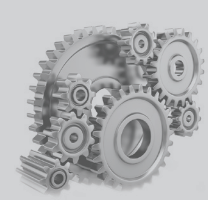
MECHANICAL ENGINEERING

Mechatronics and Robotics



Comprehensive Theory

with Solved Examples *and* Practice Questions

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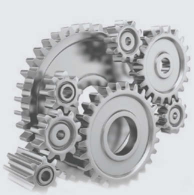

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Mechatronics and Robotics

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CHAPTER 1

Microprocessor, Microcontroller & PLC

1.1 INTRODUCTION

The most important technological invention of modern times is the "microprocessor". A microprocessor, usually abbreviated as μP, is a large scale integration (LSI) chip that is capable of performing arithmetic and logic functions as defined by a given programme. A microprocessor is a multiple purpose programmable clock driven, register based electronic device that reads binary instructions from memory, accepts binary data as input and processing this data according to the instructions written in the memory.

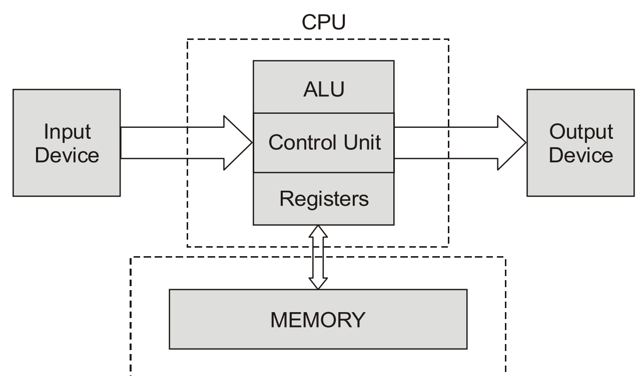


Figure: Block diagram of microcomputer

The microprocessor is capable of performing computing functions and making decisions to change the sequence of program execution.

The microprocessor can be embedded in a larger system, and can function as the CPU of a computer called a microcomputer. A state machine on a single IC chip with very large scale integration, capable at a desired instant of working as per programme or an instruction of a programe, and which is driven by a clock of frequency of 1 MHz or more, is called as microprocessor. Such a machine is also called a central processing unit (CPU). A CPU forms the main part of a computer.

The figure shows the basic block diagram of a microcomputer which processes binary data and traditionally represented by four blocks i.e. CPU, memory, input device and output device. Here, input device is a device that transfers information from outside world to the computer for example: Key board, mouse, webcam, microphone, scanner, electronic white boards, etc. The output device transfers information from computer to the outside world like monitor, printers (all types), speakers, headphones, projector, plotter, Braille embosser, LCD projection panel, computer output microfilm (COM) etc. Memory is an electronic medium that stores binary information. Central Processing Unit (CPU) is the heart of computer systems. The microprocessors in any microcomputer act as a CPU. The CPU can be made up of the following:

1. **Arithmetic logic unit (ALU):** In this area of the microprocessor, computing functions are performed on data. The ALU performs arithmetic operations such as addition and subtraction, and logic operations such as AND, OR and exclusive OR. Results are stored either in registers or in memory or sent to output devices.
2. **Register unit:** This area of the microprocessor consists of various registers. The registers are used primarily to store data temporarily during the execution of a program. Some of the registers are accessible to the user through instructions.
3. **Control unit:** The control unit provides the necessary timing and control signals to all the operations in the microcomputer. It controls the flow of data between the microprocessor and peripherals including memory.

Microcontroller is a programmable device that includes microprocessor, memory and I/O signal lines on a single chip, fabricated using VLSI technology. Microcontrollers are also known as single chip microcomputers. They are mostly used to perform dedicated functions such as automatic control of equipment, machines and process in industries and consumer appliances.

Characteristics of Microprocessor

1. It handles shorter words than other computers, usually 4 to as many as 16 bits.
2. It consists of integrated circuits from 1 to 30 in number.
3. It contains arithmetic logic unit (ALU), registers, control, random access memory (RAM), data buses and read only memory (ROM) with programs.

Important features of microprocessors:

- Low cost
- Small size
- Low power consumption
- Versatile
- Extremely reliable

1.1.1 System Bus

Buses are the baths along which digital signals move from one section to another. A bus is a group of wires/lines used to transfer data (bits) between components inside a computer or between computers. In most simple form, they are communication path used to carry the signals between microprocessor and peripherals. A bus is just a number of conductors along which electrical signals can be carried. It might be tracks on a printed circuit board or wires in a ribbon cable.

