**1**
**UNIT**

# Introduction to Microprocessor

## CONTENTS

## PART-1

*Introduction of Microprocessor and its Applications.*

### CONCEPT OUTLINE

- **Microprocessor :** It is an IC which is capable of performing arithmetic and logic operations.

### Questions-Answers

### Long Answer Type and Medium Answer Type Questions

**Que 1.1.** **What do you understand by microprocessor ?**

**Answer**

1. The microprocessor is a programmable integrated device that has computing and decision-making capability similar to that of central processing unit (CPU).
2. A microprocessor is designed to perform arithmetic and logic operations that make use of small number-holding areas called registers.
3. Typical microprocessor operations include adding, subtracting, comparing two numbers and fetching numbers from one area to another.
4. A microprocessor typically serves as a central processing unit microprocessor in a computer system.

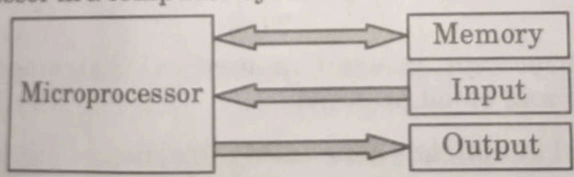


**Fig. 1.1.1.**

**Que 1.2.** **Explain the different types of microprocessor.**

**Answer**

There are three types of microprocessor :

A. **Single chip microprocessors :** It contains ROM, RAM, I/O ports, Clock and Timer.

B. **General purpose microprocessor :**

1. It contains ALU with more than one registers that functions as accumulator, a control unit, an instruction decoder which handles a

fixed instruction set and special and general purpose registers which varies significantly from one microprocessor to other.

2. A microprocessor may have an internal stack of fixed length or use external memory for stack. The general purpose microprocessor is available in word length of 1, 4, 8, 16, 32 and 64-bits.

**C. Bit slice microprocessor :**

1. The word bit slice comes from the way someone assembles a microprocessor of desired word width by adding number of bit-slice units.
2. The term slice comes from the fact that part like ALU, multiplexer, sequencer, and other part needed for custom building a CPU can be connected in parallel to work with 8-bit word, 16-bit word, or 32-bit word.
3. In other sense, we can say that designer can add as many slices as needed for a particular application. A popular bit slice unit is AMD 2900 series.
4. This microprocessor divides the functions of ALU, general purpose and special purpose registers and control unit into several IC's.
5. Each register of ALU package is essentially equivalent to 2 or 4-bit wide slice of registers and ALU of microprocessor.

**Que 1.3.** **What are the applications of the microprocessor ?**

**Answer**

1. The microprocessor is used in personal computers (PCs).
2. The microprocessor is used in LASER printers for good speed and making automatic photo copies.
3. The microprocessors are used in modems, telephone, digital telephone sets, and also in air reservation systems and railway reservation systems.
4. The microprocessor is used in medical instrument to measure temperature and blood pressure.
5. It is also used in mobile phones and television.
6. It is used in calculators and game machine.
7. It is used in accounting system and data acquisition system.
8. It is used in military applications.
9. It is also used in traffic light control.
10. Microprocessor is used in home appliances such as microwave ovens, washing machine etc.

## PART-2

*Microprocessor Evolution Tree.*

## CONCEPT OUTLINE

- **Various Microprocessors :**

1. 8085 μp
2. 8086 μp
3. 80286 μp
4. 80386 μp
5. 80486 μp
6. Pentium μp

## Questions-Answers

### Long Answer Type and Medium Answer Type Questions

**Que 1.4.** **Write a short note on evolution of the microprocessor.**

**Answer**

**A. 1st generation (1971-1973) :**

1. Intel corporation introduced the first microprocessor, the 4004, in 1971. The 4004 evolved from a development effort while designing a calculator chip set.
2. Soon after the 4004 appeared in the commercial market, three other microprocessors were introduced. These were the Rockwell International PPS-4, the Intel 8-bit 8008, and the National Semiconductor 16-bit IMP-16.
3. The microprocessors introduced between 1971 and 1973 were the first-generation system. They were designed using the PMOS (p-type MOS) technology.

