line in a system with 16-bit register

- 1- How many address locations each chip has?
- 2- What is the word length?
- 3- How many cells each chip can hold?
- 4- What is the total capacity of the RAM board?
- 5- What is the last address that can be reached by the address line?



**You will be required to submit the solution for the three homework through Google Class on 4 March 2021 at 7 pm. (your answers will be marked).**

# المحاضرة السابعة

حلول الواجب البيتي للمحاضرة السادسة

**HW1:** Suppose you have a 2K x 16 memory system

1- What is the word length?

- 16 bits

2- How many lines for the address and data?

- 11 lines for the address bus ( $2K = 2^1 \times 2^{10} = 2^{11} = 11$  lines for the address bus)

- 16 lines for data bus

3- How many memory locations that can be addressed?

-  $2k = 2^1 \times 2^{10} = 2048$  locations

4- What is the register size?

- Register size= 16 bits

5- How many cells this memory system can hold?

-  $2K \times 16 = 2048 \times 16 = 32768$  cells (bits)

**HW2:** A system with memory capacity with 1Gbyte  $\times$  1, organized as 1Gbyte row and 1Kbyte column

1- What is the number of address required to select a row of data?

- 1Gbyte =  $2^{30}$  bits, so the number of address is 30 addresses.

2- What is the register width?

- 1Kbyte = 1024 bits

3- What is the memory capacity in bits?

-  $1\text{Gbyte} \times 1\text{Kbyte} = 2^{30} \times 2^{10} = 2^{40} = 1 \text{ Terabyte} = 1,099,511,627,776$  bits

**HW3:** A memory board with 3 chips on it. Each chip has 32 address line in a system with 16-bit register

1- How many address locations each chip has?

- Address locations =  $2^{\text{address line}} = 2^{32} = 4,294,967,296$  locations

2- What is the word length?

- 16 bits

3- How many cells each chip can hold?

-  $2^{32} \times 16 = 2^{32} \times 2^4 = 2^{36} = 68,719,476,736$  bits

4- What is the total capacity of the RAM board?

-  $2^{32} \times 16 = 2^{32} \times 2^4 = 2^{36} = 2^6 \times 2^{30} = 64$  Gigabyte

// this is the capacity of one chip, so the capacity for the whole RAM chip

= the size of each chip  $\times$  total number of chips

= 64 Gigabyte  $\times$  3 = 192 Gigabyte (= 206,158,430,208 bits)

5- What is the last address that can be reached by the address line?

-  $2^{32} - 1 = 4,294,967,296 - 1 = 4,294,967,295$  is the last location in each memory chip.





# المحاضرة الثامنة

## Lecture7

### 5. External Memory/ Storage/ Secondary Storage

External memory is also called *external storage devices* or *secondary storage device*. It is normally a place where large amount of data and programs are stored permanently when the power of computer device is turned off. The physical materials on which data is stored are called **Storage media**. While the hardware components that write data to, and read it from storage media are called **Storage devices**. The software that will allow the computer to communicate with a particular device (besides to the operating system) is called **Device driver**.

Storage involves two processes; **writing** or **recording** data on the surface of a storage media for later use, **reading** or **retrieving** data from the storage media to be transferred to the computer's memory. So, the *main purpose* of storage devices is to hold data and program in a *non-volatile* format (even when the computer is turned off). Once the stored program in external storage is opened, it will be loaded into internal memory to be process by the CPU. As the external storage is not directly accessible by the CPU. See Figure 1. The *other purpose* of using external storages is either as input device when data are transferred to main memory of the computer system to be executed by the CPU, or as output device when the processed data (information) are transferred outside the computer device via peripheral devices like printer, keyboard, or display screen.

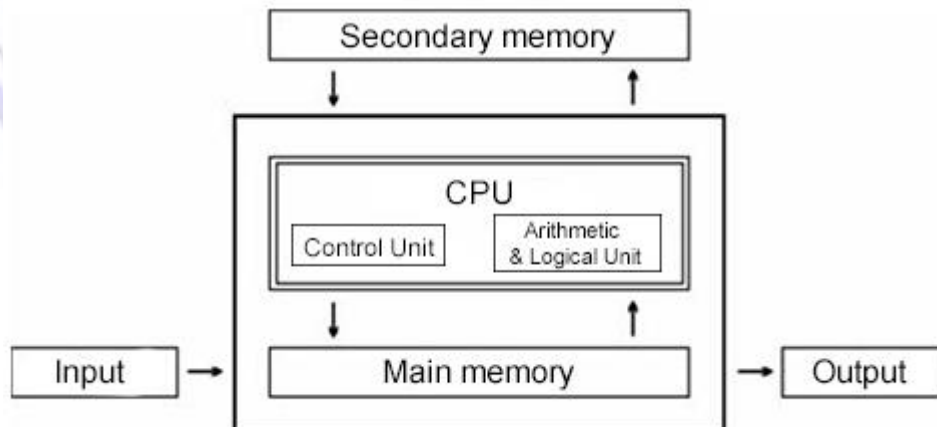


Figure 1 External storage within hardware component.

## 5.1 External Storage Types

External storages (memory) are generally classified according to the techniques used to store data on it into four types Mechanical, Magnetic, Optical, and Solid-State storage. See Figure 2.

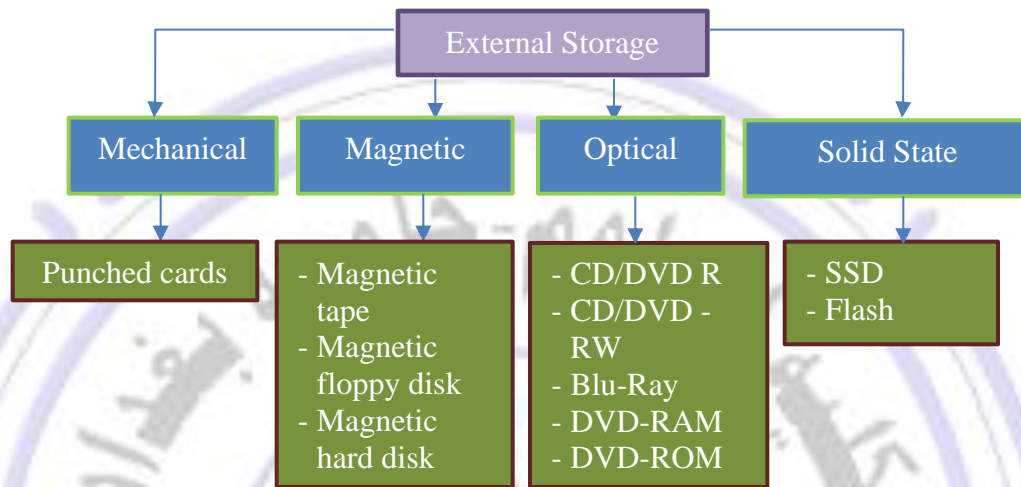


Figure 2 External Storage Types.

### 5.1.1 Mechanical Storage

Punched card or punched tape is a piece of stiff paper that holds digital data represented by the presence or absence of holes in predefined positions. The punched cards used in 20<sup>th</sup> century for data input, output, and storage. However, they were not used as a storage medium (medium is a single of media) in today's personal computer. See Figure 3.

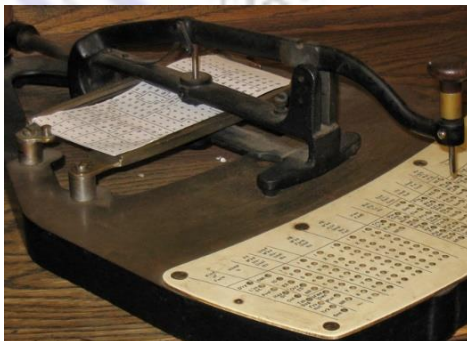


Figure 3 Punched Card as a Storage media.

