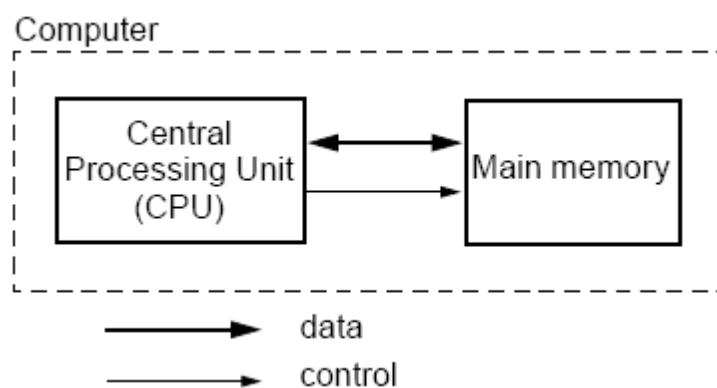


## 1. Fundamental Concepts

### 1.1 What is a computer?

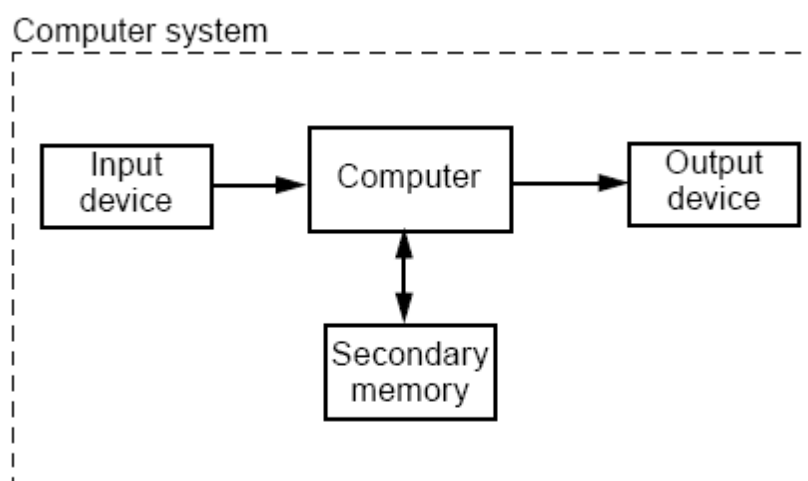
A **computer** is a data processing machine which is operated automatically under the control of a list of instructions (called a program) stored in its main Memory.



Fig(1) computer.

### 1.2 What is a computer system?

- A **computer system** consists usually of a computer and its peripherals.
- **Computer peripherals** include input devices, output devices, and secondary memories.



Fig(2) computer system.



- CPU + main memory constitute the "core" of the computer system.
- Secondary memory + I/O devices are the so called peripherals.
- Communication between different components of the system is usually performed using one or several buses.

## 2. The Computer Level Hierarchy

The machine built from a hierarchy of levels, in which each level has a specific function and exists as a distinct hypothetical machine. We call the hypothetical computer at each level a virtual machine. Each level's virtual machine executes its own particular set of instructions, calling upon machines at lower levels to carry out the tasks when necessary. As well as how these layers are implemented and interface with each other. Figure (3) shows the commonly accepted layers representing the abstract virtual machines.

**Level 6**, the User Level, is composed of applications and is the level with which everyone is most familiar. At this level, we run programs such as word processors, graphics packages, or games.

**Level 5**, the High-Level Language Level, consists of languages such as C, C++, FORTRAN, Lisp, Pascal, and Prolog. These languages must be translated (using either a compiler or an interpreter) to a language the machine can understand..

Level 4, the Assembly Language Level, encompasses some type of assembly language. This is a one-to-one translation, meaning that one assembly language instruction is translated to exactly one machine language instruction.

Level 3, the System Software Level, deals with operating system instructions. This level is responsible for multiprogramming, protecting memory, synchronizing processes, and various other important functions.