**B. 2nd generation (1973-1978) :**

1. After 1973, second-generation microprocessors such as Motorola 6800 and 6809, Intel 8085, and Zilog Z80 evolved.
2. These processors were fabricated using the NMOS (n-type MOS) technology.

**C. 3rd generation (1979-1980) :**

1. After 1978, the third-generation microprocessors were introduced. These processors are 16 bits wide and include typical processors such as Intel 8086 / 80186 / 80286 and Motorola 68000 / 68010.
2. Recently, Intel utilized the HMOS technology to fabricate the 8085A.

**D. 4th generation (1980-1995) :**

1. In 1980, fourth-generation microprocessors evolved. Intel introduced the first commercial 32-bit microprocessor, the problematic Intel 432. This processor was eventually discontinued by Intel.

2. Since 1985, more 32-bit microprocessors have been introduced. These include Motorola's MC 68020 and 68030 and Intel 80386.
3. These processors are fabricated using the low-power version of the HMOS technology called the HCMOS.
4. Recently, Motorola has introduced a 32-bit RISC (Reduced instruction set computer) microprocessor with a simplified instruction set called the MC88100.

**E. 5th Generation (1995 onwards) :**

1. From 1995 to until now this generation has been bringing out high-performance and high-speed processors that make use of 64-bit processors.
2. Such processors include Pentium, Celeron, Dual and Quad core processors.
3. The fifth generation microprocessors represent advancement in specifications.

**Que 1.5.** **Explain various types of microprocessor.**

**Answer**

**A. 8085 microprocessor :**

1. The 8085 CPU is the most popular CPU amongst all the 8-bit CPUs.
2. The 8085 CPU houses an on-chip clock generator and provides good performance utilizing an optimum set of registers and reasonably powerful ALU.
3. The major limitation of this 8-bit microprocessors are limited memory addressing capacity, slow speed of execution, limited number of scratchpad registers and non-availability of compiler instruction set and addressing modes.

**B. 8086 microprocessor :**

1. The first 16-bit CPU from Intel was a result of the designer's efforts to produce more powerful and efficient computing machine.
2. The 8086 contains a set of 16-bit general purpose registers, supports a 16-bit ALU, a rich instruction set and provides segmented memory addressing scheme.
3. The introduction of a set of segment registers for addressing the segmented memory in 8086 was indeed a major step in the process of evaluation.
4. The major limitation in 8086 was that it did not have the memory management and protection capabilities.

**C. 80286 microprocessor :**

1. 80286 was the first CPU to possess the ability of memory management, privilege and protection.

2. However, the 80286 CPU had a limitation on the maximum segment size supported by it.
3. Another limitation of 80286 was that, once it was switched to protected mode, it was difficult to get it back to real mode.
4. The only way of reverting it to the real mode was to reset the system.

**D. 80386 microprocessor :**

1. 80386 was the first 32-bit CPU from Intel.
2. The memory management capability of 80386 was enhanced to support virtual memory, paging and four levels of protection.
3. The maximum segment size in 80386 was enhanced and this could be as large as 4 GB.
4. The 80386 along with its math coprocessor 80387 provided a high speed environment.

**E. 80486 microprocessor :**

1. The 80486 was designed with an integrated math coprocessor.
2. After getting integrated, the speed of execution of mathematical operations enhanced three folds.
3. Also for the first time, an 8 kB four-way set associative code and data cache was introduced in 80486.
4. A five stage instruction pipeline was also introduced.

**F. Pentium microprocessor :**

1. It has a super scalar, super pipelined architecture.
2. It has two integer pipelines U and V, where each one is a 4-stage pipeline.
3. It has an on-chip floating point unit, which has increased the floating point performance.
4. Pentium-II is the next version of Pentium.
5. It incorporates all features of Pentium-Pro and it has a large cache.
6. Pentium-III has been developed on 0.25 microtechnology and includes over 9.5 million transistors.