### 5.1.2 Magnetic Storage Device

A magnetic storage device uses a surface coated with material that can be magnetized in two possible ways. The surface rotates under a small electromagnet that magnetizes each spot on the surface to record a 0 or 1. This way guarantees *permanent storage (non-volatile storage)* because the magnetic spots do not need a constant supply of power to "refresh" them-selves (like DRAM chip do). To retrieve data, the surface passes under a sensor that determines whether the magnetism was set for a 0 or 1. Also, it is *cheaper per unit of storage* than internal memory.

The most three common forms of magnetic media are **Cassette Tape**, **Floppy disk** and **hard disks**. All these types can be erased and recorded again and again. As new information is written, it automatically covers up whatever was before. To avoid accident eraser, both cassette tapes and floppy disks can be *write-protected* by write protected media. See Figure 4, which provides examples of magnetic storage devices.



Figure 4 Example of Magnetic Storage device.

#### 5.1.2. A Cassette Tape:

Magnetic tape is a thin strip of magnetic plastic which is wrapped onto a reel, see Figure 5. It is one of the oldest technologies for electronic data storage. While tape has largely been displaced as a primary and backup storage medium, it remains well-suited for archiving (backing up), in case of hard drive malfunctions or valuable file is deleted accidentally. Due to of its *high capacity*, *low cost* and *long durability (advantages)*.



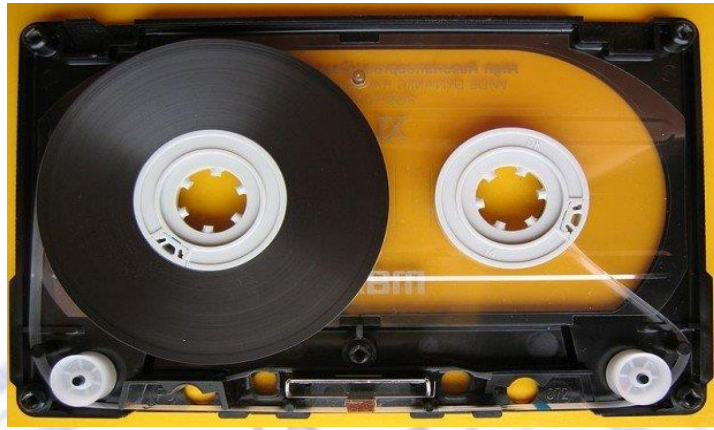


Figure 5 Cassette Tape of 185 TB of data designed by Sony.

#### Tape Access time:

Because the tape is a long strip of magnetic material, the tape drive has to write data to it *serially* (one byte after another). The main *disadvantage* of cassettes tape is that they are sequential-access storage devices. *Sequential access* (serial access) is slower than *direct access* provided by media such as disks. A cassette tape recorder has very poor (slow) access time (the time that device takes to begin reading the desired information from tape), because it takes several minutes to get to the right spot on the tape. The device access time depends on:

- 1- The speed of the tape drive.
- 2- The length of the tape.
- 3- The position on the tape to which the head wrote the data originally.

#### Data transfer rate of tape:

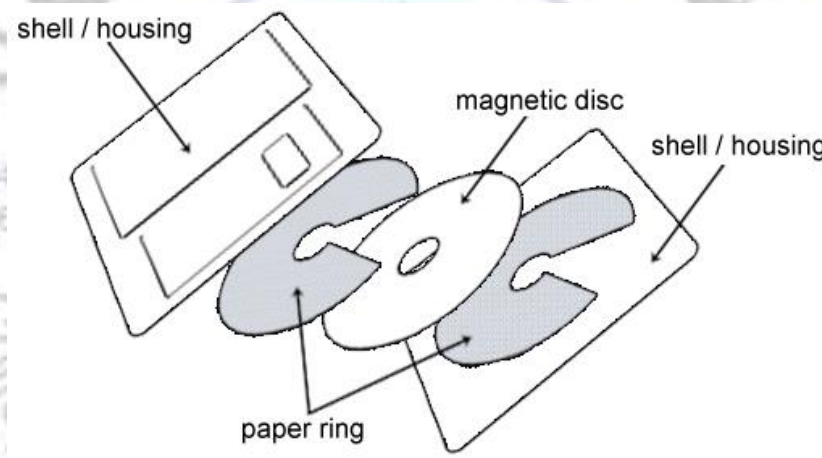
The rate at which data are read once an information transfer has begun is *the data transfer rate*. The standard cassette tape recorder has an effective data transfer between 300 and 1500 bits per second, it takes more than five minutes to load a 16 KB file into internal memory.

The combination of sequential access storage and slow data transfer rate makes cassette tape unsuitable for most practical application of personal computer.

Case tape advantages	Case tape disadvantages
Used for data back up, so it is used for archiving valuable data	Sequential (serial) access for the stored data
High capacity reaches 185 tera byte	Slow access time compared to hard disk
Low cost	Slow data transfer rate
Durable (long lasting)	
Very robust as it is not easily damaged	

### **5.1.3. B Diskettes (Floppy Disks):**

A floppy disk is an old portable (removable) computer storage device where information is held on a thin plastic disc. The floppy disk consists of flat, circular plates made of metal or plastic and coated with iron oxide, see Figure 6.



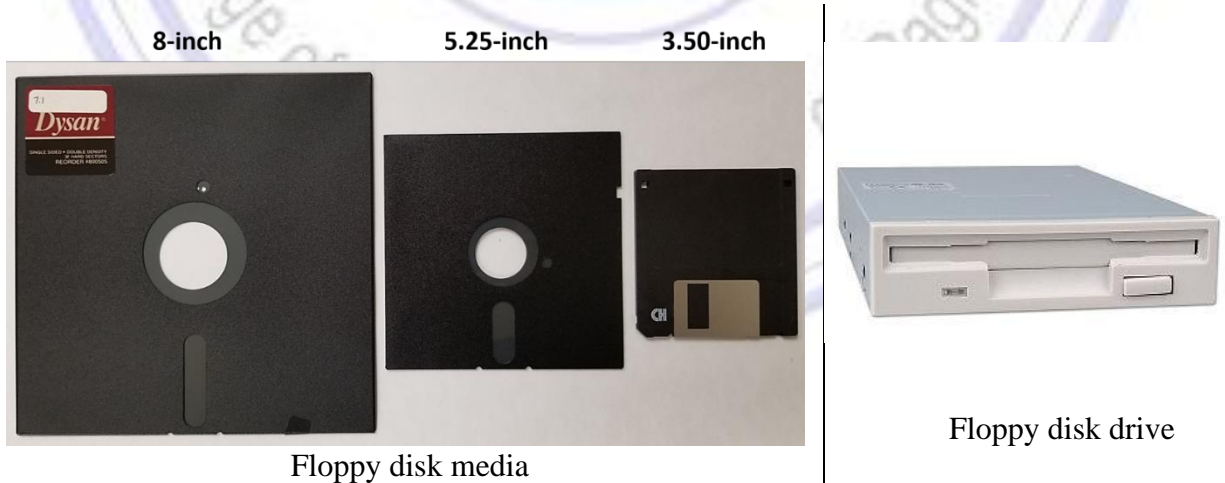
*Figure 6 Floppy disk internal design.*

When a disk is inserted into the disk drive of a computer, information can be magnetically imprinted on this coating, which will thereafter permit easy location and retrieval of the same data. Data transferred from the computer to the floppy disk in (0, 1) binary code and received in the form of magnetic pulses. While the computer system is only deal with binary coding 1's and 0's, so the data are presented on floppy disk as single magnetic pulses and the absences of pulses, respectively. Binary code is used because it most effectively utilizes the natural two-state characteristics of electricity and magnetism.