The system bus of a microprocessor is of three types:

1. **Address Bus**
   - It is a group of lines that are used to send a memory address or a device address from the Microprocessor Unit (MPU) to the memory or the peripheral.
   - The address bus is always uni-directional i.e address always goes out of the microprocessor.
   - If the address line are 'n' for a MPU then its addressing capacity is 2^n.
   - It carries signals which indicate where data is to be found and so the selection of certain memory locations or input or output ports.

- Each storage location within a memory device has a unique identification, termed its address, so that system is able to select a particular instruction or data item in the memory.
- Each input/output interface also has an address.

2. Data Bus

- It is a group of lines used to transfer data between the microprocessor and peripherals and/or memory
- Data bus is always bi-directional.
- The data bus carries the data associated with the processing function of the CPU.
- Each wire in the bus carries a binary signal i.e., a0 or a1.
- The more the wires, the data bus has the longer the word length that can be used.

3. Control Bus

- Control bus provides signals to control the flow of data.
- This bus carries the signals relating to control actions.
- It is also used to carry the system clock signals; these are to synchronize all the actions of the microprocessor system.

NOTE: The internal architecture of the microprocessor unit depends on the data bus width, which is equal to the bit-capacity of the microprocessor.

1.2 EVOLUTION OF MICROPROCESSORS

- In 1971, the first microprocessor was introduced by "Intel corporation". This was 'Intel 4004", a processor on a single chip. It had the capability of performing simple arithmetic and logical operations, e.g., addition, subtraction, comparisons, AND, and OR. It also had control unit which could perform various control functions like fetching an instruction from the memory, decoding it and generating control pulses to execute it. It was a 4 - bit microprocessor operating on 4 - bits of data at a time.
- In the first few years the microprocessor has changed the calculators to video games and computers. Several microprocessors have been manufactured for all sorts of products, some have succeeded and some have not.
- The first microprocessor to make it into a home computer was the Intel 8080, a complete 8-bit computer on one chip, introduced in 1974.
- The first microprocessor to make a real splash in the market was the Intel 8088, introduced in 1979 and incorporated into the IBMPC which first appeared around 1982.
- The PC market moved from the 8088 to 80286 to the 80386 to the 80486 to the pentium to the pentium II to the pentium III, to the pentium 4. All of the these microprocessors are made by Intel and all of them are improvements on the basic design of the 8088. The "Pentium 4" can execute any piece of code that ran on the original 8088 but it does it about 5000 times faster.

Table: Differences among different Processors

Name	Date	Transistors	Data with (Bits)	Microns	Clock speed (MHz)	MIPS
4004	1971	2250	4	10	0.1	0.06
8008	1972	3500	8	10	0.2	0.06
8080	1974	6000	8	6	2	0.64
8085	1974	6500	8	3	5	0.37
8086	1978	29000	16	3	5 8 10	0.33 0.66 0.75
8088	1979	29000	16	3	5	0.33
80286	1982	134000	16	1.5	16	1
80386	1985	275000	32	1.5	16	5
80486	1989	1200000	32	1	25	20
Pentium	1993	3100000	32	0.8	60	100
Pentium II	1997	7500000	32	0.035	233	~300
Pentium III	1999	9500000	32	0.25	450	~510
Pentium 4	2000	42000000	64	0.18	1500	~1700
Pentium 4 “Prescott”	2004	125000000	64	0.09	3.6 Hz	~7000

NOTE: Most of the general purpose microprocessors used in the modern world computers are the family of 8086.

1.3 COMPUTER LANGUAGE

- **Scale of integration:**
  - **SSI (Small Scale Integration):** The term refers to the technology used to fabricate discrete logic gates on a chip.
  - **MSI (Medium Scale Integration):** The process of designing few tens of gates on a single chip.
  - **LSI (Large Scale Integration):** The process of designing hundreds of gates on a single chip similarly terms VLSI (very large scale integration), ULSI (ultra large scale integration) are used to indicate the scale of integration.
- **Digital computer** is a programmable machine that process binary data. It is traditionally represented by five components: CPU, ALU, CU, memory, input and output.
- **Instruction** is a command in binary that is recognized and executed by the computer in order to accomplish a task. Some instructions are designed with one word, and some require multiple words.
- **Mnemonic** is a combination of letters to suggest the operation of an instruction.
- **Program** is a set of instructions written in a specific sequence for the computer to accomplish a given task.