## PART-3

*Microprocessor Architecture (Harvard and Princeton)*

### CONCEPT OUTLINE

- Princeton suggested computer architecture with a single memory interface.
- Harvard suggested a computer with two different memory interfaces, one for the data / variables and the other for program / instructions.

## Questions-Answers

### Long Answer Type and Medium Answer Type Questions

**Que 1.6.** **Discuss Harvard architecture of microprocessor.**

**Answer**

**A. Harvard architecture :**

1. Harvard architecture uses separate memories for program and data with their independent address and data buses.
2. Because of two different streams of data and address, there is no need to have any time division multiplexing of address and data buses.
3. Not only the architecture supports parallel buses for address and data, but also it allows a different internal organization such that instruction can be prefetched and decoded while multiple data are being fetched and operated on.
4. Further, the data bus may have different size than the address bus. This allows the optimal bus widths of the data and address buses for fast execution of the instruction.

**B. Example :**

1. MCS-51 family of microcontrollers by Intel has Harvard architecture because there are different memory spaces for program and data and separate (internal) buses for address and data.
2. PIC microcontrollers by microchip use Harvard architecture.

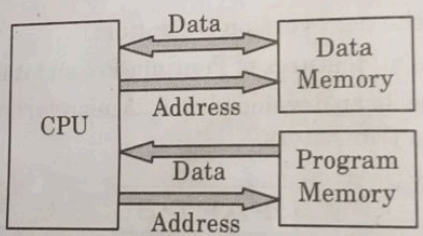


**Fig. 1.6.1.** Harvard architecture.

**Que 1.7.** **Explain Princeton architecture of microprocessor.**

**Answer**

**A. Princeton architecture :**

1. In Princeton or Von-Neumann architecture, programs and data share the same memory space.

2. Fig. 1.7.1 shows the Princeton architecture that allow storing or modifying the programs easily.
3. However, the code storage may not be optimal and requires multiple fetches to form the instruction.
4. Program and data fetches are done using time division multiplexing which affect its performance.

B. **Example :** Microcontroller using the Princeton architecture is Motorola 68HC11 microcontroller.

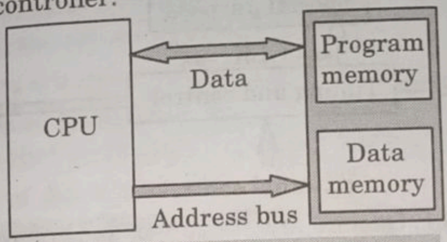


**Fig. 1.7.1.** Princeton architecture.

## PART-4

*General Architecture of Microprocessor and its Operation.*

### CONCEPT OUTLINE

- **Architecture of Microprocessor Contains :**

1. ALU
2. Registers
3. Instruction decoder
4. Address bus
5. Control bus
6. Timing and control unit

### Questions-Answers

**Long Answer Type and Medium Answer Type Questions**

**Que 1.8.** **Explain the microprocessor architecture and operation of its components.**

**Answer**

A. **Architecture :**

1. Microprocessor architecture defines suitable placement of its various functional blocks in the form of required circuitry for efficient flow of data and result from one block to another.
2. The general purpose architecture of microprocessor is shown in Fig. 1.8.1.