- To record information on a disk, a magnetic head contacts the disk's recording surface and magnetically imprints data onto it, translating the computer's binary codes into the disk's magnetic

pulses. Once a magnetic pattern consisting of many pulses and absences has been recorded, the disk keeps the encoded information just like a permanent magnet.

- Retrieving info from the disk involves the opposite process. The magnetic head senses the magnetic pattern on the disk's recorded surface and converts it back into an electronic binary code. The computer then "reads" this information, using it to perform calculations or translating it into letters and figures for display on the monitor.
- This diskette is housed in a flexible jacket (8-inch) or stiff cardboard envelop (5.25 inch) or rigid plastic shell (3.5 inch). The purpose of the diskette house is to keep fingerprints off the disk surfaces and to limit the amount of dust and dirt that gets on the its surfaces, which cause scratches on the disks and lost data, damage or contamination of the magnetic heads in the floppy drive, or simply errors when the floppy disc is read.
- The floppy disks come in several sizes differ in diameter, see Figure 7:
  - 1- 8-inch format in diameter was the first read only disk that was introduced in 1971 by IBM and it was still in use till the late of 1980's.
  - 2- Floppy B (5.25 inch) in diameter, also called mini floppy disk that was introduced in 1976 and still in use till 1990.
  - 3- Floppy A (3.5 inch) in diameter: Also called micro floppy disk is housed in a rigid. In 1982, it was introduced by Sony, with the last version being introduced in 1999.



*Figure 7 Floppy disk types.*



### **Physical view:**

The thin, circular, plastic floppy disk is enclosed in a plastic jacket. The floppy disk is coated with a magnetic material (*iron oxide*) similar to that on the tape. Several holes are cut in both sides of the plastic jacket (as shown in Figure 8). *The round center hole* in the jacket provides access to the center hub area of the disk. The hub of the disk drive clamps on the area to spin the disk. *The larger (oval) hole* in the jacket near the bottom of the disk where the read/write head of the disk drive touches the spinning disk at this point to either store data on the disk or retrieve data from it. *The small round hole* cut in the jacket and disk is used as an index hole by some microcomputers.

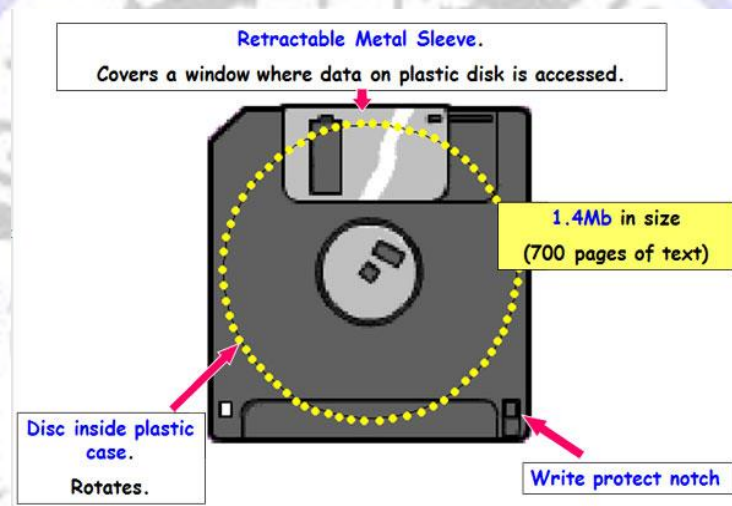


Figure 8.a Floppy disk outer layout.

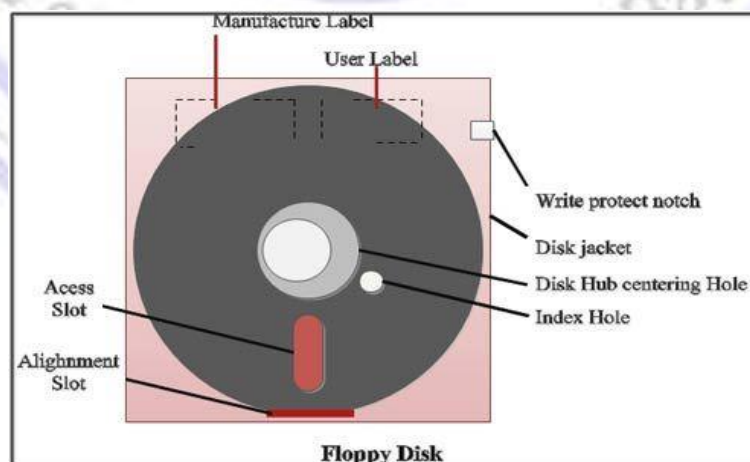


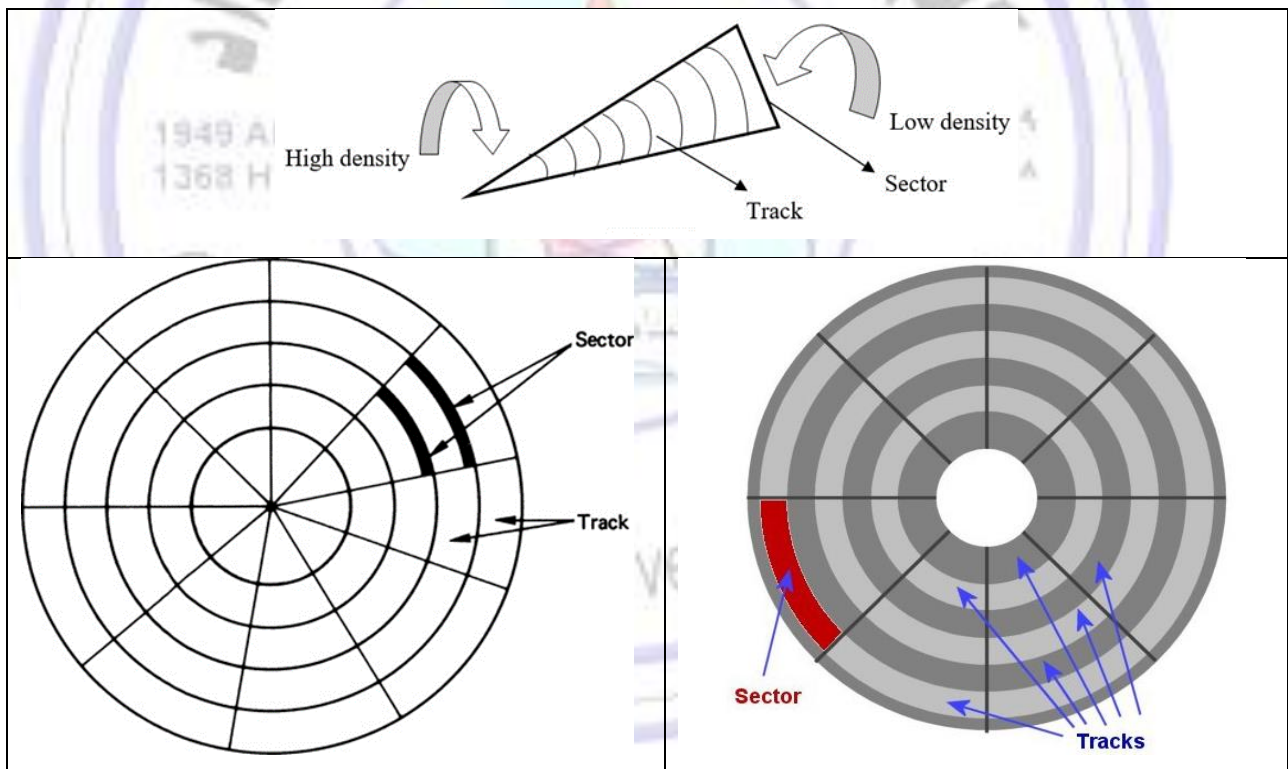
Figure 9.b Floppy disk inter layout.