- **Machine Language** is the binary medium of communication with a computer through a designed set of instructions specific to computer.
- **Assembly Language** is a medium of communication with a computer in which programs are written in mnemonics. An assembly language is specific to a given computer.
- **Low-Level Language** is a medium of communication that is machine-dependent or specific to a given computer. The machine and the assembly languages of a computer are considered low-level languages. Programs written in these languages are not transferrable to different types of machines.
- **High-Level Language** is a medium of communication that is independent of a given computer. Programs are written in English-like words, and they can be executed on a machine using a written translator (a compiler or an interpreter).
- **Compiler** is a program that translates English-like words of a high-level language into the machine language of a computer. A compiler reads a given program, called a source code, in its entirety, and then translates the program into the machine language which is called an object code. (Ex. *C*, *C*++)
- **Interpreter** is a program that translates the English-like statements of a high-level language into the machine language of a computer. An interpreter translates one statement at a time from a source code to an object code. (Ex. BASIC)
- **Assembler** is a computer program that translates an assembly language program from mnemonics to the binary machine code of a computer and these machine codes are called object programme .
- **Bit** is a binary digit, 0 or 1.
- **Byte** is a group of eight bits.
- **Nibble** is a group of four bits.
- **Word:** a group of byte the computer recognizes and processes at a time.
- **Subrouting:** a "Subroutine" is a group of instructions written separately from the main program to perform a function that occurs repeatedly in the main program.
- **Cross assembler:** used to translate opcodes of one processor to opcode of another processor.

NOTE

Difference between compiler and interpreter: Interpreter reads one line of a program at a time, converts it into object code, executes and then reads next line. Whereas, compiler reads whole program at a time and convert it into the object code and then execute.

EXAMPLE : 1.1

Machine instructions are written using which of the following?
(a) Bits 0 and 1 only
(b) Digits 0 and 9 only
(c) Digits 0 and 9 and the capital alphabets *A* to *Z* only
(d) Digits 0 to 9, the capital alphabets *A* to *Z* and certain special characters

Solution: (a)

Machine instructions are written using bits 0 and 1 only.

EXAMPLE : 1.2

Output of the assembler in machine code is referred to as
(a) Object program (b) Source program
(c) Macroinstruction (d) Symbolic addressing

Solution: (a)

Output of the assembler in machine code is referred to as object program.

EXAMPLE : 1.3

Which one of the following statements is correct?

A micro-controller differs from a microprocessor in that it has

(a) Both on-chip memory and on-chip ports
(b) Only on-chip memory but not on-chip ports
(c) Only on-chip ports but not on-chip memory
(d) Neither on-chip memory nor on-chip ports

Solution: (a)

A micro-controller differs from a microprocessor in that has both on-chip memory and on-chip ports.

EXAMPLE : 1.4

Statement (I) : Many programmers prefer assembly level programming to machine language programming.

Statement (II) : It is possible to efficiently utilize the hardware of the computer in machine language programming.

(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are true but Statement (II) is not a correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

Solution : (b)

Many programmers prefer assembly level programing to machine language programming because assembly language is simple and easily understandable. So assertion is true. Also it is possible to efficiently utilize the hardware of the computer in machine language programming because the machine language is directly understood by microprocessor.

Application of Microprocessors

A few more applications of microprocessors are mentioned below:

- A microprocessor based stepping motor controller used for controlling several stepping motors in a pulsed Laser system. The motors are used to precisely align a set of mirrors used in this system.
- There are several other motor control applications reported in the literature, Lin (1977) describes one approach to motor speed control using an SCR chopper.
- A microprocessor controlled Railways Signaling Inter lock was developed to exhibit the applications of microprocessors in signaling. The system mirrors train positions in different blocks on a section and sends speed codes to each block. The speed codes are displayed and used by train drivers to control the speed.
- A patient surveillance system was designed using distributed processing.
- Microprocessors have been used in a variety of automation applications. Control of tester for surveillance checking the electronic functioning capability of a target detecting device (Frantz, 1977) is one of these. A microprocessor based blood gas analyzer has been developed by Margalith et al. (1977).
- Some of the important uses of microprocessors in instrumentation area are listed below:
  (a) Frequency meters
  (b) Function generators
  (c) Frequency synthesizers
  (d) Spectrum synthesizers
  (e) Intelligent instruments CRT terminals
  (f) Digital millimeters
  (g) Oscilloscopes
  (h) Counters