Microprocessor

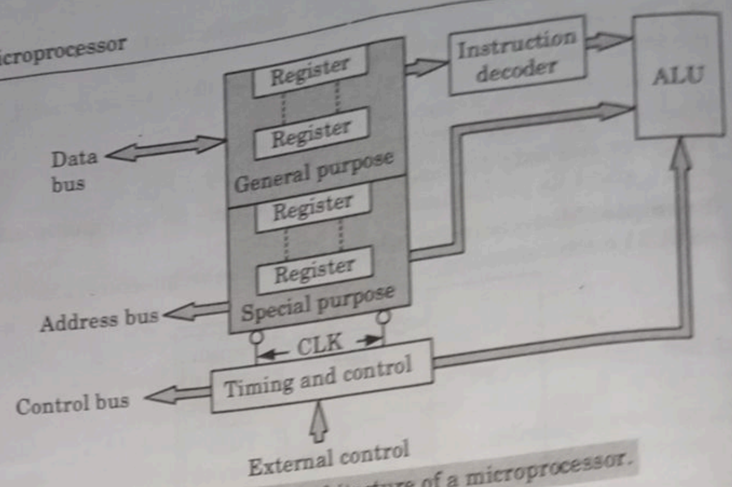


Fig. 1.8.1. General architecture of a microprocessor.

**B. Architecture of microprocessor contains :**

1. **ALU (Arithmetic logical unit) :**
   i. It consists of an adder, an accumulator, a temporary register, and a shift register and a status register.
   ii. This ALU unit performs various arithmetic and logical operation.
2. **General purpose register :**
   i. In the microprocessor, there are 8-bit general purpose register or as a 16-bit register pairs, when used in register pair mode.
   ii. These are used for both storing data as well as the address.
3. **Special purpose register :**
   i. This consist of accumulator, program counter (PC), stack pointer (SP) and status flag register.
   ii. These registers are used for some specific applications designated by the manufacturers.
4. **Instruction decoder :** This receives the contents of instruction register and develops control signals that enable data paths necessary to execute the instruction.
5. **Timing and control unit :**
   i. This unit controls and synchronizes all the operations inside and outside the microprocessor.
   ii. The timing and control signals are derived from the master clock.
   iii. The control unit also accepts the control signals generated by the other devices associated with microprocessor system.
6. **Address bus :**
   i. This is used for transmitting address information.

ii. The address bus will normally contain 16-bits to provide for addressing and addressing capability of up to 64 kB of memory.

7. **Control bus :** This comprises of various signal lines used for carrying synchronization signals. The microprocessor uses such lines for providing timing signals.

**Que 1.9.** **How does the microprocessor work ? Explain in detail.**

**Answer**

1. The process of program execution in a microprocessor can be described in the following sequence : read, interpret and perform.
2. The instructions are stored sequentially in the memory.
3. The microprocessor fetches the first instruction from its memory, decodes it and executes that instruction.
4. The sequence of fetch, decode, and execute is continued until the microprocessor comes across an instruction to stop.
5. During the entire process, the microprocessor uses the system bus to fetch the binary instructions and data from the memory.
6. It uses registers from the register section to store data temporarily, and it performs the computing function in the ALU section.
7. Finally, it sends out the result in binary, using the same bus lines, to the output device.

**Que 1.10.** **What are the operations performed by microprocessor ?**

**Answer**

The operations performed by microprocessor can be classified as follows :

A. **Internal operations :**
1. Store 8-bit data.
2. Perform arithmetic and logical operations.
3. Test for conditions.
4. Sequence the execution of instructions.
5. Store data temporarily into the stack.

B. **Operations initiated by microprocessor :** To communicate with external devices or with memory, microprocessor performs primarily four operations :
1. Read data or instruction from the memory.
2. Write data into the memory.
3. Read data from input devices.
4. Write data into the output devices.

C. **Operations initiated by external devices :** External devices can initiate the operation by activating Reset, Interrupt, READY and HOLD pins of the microprocessor. These operations are as follows :

1. After activation of Reset pin, suspend all internal operations and clear program counter so that it can fetch the next instruction from the predefined memory address.
2. After activation of any interrupt pin, execute specific sequence of instructions called interrupt service routine and after completion, resume its interrupted operation.
3. After activation of READY pin, extend the machine cycle until the activation of READY pin to interface with the slower devices.
4. After activation of HOLD pin, relinquish the control of buses and allow the external controller to use them.