### **Logical view:**

Floppy disks are organized in tracks and sectors, which determine how much data can be stored.

- **Tracks:** the bits are recorded in "tracks", which represent the concentric rings on the surface of the disk. On simple disk units, all tracks hold the same number of bits; since the outermost tracks are slightly longer; their bits are spaced further apart than those on the innermost tracks. More disks can arrange to have the bits recorded at the same density<sup>1</sup>; the outer tracks then hold more bits than the inner tracks.). See Figure 10.
- **Sectors (Blocks):** the tracks are too large a unit of storage; they can hold tens of thousands of bits. Storage on a track is normally broken down into "blocks" or sectors. The programmers could select the size of blocks; however, the operating system program like DOS determines a particular block size. This is typically in the range 512 bytes to 4096 bytes (sometimes more).



*Figure 10 Floppy disk tracks & sectors.*

<sup>1</sup> The density of the disk is a measure of its capacity, i.e., how much data the disk can store.

- There are two types of floppy disks: **single side** (has one read/write head), and **double side** (has two read/write head) as shown in Figure 11. Also, floppy disk can be *single density*, *double density* and *high density*. Early versions of disks were double density (DD). As disk media improved, storage capacity increased; double density disks have been almost completely replaced by high density (HD) disk, which provide more storage.

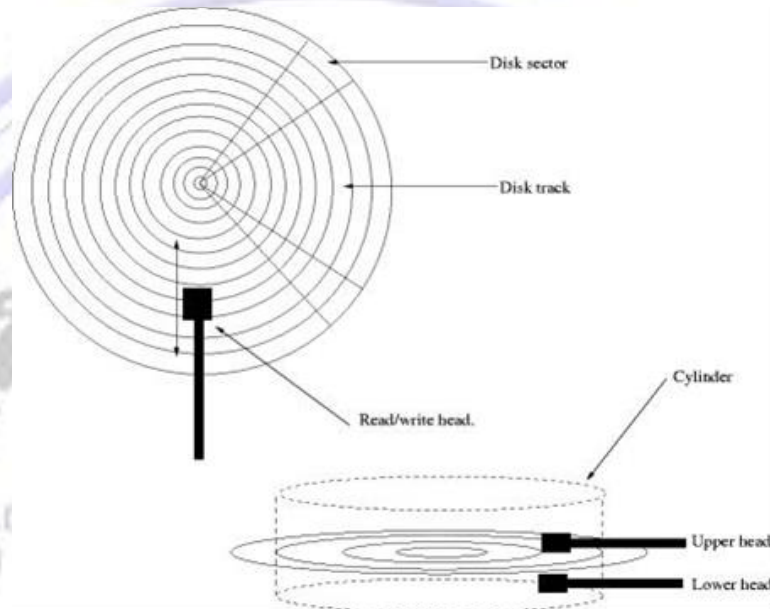


Figure 11 Single & Double disk head.

**Note:**

The number of tracks & sectors varies according to manufactures, for example standard 5.25 inch (IBM disk) has 40 tracks on each side. Double sided 3.5-inch disk have 77 tracks per side. The number of sectors also varies. The IBM standard is 9 sectors per track, while Apple disks have 16 sectors per track. See Table 1 below.

Table 1 Formats & Capacities for 3.5-inch disk of IBM PCs only

Density	Tracks	Sectors per track	Bytes per sector	Capacity
double	80	9	512	720 Kb
high	80	18	512	1.44 Mb

### **Disk Access time:**

A disk drive, access time depends on a combination of two factors:

1. The speed at which a disk spins (revolutions per minute or rpm).
2. The time it takes to move the heads from one track to another.

For example, the longest amount of time needed for the disk drive's read/write head to access any point is about 0.2 second, which is the amount of time needed for the disk to complete one revolution at 300 rpm. The maximum access time is 200 milliseconds. The average is half the maximum (100 ms).

### **Data transfer rate of disk:**

Also called *throughput time* (is the time required to move a specific amount of data from one device to another such as from disk to memory). It measures in second. Data transfer rates can vary greatly from one device to another. The average data transfer rate of disk drive about 45 KBps.

### **Advantages/Disadvantages of Floppy Disks:**

<b>Advantages</b>	<b>Disadvantages</b>
<b>Cost very little</b> to buy.	<b>Very low storage capacity</b> when compared to other media (1.44 Mb).
Can be <b>write protected easily</b> which protects against accidentally copying over files.	<b>Very few</b> modern computers have floppy disc drives (device used to read the disk).
Very <b>small, light</b> and <b>easy to carry</b> (portable).	Floppy discs are <b>very delicate</b> and easy to damage (Not robust).
	<b>Slow data transfer rate</b> (Takes a long time to save/read from the disk).

# المحاضرة التاسعة



## Lecture8

### 5.1.2. C Hard Disk Drive (HDD):

HDD is an external storage device that stores digital data permanently and can be accessed randomly. The HDD consist of metal platter coated with magnetic oxide and housed within a metal case that can be magnetized to represent data. HDD is usually located inside the computer system unit (case), otherwise is connected to the system unit externally which is called then an external HDD (potable). see Figure 1.



*Figure 1 Internal vs External HHD.*

HDDs come in various shapes and sizes. The hard drive suppliers and computer industry refer to them as 1.8, 2.5, or 3.5 inches form factor drives. These form factor descriptions refer to the approximate physical diameter size of the platters that are housed within the drive casing. The common size for laptop hard drives in the 2.5" model, while a larger 3.5" model is usually found in desktop computers.

### Physical view:

Commonly, hard disks have several disk **platters** mounted on a single central **spindle**. There are **read/write heads** for each disk platter. Several platters are organized into a disk pack (or disk drive).

Data can be recorded on both sides of the disk platters (often the topmost and bottommost surfaces are unused). The read/write heads are all mounted on the same stepping motor mechanism and move together between the disk platters, see Figure 2.

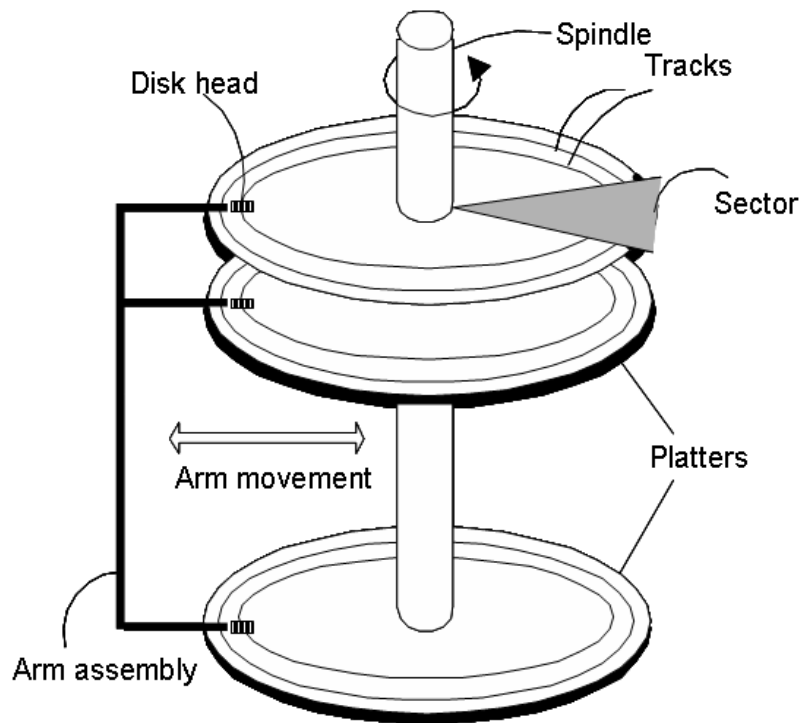


Figure 2 HDD Components.