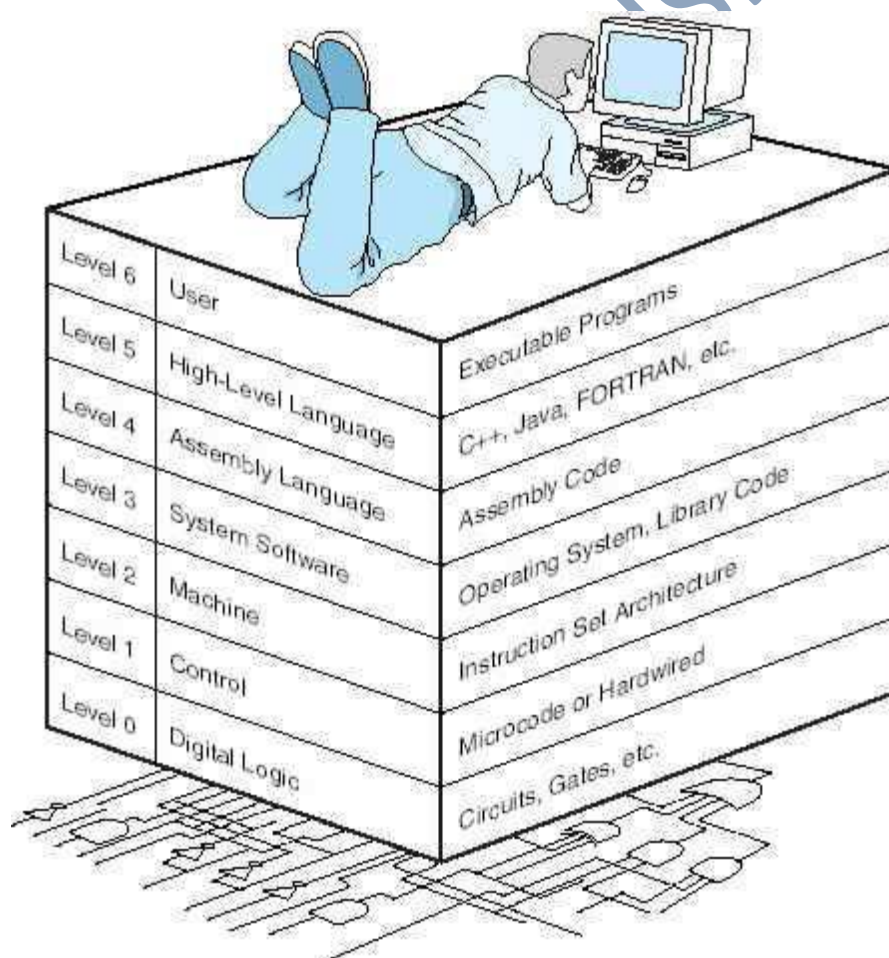
Level 2, the Instruction Set Architecture (ISA), or Machine Level, consists of the machine language recognized by the particular architecture of the



computer system. Programs written in a computer's true machine language on a hardwired computer can be executed directly by the electronic circuits without any interpreters, translators, or compilers.

Level 1, the Control Level, is where a control unit makes sure that instructions are decoded and executed properly and that data is moved where and when it should be. The control unit interprets the machine instructions passed to it, one at a time, from the level above, causing the required actions to take place. Control units can be designed in one of two ways: They can be hardwired or they can be microprogrammed (will be discussed later).

Level 0, the Digital Logic Level, is where we find the physical components of the computer system: the gates and wires. These are the fundamental building blocks, the implementations of the mathematical logic that are common to all computer systems.



**Figure (3) the Abstract Levels of Modern Computing Systems.**



### 3.Important Concepts.

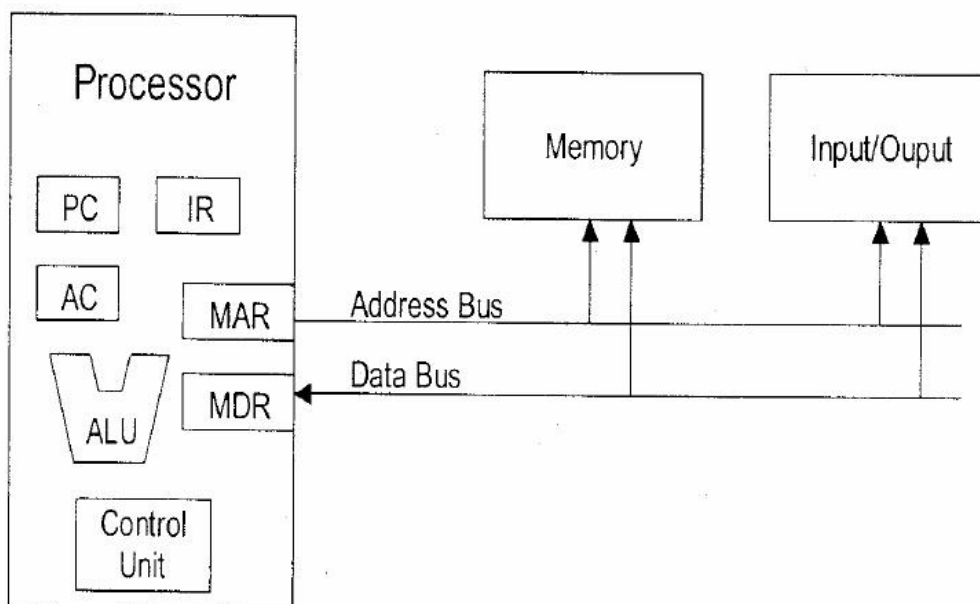
*Computer organization* is concerned with **the way the hardware components operate and the way they are connected together** to form the computer system. The various components are assumed to be in place and the task is to investigate the organizational structure to verify that the computer parts operate as intended.