## PART-5

*Components of Microprocessor System : Processor, Buses.*

| Questions-Answers |
|---|
| **Long Answer Type and Medium Answer Type Questions** |

**Que 1.11.** **Explain CPU and buses of the microprocessor.**

**Answer**

A. **CPU (Central processing unit) :**

1. Its purpose is to fetch binary coded instruction from memory then decodes the fetched signal and generates the control signal required to execute the instructions.
2. It executes instructions, controls and directs the inputs, informs ALU (Arithmetic and logic Unit) for processing, arranges the storage and directs the data to the output device.
3. It is responsible for directing the flow of instruction and data within control signals.
4. It contains the necessary logic to interpret instructions and to generate the signals necessary for the execution of those instructions.

B. **System Buses :** Buses are data communication path over which information is transferred a byte or word at a time. The system Bus consists of three types of buses :

i. **Data Bus :**

1. A type of bus that is used to transfer data from memory to CPU and I/O device to memory is called Data Bus.
2. Data bus is the bidirectional bus *i.e.*, it can communicate in two ways, but in one direction at a time.
3. It handles the transfer of data and instructions.
4. It carries data (Operands) to and from the CPU and memory as required.
5. It is also used to transfer data between memory and I/O devices during input output operations.

ii. **Address Bus :**

1. A type of bus that is used to carry the address (not data) is called Address Bus.
2. It carries address between memory and CPU (central processing unit) and between memory and I/O devices.
3. An address is defined as a label, symbol, or other set of characters used to designate a location or register where information is store.
4. Before data or instructions can be written into or read from memory by the CPU or I/O sections, an address must be transmitted to memory over the address bus.
5. The number of lines on the bus determines the number of addressable memory elements.

iii. **Control Bus :**

1. Control Bus is a type of bus that carries control instructions to run operates hardware.
2. The Control Bus is used by the CPU (central processing unit) to direct and monitor the actions of the other functional areas of the computer.
3. It is used to transmit a variety of individual signals (read, write, interrupt, acknowledge) and coordinate the operations of the computer.
4. The size of control bus is from 8 to 16 bits.

## PART-6

*Memory, Input / Outputs (I / Os) and other Interfacing Devices.*

### Questions-Answers

### Long Answer Type and Medium Answer Type Questions

**Que 1.12.** **Define interfacing and gives its types.**

**Answer**

A. **Interfacing :** It is the method to provide path for communication between two components.

B. **Types of Interfacing :**

i. **Memory Interfacing :**

1. When we are executing any instruction, we need the microprocessor to access the memory for reading instruction codes and the data stored in the memory.
2. For this, both the memory and the microprocessor requires some signals to read from and write to registers.
3. The interfacing process includes some key factors to match with the memory requirements and microprocessor signals.
4. The interfacing circuit therefore should be designed in such a way that it matches the memory signal requirements with the signals of the microprocessor.

ii. **I/O Interfacing :**

1. There are various communication devices like the keyboard, mouse, printer, etc.
2. So, we need to interface the keyboard and other devices with the microprocessor by using latches and buffers. This type of interfacing is known as I/O interfacing.

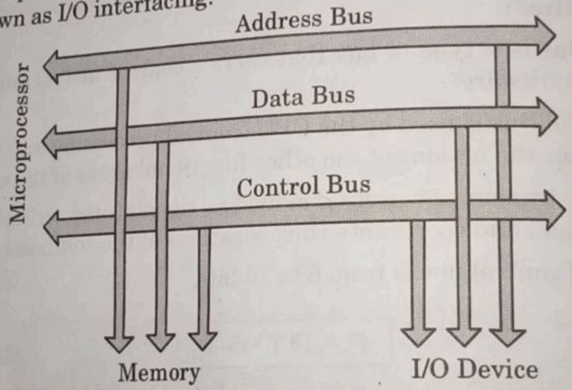


**Fig. 1.12.1.** Block Diagram of Memory and I/O Interfacing.

**Que 1.13.** **What do you understand by memory ? Also give its classification.**

**Answer**

A. **Memory :** A memory unit is a device to which binary information is transferred for storage and from which information is retrieved when needed for processing.