1.4 MICROPROCESSOR ARCHITECTURE

The process of data manipulation and communication is determined by the logic design of microprocessor, called the “Architecture”. There are two types of architecture depending upon storage of program and data in memory:

- Von Neumann architecture of computers
- Harvard architecture of computers

Von Neumann Architecture

The idea of basic organization of a digital computer containing a CPU, a main memory, input and output device and secondary storage devices was given by John von Neumann in 1945. He introduced the “stored – program concept”-where the programs and data are stored in the same high speed memory unit. This is a hypothetical architecture that is derived from the idea of stored-program computers, in which the memory is used for storing both the program data and instruction data. In Von Neumann architecture there is a program counter and instructions are executed in sequential manner. The MPU fetches one instruction of the program and executes it, then it goes to the next instruction. The speed of computer is limited by the speed at which the MPU can fetch the instructions and data from the memory and process them. Digital computers based on this principle are called control-flow or control driven computers.

Prior to the introduction of the Von Neumann idea of computer design, computing machines were developed for a single predetermined function, and their level of Sophistication was limited as a result of the need for human rewiring of the circuitry. The ability to keep instructions in the memory along with the data that the instructions operate on is the central tenet of the Von Neumann Architectures.

Examples: Intel 8085 and Intel 8086

Harvard Architecture

It is a type of computer architecture that keeps program data and instructions in storage and signal channels that are physically independent from one another. In contrast to the Von Neumann design, which retrieves instructions from memory using a single us while simultaneously moving data from one component of a computer to another, the Harvard Architecture keeps data and instructions in their own distinct memory spaces. The Harvard architecture is based on the concept of separating the memory into two distinct sections, with one section dedicated to storing data and the other to storing programs. Real-world computer designs are really based on a modified version of the Harvard architecture, which is frequently utilized in digital signal processors and microcontrollers (Digital Signal Processing).

Examples: Intel 8051, Intel’s Pentium, TMS 32010 etc.

1.5 DIGITAL NUMBER SYSTEMS

Digital systems are used for many applications including data processing, signal processing, process controls etc. Further, digital systems consist of digital circuits and digital signal. Digital circuits consist of inter connections of elements that perform simple logical operations. At the lowest level, digital systems operate between two possible states which can be considered as either 'on' or "off", "high" or "low" or "1" or "0". A 1 or 0 can tell the state of a system such as whether a bulb is ON or OFF or air conditioner is ON or OFF. Likewise many situations can be understood by this simple logic of ON and OFF. Hence, digital systems are essentially discrete in operation with the circuits either conducting or nonconducting. The two levels of 0 and 1 may represent levels of ON or OFF, open or closed, yes or no, true or false, etc. However, they can also represent decimal digits, alphanumeric characters and various symbols such as periods and commas. But this requires an agreed upon code and a method for representing in binary form the symbol or character it represents. Many number systems are used in digital technology. The most commonly used number systems are:

- Decimal number system
- Binary number system
- Octal number system
- Hexadecimal number system

A number system with base or radix 'r' will have r number of different digits from $0 \rightarrow (r - 1)$ thus, number system is represented by $(N)_b$

where, N = Number ; b = Base or radix

In general a number with an integer part of 'n' bits and a fraction part of 'm' bits can be written as

$$(N)_b = \underbrace{b_{n-1}\, b_{n-2} \cdots b_1 b_0}_{\text{Integer part}} \underset{\text{Radix point}}{\overset{\bullet}{\uparrow}} \underbrace{b_{-1}\, b_{-2} \cdots b_{-m}}_{\text{Fraction part}}$$

1.5.1 Decimal Number System

- This system has **'base 10'**.
- The base of the numbering system is the number of symbols a numbering system uses.
- It has 10 distinct symbols to represent numbers (0, 1, 2, 3, 4, 5, 6, 7, 8 and 9).
- This is a positional value system in which the value of a digit depends on its position.
- The positions are numbered from from right to left, starting with the rightmost position.

  ⇒ Let we have $(453)_{10}$ is a decimal number

  then,

  4 5 3

  $3 \times 10^0 = 3$

  $5 \times 10^1 = 50$

  $4 \times 10^2 = 400$

  Finally we get, $(453)_{10}$

∴ We can say "3" is the least significant digit(LSD) and "4" is the most significant digit(MSD).