**Platter** is the circular disk on which magnetic data is stored in a hard disk drive. The rigid nature of the platters in a hard drive is what gives them their name (as opposed to the flexible materials which are used to make floppy disks). A typical consumer HDD may have up to five platters. The weight of the drive is often a good indicator of the number of platters used.

Hard disks pack data more closely together than floppy disk can, but they also hold more data, because they usually include multiple platters stacked one on top of another. This configuration means that the disk has more than two sides; sides 0, 1, 2, 3, 4, and so on. Larger capacity hard disk drives may use twelve or more platters, but both sides of every platter are not always used.

The platter *speed* varying from 4,200 rpm in energy-efficient portable devices, to 15,000 rpm for high-performance servers. The first HDDs spun at 1,200 rpm and, for many years, 3,600 rpm was the norm. By compare hard disks with floppy disks (which have 300 rpm), you see the hard disk is *faster* than floppy. The speed at which the disk spins is a major factor in the overall performance of the drive.

**Assembly arms** is moved in or out to position a head on a desired track. The mechanical arm moves the read/write head across the surface of a hard disk.

**Disk head:** A read/write head or RW head is a device on the arm of a hard drive. It reads and writes data from the hard drive's disk platter. Hard drives usually have one read/write head for each platter side that resides on the platter while idle. Read/write head assembly is mounted on an arm that moves across the surface of the platters. See Figure 3.

The number of *read/write heads* specify the number of *sides* that disk has; for example, a particular hard disk drive might have six disk platters (that is, twelve sides) but only eleven heads are available, indicating that one side is not used to store data. Often, the unused side is the bottom side of the bottom disk.

Basically, all hard drives work the same way as floppy disk works, where the data is encoded and "written" onto a round, spinning platter that's been coated with magnetic material. The *writing* is done by a magnetic head, mounted at the end of an arm that moves in such a way that the head can be positioned over any part of the platter. The same head also *reads* the stored data.

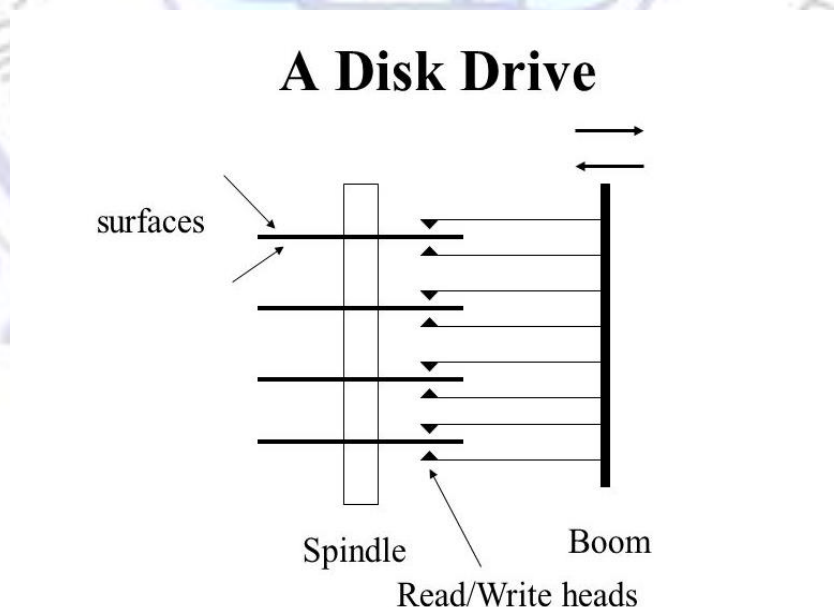


Figure 3 A disk drive with 4 platters and 8 surfaces and 8 RW heads.

### Logical view:

Physically, however hard disks look different from diskette (floppy disk), hard drives also store data in concentric *tracks* which divides into *sectors* (the smallest addressable unit in a disk). Like diskette, hard disks generally store 512 bytes of data in a sector or more. Data on hard disk have been organized in two ways **sector method** and **cylinder method**, see Figure 4.

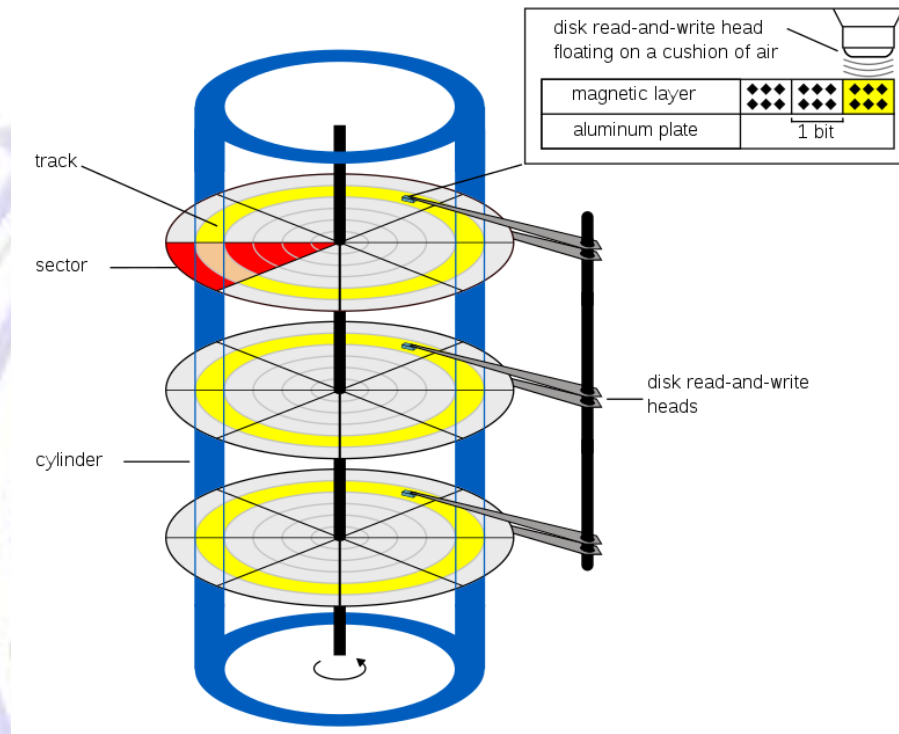


Figure 4 Sector vs Cylinder method for data organization on HDD.

➤ The two way for organizing data on hard disk are:

#### **1- Sector method:**

In the sector method, each track on a disk is divided into sectors that hold a specific amount of data. When a program reads a byte from the disk, the operating system locates the surface, track and sector containing that byte, and reads the entire sector into a special area in main memory called buffer (temporary storage).