*Computer design* is concerned with the hardware design of the computer. **Once the computer specifications are formulated, it is the task of the designer to develop hardware for the system.** Computer design is concerned with the determination of **what hardware should be used** and how the parts should be connected. This aspect of computer hardware is sometimes referred to as computer implementation.

*Computer architecture* is concerned with the structure and behavior of the computer as seen by the user. It includes the information formats, the instruction set, and techniques for addressing memory. The architectural design of a computer system is concerned with the specifications of the various functional modules, such as processors and memories, and structuring them together into a computer system.



#### **4.Architecture of a Simple Digital Computer**



**Fig(4) Architecture of a Simple Digital Computer**

The main component of any computer system, the central processing unit (CPU). The primary function of the CPU is to execute a set of instructions stored in the computer's memory.

CPU BASICS A typical CPU has three major components:

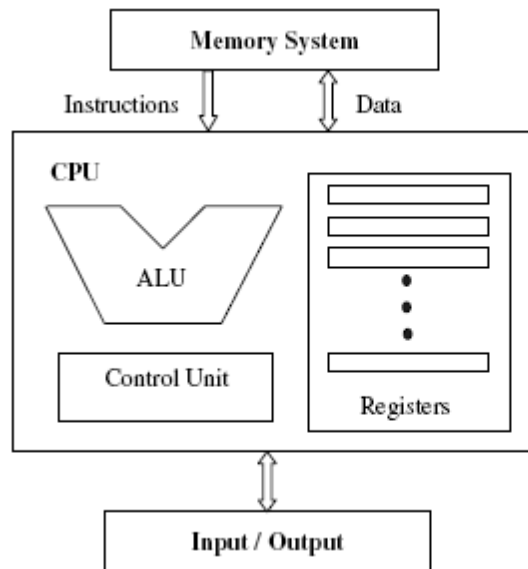
- (1) register set,
- (2) arithmetic logic unit (ALU), and
- (3) control unit (CU).

The register set differs from one computer architecture to another. It is usually a combination of general-purpose and special purpose registers. General-purpose registers are used for any purpose, hence the name general purpose. Special-purpose registers have specific functions within the CPU. For example, the program counter (PC) is a special-purpose register that is used to hold the address of the instruction to be executed next. Another example of special-purpose registers is the instruction register (IR), which is used to hold the instruction that is currently executed.

The ALU provides the circuitry needed to perform the arithmetic, logical and shift operations demanded of the instruction set.



The control unit is the entity responsible for fetching the instruction to be executed from the main memory and decoding and then executing it. Figure shows the main components of the CPU and its interactions with the memory system and the input/ output devices.



**Fig(5)components of CPU with connections of memory and I/O devices**

- A typical computing task consists of a series of steps specified by a sequence of machine instructions that constitute a program.
- An instruction is executed by carrying out a sequence of more rudimentary operations.
- Processor fetches one instruction at a time and perform the operation specified.
- Instructions are fetched from successive memory locations until a branch or a jump instruction is encountered.
- Processor keeps track of the address of the memory location containing the next instruction to be fetched using Program Counter (PC).
- 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.



The CPU fetches instructions from memory, reads and writes data from and to memory, and transfers data from and to input/output devices.

Three basic steps are needed in order for the CPU to perform a write operation into a specified memory location:

1. The word to be stored into the memory location is first loaded by the CPU into a specified register, called the memory data register (MDR).
2. The address of the location into which the word is to be stored is loaded by the CPU into a specified register, called the memory address register (MAR).
3. A signal, called write, is issued by the CPU indicating that the word stored in the MDR is to be stored in the memory location whose address is loaded in the MAR.

Similar to the write operation, three basic steps are needed in order to perform a memory read operation:

1. The address of the location from which the word is to be read is loaded into the MAR.
2. A signal, called read, is issued by the CPU indicating that the word whose address is in the MAR is to be read into the MDR.
3. After some time, corresponding to the memory delay in reading the specified word, the required word will be loaded by the memory into the MDR ready for use by the CPU.