1.5.2 Binary Number System

- It has base '2' i.e. it has two base numbers 0 and 1 and these base numbers are called "Bits".
- It works just like the decimal system; however, with only two symbols (0 and 1) the binary system is weighted by a power of 2:

  $$2^0 = 1,\ 2^1 = 2,\ 2^2 = 4,\ 2^3 = 8,\ 2^4 = 16 \text{ and so on,}$$

- The digits in different positions are designated as zero-order bit, first-order fit, etc.
- In this number system, group of "Four bits" is known as "Nibble" and group of "Eight bits" is known as "Byte".

i.e. 4 bits = 1 Nibble; 8 bits = 1 Byte

Binary to Decimal Conversion

A binary number is converted to decimal equivalent simply by summing together the weights of various positions in the binary number which contains **'1'**.

EXAMPLE : 1.5 The decimal number representation of 101101.10101 is

Solution:

$$(101101.10101)_2 = 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3} + 0 \times 2^{-4} + 1 \times 2^{-5}$$

$$= 32 + 0 + 8 + 4 + 0 + 1 + \frac{1}{2} + 0 + \frac{1}{8} + 0 + \frac{1}{32} = (45.65625)_{10}$$

Decimal to Binary Conversion

The integral decimal number is repeatedly divided by '2' and writing the remainders after each division until a quotient '0' is obtained.

EXAMPLE : 1.6 Convert $(13)_{10}$ to binary.

Solution:

	Quotient	Remainder	
$13 \div 2$	6	1	LSB
$6 \div 2$	3	0	
$3 \div 2$	1	1	
$1 \div 2$	0	1	MSB

$\therefore$ $(13)_{10} \Rightarrow (1101)_2$

REMEMBER To convert Fractional decimal into binary, Multiply the number by '2'. After first multiplication integer digit of the product is the first digit after binary point. Later only fraction part of the first product is multiplied by 2. The integer digit of second multiplication is second digit after binary point, and so on. The multiplication by 2 only on the fraction will continue like this based on conversion accuracy or until fractional part becomes zero.

EXAMPLE : 1.7 Convert $(0.65625)_{10}$ to an equivalent base-2 number.

Solution:

0.65625	0.31250	0.62500	0.25000	0.50000
× 2	× 2	× 2	× 2	× 2
1.31250	0.62500	1.25000	0.50000	1.00000
1	0	1	0	1

Thus, $(0.65625)_{10} = (0.10101)_2$

1.5.3 Octal Number System

- It is very important in digital computer because by using the octal number system, the user can simplify the task of entering or reading computer instructions and thus save time.
- It has a base of '8' and it posses 8 distinct symbols (0,1...7).
- It is a method of grouping binary numbers in group of three bits.
- Each position in the octal system is weighted by a power of 8 : $8^0 = 1$, $8^1 = 8$, $8^2 = 64$, $8^3 = 512$ and so on.

Octal to Decimal Conversion

An octal number can be converted to decimal equivalent by multiplying each octal digit by its positional weightage.

EXAMPLE : 1.8 Convert $(6327.4051)_8$ into its equivalent decimal number.

Solution:

$$(6327.4051)_8 = 6\times 8^3+3\times 8^2+2\times 8^1+7\times 8^0+4\times 8^{-1}+0\times 8^{-2}+5\times 8^{-3}+1\times 8^{-4}$$

$$= 3072+192+16+7+\frac{4}{8}+0+\frac{5}{512}+\frac{1}{4096}$$

$$= (3287.5100098)_{10}$$

Thus, $(6327.4051)_8 = (3287.5100098)_{10}$

Decimal to Octal Conversion

- It is similar to decimal to binary conversion.
- For integral decimal, number is repeatedly divided by '8' and for fraction, number is multiplied by '8'.

EXAMPLE : 1.9 Convert $(3287.5100098)_{10}$ into octal.

Solution:
For integral part:

	Quotient	Remainder
3287 ÷ 8	410	7
410 ÷ 8	51	2
51 ÷ 8	6	3
6 ÷ 8	0	6

$\therefore$ $(3287)_{10} = (6327)_8$

Now for fractional part:

0.5100098	0.0800784	0.6406272	0.1250176
× 8	× 8	× 8	× 8
4.0800784	0.6406272	5.1250176	1.0001408
↓	↓	↓	↓
4	0	5	1

∴ $(0.5100098)_{10} = (0.4051)_8$

Finally, $(3287.5100098)_{10} = (6327.4051)_8$

Octal-to-Binary Conversion

This conversion can be done by converting each octal digit into binary individually.