#### **2- Cylinder method:**

The data is stored *vertically* within the disk pack. *Cylinder* is the set of tracks at a given radius of a disk pack (drive); i.e., a cylinder is the set of tracks that can be accessed without moving the disk



arm, so all the information on a cylinder can be accessed without moving the read/write arm. To store a file in specific tracks, it makes sense that are below/above each other on different surfaces, rather than in several tracks on the same surface (like sector method). See Figure 5.

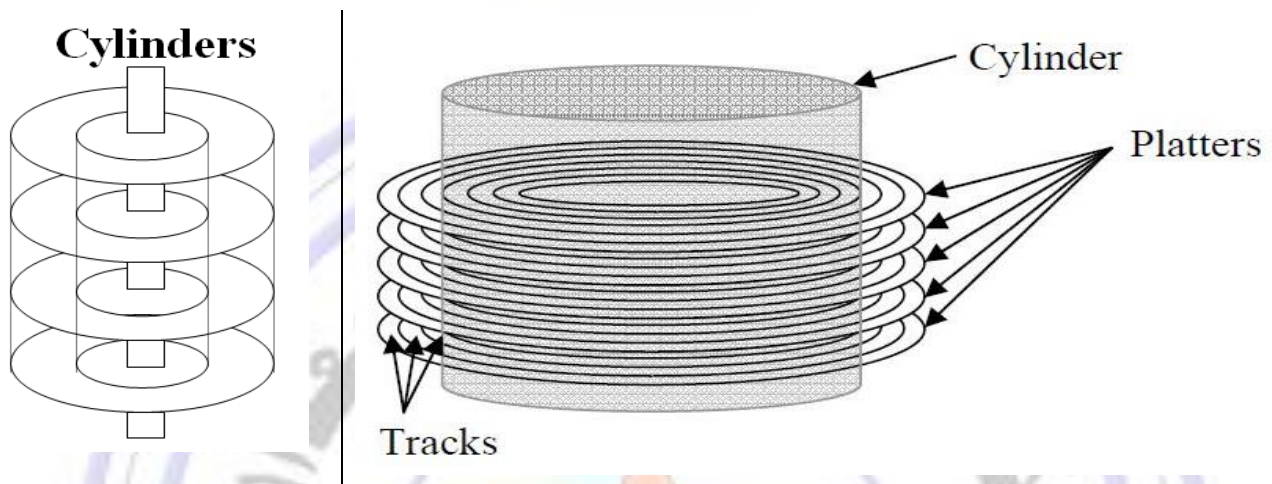


Figure 5 HDD Cylinder.

#### Hard Disk bottleneck:

- The two major problems with hard drives are they are relatively *slow* and they can *fail* - which could mean the loss of important data. **RAID (Redundant Array of Inexpensive Disks)** is a technique used to reduce the risk of hard drive failure and/or increase the read/write speed of data from the hard drives. Two ways for using RAID and they are accomplished by using multiple hard drives (i.e., an array of hard drives). See Figure 6.
  - RAID 0 (two or more hard drives are used together to increase speed).
  - RAID 1 (data are duplicated on two or more hard drives, there will be an exact copy of the data on the other drives).
- Another major drawback for HDD is the *head crash*. To achieve optimum performance, the read/write head must be extremely close to the surface of the disk without actually touching the disk. In fact, the read/write heads fly so close to the surface of the disk. This gap between the head and disk surface cause the head crash because if a human hair, a dust particle, or even a fingerprint was placed on the

disk, the problem of head crash may occur. A head crash, in which the head touches the disk, can destroy the data stored in the area of the crash.

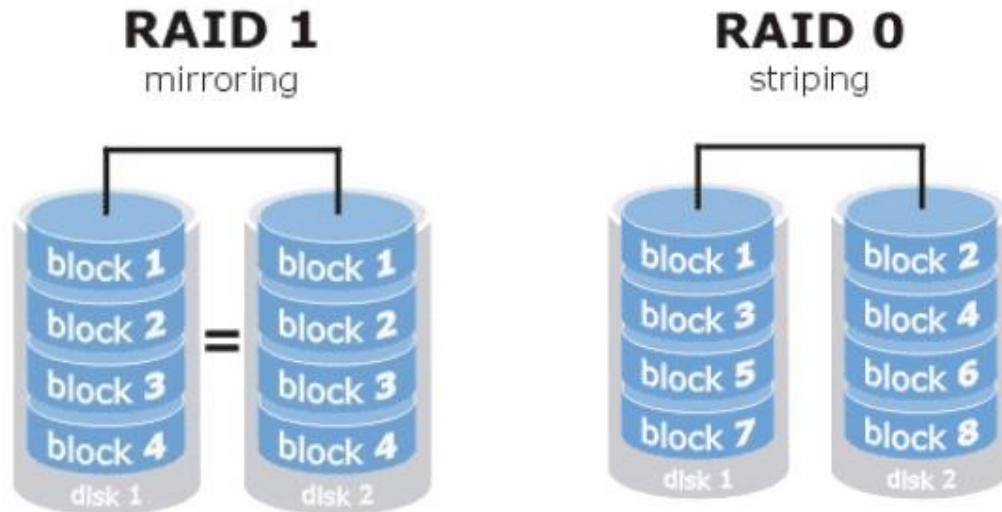


Figure 6 RAID 0 and RAID 1 techniques used with HDD.

#### Hard Disk Access time:

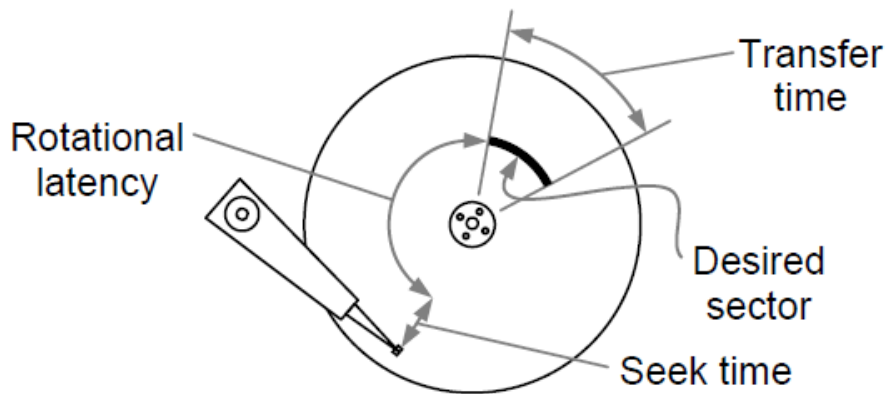
There are a number of issues affecting the HDD access time between a device requesting data and the hard drive responding with the data. Some of these issues depend on the *current state of the system* while others depend on the *physical design* of the drive and the amount of data being requested. See Figure 7.

There are four basic aspects to hard drive access time:

- 1- **Queuing time:** is the time the system must wait for the hard drive to become available after an initial request is made to it. For example, the hard drive may be busy serving another device.
- 2- **Seek time:** is the amount of time it takes to get the read/write head from its current track to the desired track
- 3- **Rotational latency time:** the time that the drive must wait for the platters to rotate to the sector containing the requested data. The worst case occurs when the start of the desired sector has just passed

under the head when the drive begins looking for the data. This requires almost a full rotation of the platters before the drive can begin transferring the data

- 4- **Transfer time:** The time required to transfer a block of data to the disk controller buffer<sup>1</sup>.