B. ***Classification :***

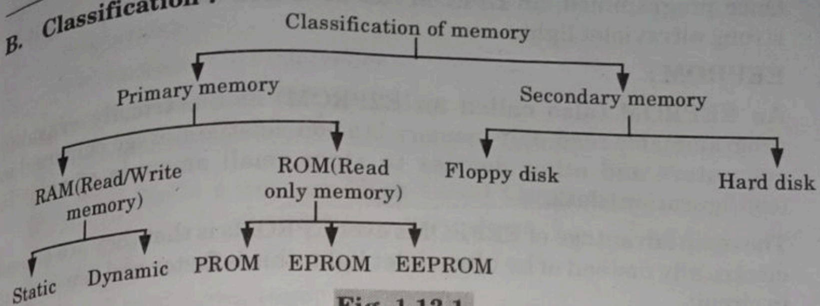


**Fig. 1.13.1.**

i. **RAM :**

1. It is the memory device which stores the binary information permanently.
2. It allows only retrieval of permanently stored data and does not permit modifications of the stored information during normal operation.
3. ROMs are non-volatile memories, *i.e.*, the stored data are not lost even when the power supply is off and refresh operation is not required.

ii. **ROM :**

1. Read-only memory (ROM) is a class of storage media used in computers and other electronic devices.
2. Because it cannot (easily) be written to, its main use lies in the distribution of firmware (software that is very closely related to hardware and not likely to need frequent upgrading).
3. Modern semiconductor ROMs typically take the shape of IC packages.
4. ROM can only be read from, but all ROMs allow data to be written into them at least once, either during initial manufacturing or during a step called "programming".

iii. **PROM :**

1. A programmable read-only memory (PROM) is a form of digital memory where the setting of each bit is locked by a fuse or antifuse. Such PROMs are used to store programs permanently.
2. A typical PROM comes with all bits reading as 1, burning fuse during programming causes its bit to read as 0.
3. The memory can be programmed just once after manufacturing by "blowing" the fuses, which is an irreversible process. Blowing a fuse opens a connection while blowing an antifuse closes a connection.

iv. **EPROM :**

1. An EPROM, or erasable programmable read-only memory, is a type of computer memory chip that retains its data when its power supply is switched off. In other words, it is non-volatile.

2. Once programmed, an EPROM can be erased only by exposing it to strong ultraviolet light.

v. **EEPROM :**

1. An EEPROM (also called an E2PROM) or electrically erasable programmable read-only memory is a non-volatile storage chip used in computers and other devices to store small amounts of volatile (configuration) data.
2. The main advantage of EEPROMs over EPROMs is that they are erased electrically instead of by ultraviolet light; this is faster and can be done in circuit.

vi. **Flash memory :**

1. It is a variation of EEPROM.
2. The difference between the flash and EEPROM is in erasure procedure.
3. EEPROM can be erased at a register level, but the flash must be erased either entirely or block level.

**Que 1.14.** **Name various interfacing devices.**

**Answer**

1. Every microprocessor based system design generally involves interfacing of the processor with one or more than one peripheral devices for communication purpose with the environment.
2. Large numbers of general and special purpose peripheral devices have been developed by the manufacturer over the past several years.
3. Their use reduces the chip count of the system and simplifies the design process.
4. Interfacing devices may be classified into two types :

i. **General purpose peripherals :** These are the devices that perform a specific task but may be used for interfacing a variety of input/output devices to the microprocessor. Some examples of general purpose peripheral are :

a. An input/output port
b. Programmable peripheral interface (also known as peripheral interface adapter)
c. Programmable interrupt controller (PIC)
d. Programmable DMA controller
e. Programmable communication interface
f. Programmable interval timer

ii. **Special purpose peripherals :** These are the devices that may be used for interfacing a microprocessor to a specific type of input/output device. These peripherals are more complex and relatively more costly than general purpose peripherals. Some examples of special purpose peripherals are :

a. Programmable CRT controller
b. Programmable hard disk controller
c. Programmable keyboard and display interface.