EXAMPLE : 1.10 Convert $(472)_8$ into binary

Solution:

4	7	2
⇓	⇓	⇓
100	111	010

∴ $(472)_8 = (100\ \ 111\ \ 010)_2$

Binary-to-Octal Conversion

In this conversion the binary bit stream are grouped into groups of three bits starting at the LSB and then each group is converted into its octal equivalent. After decimal point grouping start from left.

EXAMPLE : 1.11 Convert $(1011011110.11001010011)_2$ into octal.

Solution:

For left-side of the radix point, we grouped the bits from LSB:

001	011	011	110
↓	↓	↓	↓
1	3	3	6

Here two 0's at MSB are added to make a complete group of 3 bits.

For right-side of the radix point, we grouped the bits from MSB:

• (radix point)	110	010	100	110
	↓	↓	↓	↓
	6	2	4	6

Here a '0' at LSB is added to make a complete group of 3 bits.

Finally, $(1011011110.11001010011)_2 = (1336.6246)_8$

1.5.4 Hexadecimal Number System

- The base for this system is "16", which requires 16 distinct symbols to represent the numbers.
- It is a method of grouping 4 bits.
- This number system contains numeric digits (0, 1, 2,....9) and alphabets (*A*, *B*, *C*, *D*, *E* and *F*) both, so this is an "ALPHANUMERIC NUMBER SYSTEM".

- Microprocessor deals with instructions and data that use hexadecimal number system for programming purposes.
- To signify a hexadecimal number, a subscript 16 or letter '*H*' is used i.e. $(A7)_{16}$ or $(A7)_H$.
- Each position in this system is weighted by a power of 16:
  $16^0 = 1$, $16^1 = 16$, $16^2 = 256$, $16^3 = 4096$ and so on.

Table: Hexadecimal number system

Hexadecimal	Decimal	Binary
0	0	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

Hexadecimal-to-Decimal Conversion

EXAMPLE : 1.12 Convert $(3A.2F)_{16}$ into decimal system.

Solution:

$$(3A.2F)_{16} = 3 \times 16^1 + 10 \times 16^\circ + 2 \times 16^{-1} + 15 \times 16^{-2}$$

$$= 48 + 10 + \frac{2}{16} + \frac{15}{16^2} = (58.1836)_{10}$$

Decimal-to-Hexadecimal Conversion

EXAMPLE : 1.13 Convert $(675.625)_{10}$ into Hexadecimal.

Solution:

For Integral Part:

	Quotient	Remainder
$675 \div 16$	42	3
$42 \div 16$	2	10 = A
$2 \div 16$	0	2

$\therefore \quad (675)_{10} = (2A3)_{16}$

For fractional part:

$$625 \times 16 = 10 = A$$

$\therefore$ $(0.625)_{10} = (0.A)_{16}$

Finally, $(675.625)_{10} = (2A3.A)_{16}$

Hexadecimal-to-Binary Conversion

For this conversion replace each hexadecimal digit by its 4 bit binary equivalent.

EXAMPLE : 1.14 Convert $(2F9A)_{16}$ to Binary System

Solution:

2	F	9	A
↓	↓	↓	↓
0010	1111	1001	1010

$\therefore$ $(2F9A)_{16} = (0010\ 1111\ 1001\ 1010)_2$

Binary-to-Hexadecimal Conversion

For this conversion the binary bit stream is grouped into pairs of four (starting from LSB) and hex number is written for its equivalent binary group.

EXAMPLE : 1.15 Convert $(10100110101111)_2$ to hexadecimal number system.

Solution:

00 10	10 01	10 10	1111
↓	↓	↓	↓
2	9	A	F

Here two 0's at MSB are added to make a complete group of 4 bits.

$\therefore$ $(10100110101111)_2 = (29AF)_{16}$

The number systems can also be classified as weighted binary number and unweighted binary number. Where weighted number system is a positional weighted system for example, Binary, Octal, Hexadecimal *BCD*, 2421 etc. The unweighted number systems are non-positional weightage system for example Gray code, Excess-3 code etc.

1.6 MAIN MEMORY ORGANISATION

The memory is organized in the form of a cell, each cell is able to be identified with a unique number called address. Each cell is able to recognize control signals such as "read" and "write", generated by CPU when it wants to read or write address.

The memory hierarchy was developed based on a program behavior known as locality of references. Memory references are generated by the CPU for either instruction or data access. These accesses tend to be clustered in certain regions in time, space, and ordering. In a microprocessor, the memory unit stores binary data and takes the form of one or more integrated circuits (ICs). The data may be program instruction codes or numbers being operated on. The size of the memory is determined by the number of wires in the address.