*Figure 7 HDD Access Time.*

Disk **access time** is always given as an average, because **seek time** and latency vary depending on the current position of the head and platter. While access times of fast hard disks are typically from 5 to 10 milliseconds, solid state drive (SSD) access times are in the 25 to 100 microsecond range.

$$\text{Total Time to access a disk block} = \text{Avg. seek time} + \text{avg. latency time} + \text{avg. transfer time}$$

<sup>1</sup> Disk controllers: typically embedded in the disk drive, which acts as an interface between the CPU and the disk hardware

# المحاضرة العاشرة



## Lecture9

### 5.1.3 Solid State Storage Device

A Solid State Drive (SSD) is a newer, faster type of data storage device which store data in a *non-volatile* and *random access* format. An SSD stores data on **flash memory chips** which store data in the form of electrical charges. SSD stores data in binary patterns using billions of tiny low-voltage switches called **transistors**. If a switch is open, then this represents a binary one because the transistor keeps its charge and it is not able to drain away. If it is closed, this represents a binary zero because the charge has a path to escape. See Figure 1.

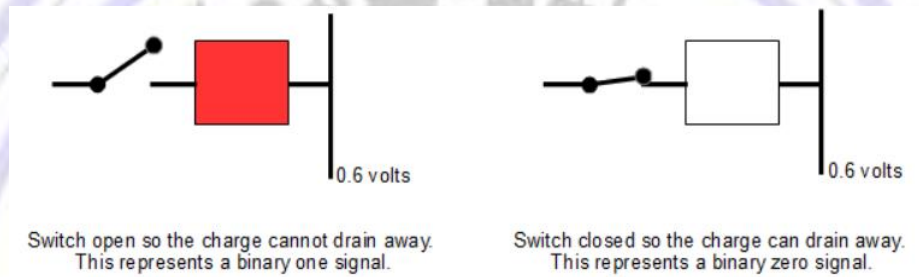


Figure 1 Binary Representation via a Transistor.

#### 5.1.3.A Solid State Drive (SSD)

SSD performs the same job as a Hard Disk Drive (HDD) in storing data; however, it differs in the way of storing data on instantly-accessible **memory chips**. While the HDD store data in a magnetic coating on top of platters, the SSD uses **flash memory chips** and an embedded processor to store, retrieve, and cache data. See Figure 2.

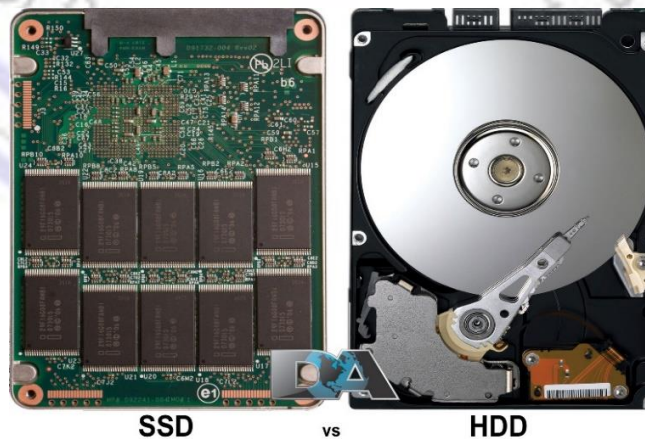


Figure 2 SSD vs HDD Storage Device.

### HDD and SSD Comparison:

The most significant difference between an SSD and the traditional HDD is that an SSD has absolutely no moving parts which make them more  **durable**. An HDD uses moving, mechanical parts to read data from specific locations; this makes the HDD slower than SSD's, which use their embedded controllers or the "brain" to control NAND cells. Look at the comparison between HDD and SSD in the following table.

Criteria	HDD	SSD
<b>Cost</b>	Economical as it is cheaper than SSD	Expensive
<b>Speed</b>	Because of disk rotation latency, it takes time to access the data	Much faster than HDDs
<b>Functioning power</b>	Consumes more power to function than SSD	Uses less power compared to HDD
<b>Durability</b>	Consist of various moving parts and components, making them susceptible to shock and damage	Less prone to physical damages as they do not have movable parts which provide better performance, reliability, and keeping files and data safe
<b>Noise</b>	Makes noises and vibrate when in use as the drive is spinning back and forth to process data	Since it does not have moving parts, it doesn't vibrate or make noise while running
<b>Heat</b>	Moving part means generate more heat than SSD	Generating less heat, helping to increase its lifespan.
<b>Data recovery</b>	Disaster recovery is easy because of availability of tools & techniques	SSDs data recovery is costly & complex

### 5.1.3.B Flash Memory Chip

Flash memory chip is a type of Electronically-Erasable Programmable Read-Only Memory (**EEPROM**). Flash memory is **non-volatile** (like ROM) and **rewritable** (like RAM). It requires erasing blocks of data before they can be written to, resulting in a lower write performance than read performance. Flash memory supports only a finite number of writes, and the number varies according to the technology used. Flash memory is available as **NAND** or **NOR** see Figure 3 .

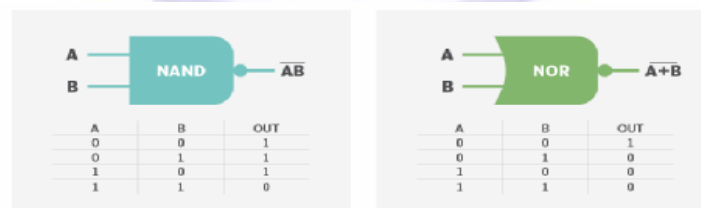


Figure 3 NAND and NOR Gates.

Flash memory can be found in many data storage devices like *USB Memory Sticks*, *Memory Cards* and *Micro-SD cards*, and even the SIM card chip in cell phone devices. See Figure 4.

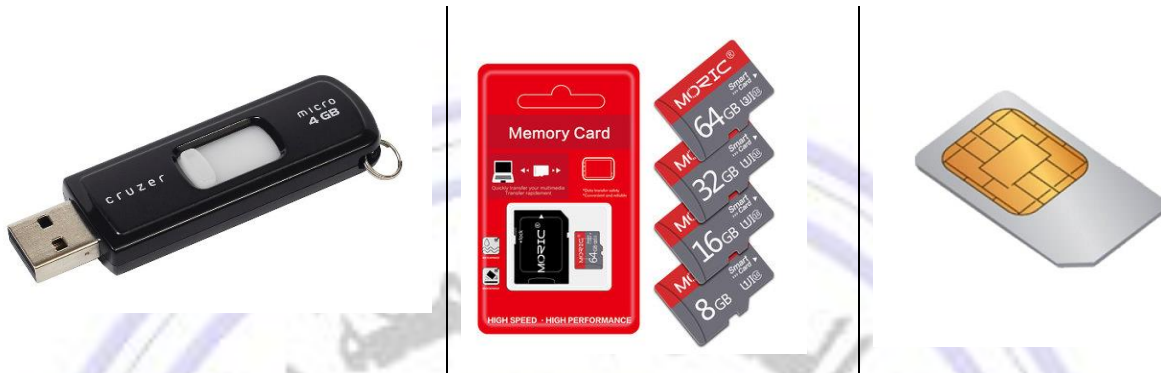


Figure 4 USB Memory Sticks, Memory Cards, and SIM card chip in cell phone devices

SSD products use NAND flash because it is more *durable*, *less expensive*, its cells are *denser*, and write/erase operations are *faster* compared to NOR flash. NOR flash memory is designed to store the binary code of programs and has high performance in read operations. The following table provides a comparison between NAND and NOR flash memory chip.