**Que 1.15.** **Write a note on High Level Languages.**

**Answer**

**A. High Level Languages :**

1. Programming languages that are intended to be machine independent are known as high level languages. These include languages such as BASIC, PASCAL, C, C++, and Java.
2. Instructions written in these languages are known as statements.
3. Each high-level statement may represent many machine code instructions.
4. These high level languages statements are translated into machine codes by a program known as compiler or an interpreter.
5. These programs accepts English like statements as their input known as source code.
6. The compiler or interpreter then translates these source codes into the machine language compatible with the microprocessor being used in the system.
7. This translation in machine language is called object code.
8. Each microprocessor needs its own compiler or interpreter for each high-level language.
9. The main difference in compiler and interpreter lies in the process of generating the machine code.
10. The compiler reads the entire program first and translates it into the object code that is executed by the microprocessor.
11. On the other hand, interpreter reads one instruction at a time, produces its object code, and executes the instruction before reading the next instruction.

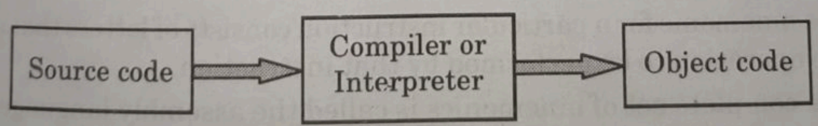


**Fig. 1.15.1.** Translation of high level language program into machine code.

12. Programs can usually be written faster in high-level languages than in assembly languages because a high-level language works with bigger building blocks.

C. **Advantages :**

1. The primary advantage of high level languages is in trouble shooting (debugging) programs.
2. It is easier to find error in program written in a high level language than to find them in a program written in assembly language.

D. **Disadvantages :**

1. Program written in high-level language always executes more slowly and requires more memory than the same programs written in assembly language.
2. Thus assembly language programs are more efficient than high level language programs.

**Que 1.16. What do you mean by "Low Level" and "High Level Language Programming" in microprocessors ? Also mention its advantages and disadvantages.** AKTU 2013-14, Marks 10

**Answer**

A. **High level languages :** Refer Q. 1.15, Page 1–16B, Unit-1.

B. **Low level languages :** Machine language and assembly language are microprocessor specific and are both considered low level languages.

i. **Machine Language :**

1. The number of bits in a word for a given machine is fixed and words are formed through various combinations of these bits.
2. The microprocessor design engineer selects combinations of bit patterns and gives a specific meaning to each combination by using electronic logic circuits, this is called an instruction.
3. The set of instructions designed into the machine makes up its machine language (a binary language composed of 0's and 1's that is specific to each computer).

ii. **Assembly Language :**

1. Each manufacturer of a microprocessor has devised a symbolic code for each instruction, called a mnemonic.
2. The mnemonic for a particular instruction consists of letters that suggest the operation to be performed by that instruction.
3. The complete set of mnemonics is called the assembly language.
4. The compiler or interpreter translates the source code *i.e.*, the program into the machine language compatible with the microprocessor being used in the system.
5. This translation in the machine language is called the object code.
6. The primary difference between a compiler and an interpreter lies in the process of generating machine code.

7. The compiler reads the entire program first and translates it into the object code that is executed by the microprocessor.
8. On the other hand, the interpreter reads one instruction at a time produces its object code and executes the instruction before reading the next instruction.

**C. Advantages :**

1. Programs developed using low level languages are fast and memory efficient.
2. Programmers can utilize processor and memory in better way using a low level language.
3. There is no need of any compiler or interpreters to translate the source to machine code. Thus, cuts the compilation and interpretation time.
4. It can directly communicate with hardware devices.

**D. Disadvantages :**

1. Programs developed using low level languages are machine dependent and are not portable.
2. It is difficult to develop, debug and maintain.
3. Low level programs are more error prone.
4. Low level programming usually results in poor programming productivity.

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