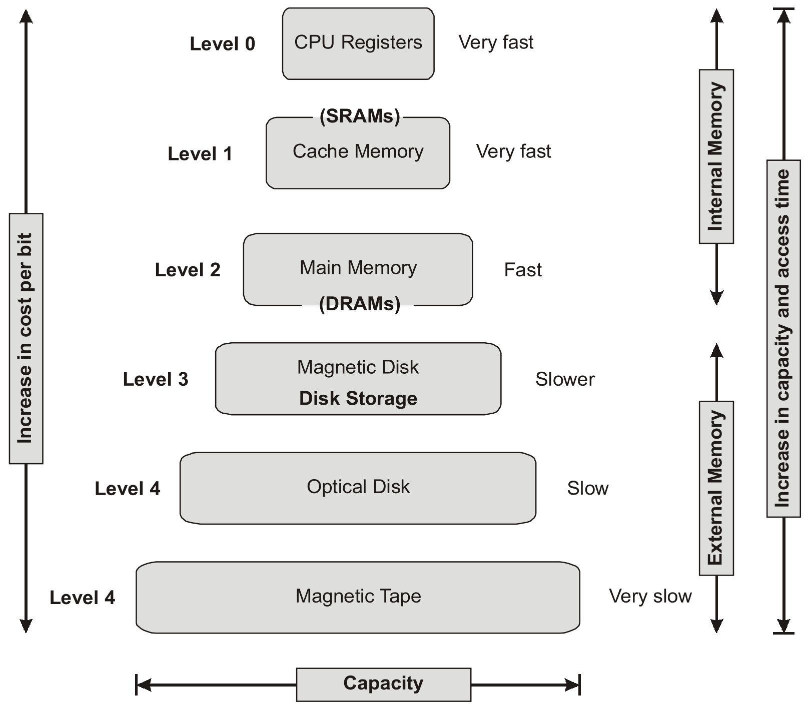


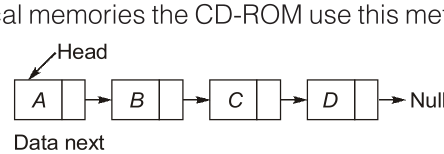
Figure: Main memory organisation

1.6.1 Types of Memory based on Access

1. **Serial Access Memory:** The system must search the storage device from the beginning of the memory address until it finds the required piece of data. Memory device which supports such access is called a Sequential Access Memory or Serial Access Memory. Serial access memory are useful in applications where data naturally needs to flow in and out in serial form. In computing, sequential access memory (SAM) is a class of data storage devices that read stored data in a sequence. Serial files are read by starting at the beginning and reading through every record until you find the one that we want.
   Example: Magnetic tape.
2. **Direct Access Memory:** Direct access memory or Random Access Memory, refers to condition in which a system can go directly to the information that the user wants. Memory device which supports such access is called a Direct Access Memory. It is feature of computer systems and allows certain hardware subsystems to access main system memory independently of the CPU. DMA can also be used for memory to memory copying or moving of data with memory.
   Example: Magnetic disk and optical disks.

1.6.2 Memory Access Methods

1. **Sequential Access:** In this method, the memory is accessed in a specific linear sequential manner like accessing in a single linked list. For example, if fourth record (collection of data) stored in a sequential access memory needs to be accessed, the first three records must be skipped. Thus, the access time in this type of memory depends on the location of the data. Magnetic disks, magnetic tapes and optical memories the CD-ROM use this method.



OBJECTIVE BRAIN TEASERS

Q.1 In 8085 microprocessor unit scratch pad memory comprises of
(a) B, C, D, E, H and L Registers
(b) W, Z, B, C, D, E, H and L Registers
(c) W, Z, B, C, D and E Registers
(d) W, Z, B, C, D, E, H, L and status Registers

Q.2 An interrupt in which the external device supplies its address as well as the interrupt request is known as
(a) vectored interrupt
(b) maskable interrupt
(c) polled interrupt
(d) non-maskable interrupt

Q.3 **Statement (I):** The data bus and address bus of 8085 microprocessor are multiplexed.
Statement (I): Multiplexing reduces number of pins.
(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are true but Statement (II) is not a correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

Q.4 **P :** Program counter is the register which stores the address of the next instruction to be executed.
Q : Stack pointer stores the address of the top of the stack.
Out of these two statements, which statement/s is/are true?
(a) Only P (b) Only Q
(c) Both P and Q (d) None of them