Criteria	NAND flash memory	NOR flash memory
Capacity	High	Low
Density	High	Low
Read/write technique	Page-orientated	Bitwise
Read data speed	Medium	High
Write data speed	Fast	Slow
Erase data speed	Fast	Very slow
Cost per bit (price)	Low	High
Erase cycle range	100000 – 1000000 cycle	10000 – 100000 cycle
Access data method	Sequential	Random



#### 5.1.4 Optical Storage Device

Optical storage is any storage type in which data is written and read with a **laser** as all read and write activities are performed by **light**. Optical storage is an electronic storage medium that uses low-power laser beams to record and retrieve digital (binary) data. A laser beam encodes digital data onto an optical, or laser, disk in the form of tiny pits arranged in a spiral track on the disk's surface. A low-power **laser scanner** is used to "read" these pits, with variations in the intensity of reflected light from the pits being converted into electric signals. Each 1 and 0 of the binary data is represented as microscopic holes (pits) on the surface of the disc. When the laser hits a flat part of the disc surface (a "**land**") its reflection hits the sensor, which is interpreted as binary 1. When the laser hits a pit on the disc surface its angle of reflection is changed so that it misses the sensor, which is interpreted as binary 0. See Figure 5.

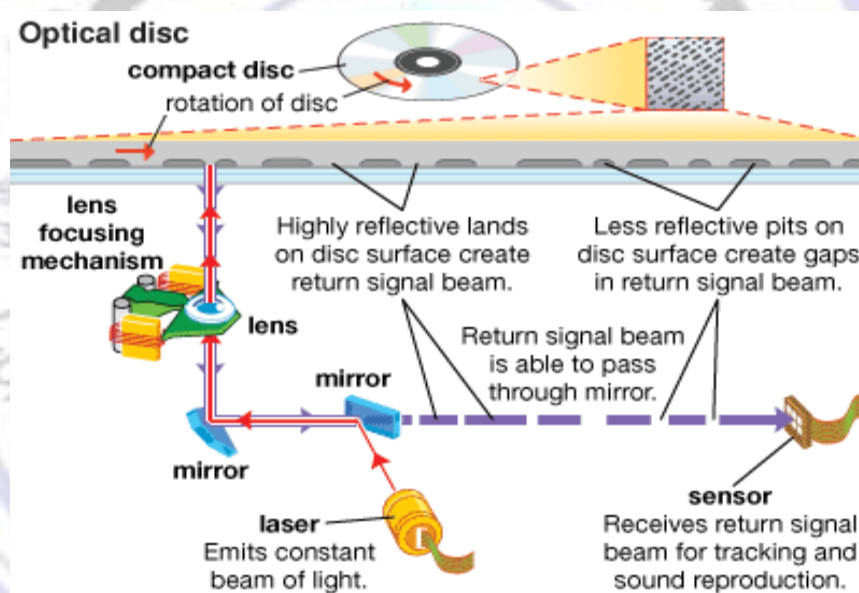


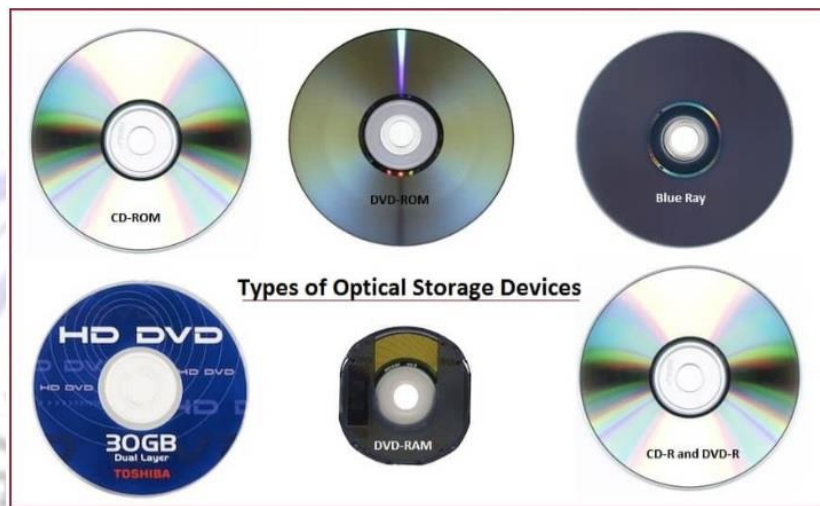
Figure 5 Optical Storage Laser Beam.

All data is saved like as patterns of dots which can be easily read with using of LIGHT. The data is read while bouncing laser beam on the surface of storage medium. Laser beam creates the all Dots while reading process, but it is used with high power mode to mark the surface of storage medium, and make a dot. This entire process is also called the "Burning" data onto Disc.



### Type of Optical Storage Devices:

- 1- Read only optical disk which have data written onto them when they are manufactured. This data cannot be changed. See Figure 6.



*Figure 6 Type of Optical Storage Devices.*

#### **- CD-ROM**

Compact Disc - Read-Only Memory (CD-ROM) discs can hold around **800MB** of data. The data cannot be altered (non-volatile), so cannot be accidentally deleted. CD-ROMs are **random-access** devices which are used to store different data type like software, sound, and text.

#### **- DVD-ROM**

Digital Versatile Disc - Read-Only Memory (DVD-ROM) discs can hold around **4.7GB** of data (a dual-layer DVD can hold twice that). DVD-ROMs are **random-access** devices which are used in the same way as CD-ROMs but they can hold more data, they are used to store high-quality **video**.

#### **- Blu-Ray**

Blu-Ray disks are a recent replacement for DVDs. A Blu-Ray disc can hold **25 - 50GB** of data (a dual-layer Blu-Ray disc can hold twice that). Blu-Ray discs are **random-access** devices. They used in the same way as DVD-ROMs but they can hold more data, they are also used to store very high-quality, **high-definition (HD) video**.

## - HD DVD

High-density DVD (HD-DVD) discs can hold around **15GB** of data (a dual-layer HD-DVD can hold twice that). HD-DVDs are **random-access** devices. They are used in the same way as DVD-ROMs but they can hold more data. They are used to store very high-quality, **high-definition (HD) video**.

## 2- Recordable Optical Discs

can have data written onto them ('burnt') by a computer user using a special disc drive (a disc 'burner').

### - CD-R and DVD-R

CD-Recordable (CD-R) and DVD-recordable (DVD-R) discs can have **data burnt** onto them, but **not erased**. You can keep adding data **until the disc is full**, but you cannot remove any data or re-use a full disc.

### - CD-RW and DVD-RW

CD-Rewritable (CD-RW) and DVD-Rewritable (DVD-RW) discs, unlike CD-Rs and DVD-Rs, can have **data burnt** onto them and **also erased** so that the discs can be **re-used**.

### - DVD-RAM

DVD-Random Access Memory (DVD-RAM) discs are a type of **re-writable** DVD. They often come in a floppy-disc style **case** (to protect the disc). DVD-RAM discs have a similar capacity to a normal DVD, holding **4.7GB** of data. DVD-RAM discs are **random-access** devices. The discs are much higher quality than normal DVD-RWs and can reliably store data for up to 30 years. This means that they are often used for video and data **backup** and **archiving**.

	Capacity	Layer	Recordable	Rewriteable
CD-ROM	650-700MB	1		
CD-R	650-700MB	1	•	
CD-RW	650-700MB	1		•
DVD-ROM	4.7GB	1		
DVD+R	4.7GB	1	•	
DVD+RW	4.7GB	1		•
DVD+R DL	8.5GB	2	•	
DVD-R	4.7GB	1	•	
DVD-RW	4.7GB	1		•
DVD-R DL	8.5GB	2	•	
DVD-RAM	4.7GB	1		•

## Hierarchy of Memories