Q.5 How many instructions does microprocessor 8085?
(a) 255 (b) 256
(c) 246 (d) 250

Q.6 How many nibbles are there in 1 kbyte data?
(a) 500 (b) 1024
(c) 2048 (d) none of these

Q.7 The items that you can physically touch in a computer system are called:
(a) software (b) firmware
(c) hardware (d) none of the above

Q.8 Single-bit indicators that may be set or cleared to show the results of logical or arithmetic operations are the:
(a) flags (b) registers
(c) monitors (d) decisions

Q.9 When referring to instruction words, a mnemonic is
(a) a short abbreviation for the operand address.
(b) a short abbreviation for the operation to be performed.
(c) a short abbreviation for the data word stored at the operand address.
(d) shorthand for machine language.

Q.10 The technique of assigning a memory address to each I/O device in the computer system is called:
(a) memory-mapped I/O
(b) ported I/O
(c) dedicated I/O
(d) wired I/O

Q.11 When was the first 8-bit microprocessor introduced?
(a) 1969 (b) 1974
(c) 1979 (d) 1985

Q.12 What type of circuit is used at the interface point of an output port?
(a) Decoder (b) Latch
(c) Tristate buffer (d) None of the above

Q.13 I/O mapped systems identify their input/output devices by giving them a/an ________.
(a) 8-bit port number
(b) 16-bit port number
(c) 8-bit buffer number
(d) 8-bit instruction

Q.14 What type of circuit is used at the interface point of an input port?
(a) Decoder (b) Latch
(c) Tristate buffer (d) None of the above

Q.15 The register in the 8085 A that is used to keep track of the memory address of the next op-code to be run in the program is the:

Q.44 Match **List-I (Interrupt)** with **List-II (Property):**

	List-I		List-II
P.	RST 7.5	1.	Non-maskable
Q.	RST 6.5	2.	Edge sensitive
R.	INTR	3.	Level sensitive
S.	TRAP	4.	Non-vectored

Codes:

	P	Q	R	S
(a)	1	3	4	2
(b)	2	4	3	1
(c)	1	4	3	2
(d)	2	3	4	1

Q.45 For fetch machine cycle the status signal S_1 and S_0 are respectively
(a) 0 and 0
(b) 0 and 1
(c) 1 and 0
(d) 1 and 1

Q.46 A stack is
(a) an 8-bit register in the microprocessor.
(b) a 16-bit register in the microprocessor.
(c) a set of memory location in R/W memory reserved for storing information temporarily during the execution of a program.
(d) A 16-bit memory address stored in the program counter.

■■■■

ANSWER KEY

1. (a)	2. (c)	3. (a)	4. (c)	5. (c)
6. (c)	7. (c)	8. (a)	9. (b)	10. (a)
11. (b)	12. (b)	13. (a)	14. (c)	15. (b)
16. (d)	17. (a)	18. (c)	19. (b)	20. (d)
21. (b)	22. (b)	23. (a)	24. (a)	25. (a)
26. (b)	27. (a)	28. (c)	29. (a)	30. (b)
31. (a)	32. (a)	33. (d)	34. (d)	35. (d)
36. (a)	37. (8 or 5)		38. (65536)	
39. (a)	40. (c)	41. (a)	42. (c)	43. (c)
44. (d)	45. (d)	46. (c)		

HINTS & EXPLANATIONS

28. (c)
8085 has 16-bit address bus which can address 64 kB.

29. (a)
For the addition 65h – 19h = 7Eh
We don't have to carry out so auxiliary carry flag will be zero.

31. (a)
When microprocessors receive interrupt signals through pins (hardware) of microprocessor they are known as hardware interrupts. There are 5 hardware interrupts in 8085 microprocessor. They are INTR, RST 7.5, RST 6.5, RST 5.5, TRAP. Software interrupts are those which are inserted in between the program which means these are mnemonics of microprocessor. There are 8 software interrupts in 8085 microprocessor 07. They are RST 0, RST 1, RST 2, RST 3, RST 4, RST 5, RST 7.

36. (a)
As long as the PLC is justify in the RUN mode, the processor executes the user program over and over again. The first operation is the input scan. During the input scan, the current status of every input module is stored in the input image table, bringing it up to date.
Following the input scan, the processor enters its user program execution. Sometimes called "program scan". The program executes with reference to input and output image tables and updates output image table.

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