Contents

33 Introduction to Computers

CHAPTER

CONTENTS

The word **Computer** is derived from the Latin word *Compute*, which means to Calculate. But today's Computers are not mere Calculators; they are much more than that. Now-a-days computers are being used almost everywhere, say, banks, hospitals, railways, airlines, industrial houses, commercial establishments, educational institutions and even at homes. Today, there is hardly any area, where computers have not made in-roads. Computer may be defined as *an electronic device, which converts (Processes) raw data (Input) into useful information (Output).*

CHARACTERISTICS OF COMPUTERS

Computers have assumed great role in our life, due to its unique strengths or characteristics, namely :

High Speed. Computers work at an amazing speed. Calculations can be done in microseconds (*i.e.* millionth of a

second). Speed of computers is measured in milliseconds (10^{-3} seconds) or nanoseconds (10^{-9} seconds)

Accuracy. In addition to its high speed, computer performs its task with great accuracy. Computers hardly commit mistake in processing the data. It produces errors only when the input (data or instructions) is given wrong. **GIGO principle** *i.e.* (*Garbage In Garbage Out*) or (*Gold In Gold Out*) works well with the computer.

High Storage Capacity. Computers have the memory to store large amount of data, which can be retrieved whenever required.

Reliability. Computers are very reliable. Neither they get bored of the repetitive tasks, nor they get tired.

Versatility. Computers can perform variety of jobs with efficiency. We can also perform multiple tasks at the same time, say, listen songs while typing a document.

Reduction in Manpower. Computers have enabled the entrepreneurs to be more efficient than in the past. Lesser staff is required to do more jobs. This can be seen in banks, industries and almost all the private and govt. enterprises, wherein computerization has resulted into a lean organizational structure.

Reduced Paper Work. Computer has reduced a lot of paper work in all the organizations. For example : The accounts and records of all the customers in a Bank are now stored in a computer than in the huge piles of ledgers, registers and manual files. Besides reducing the paper work, the computers have also made the retrieval of data easy and fast.

Reduced Space Requirements. With the advent of computers, the requirement of office space has reduced considerably. An ATM installed in a very small room can handle thousands of customers per day, which would have otherwise required large space in the banking hall.

Evolution/Generations of Computer

Evolution of modern computers is commonly classified in Generations of Computers. Each new generation resulted in following common improvements :

Increase in Speed, Storage Capacity and Reliability.

Decrease in Cost and Size.

TYPES OF COMPUTERS

Computers can be broadly classified as :

(1) Analog, Digital and Hybrid Computers

Analog Computers measures continuous type of data and use a physical quantity like electric current flow, temperature etc. They derive all their data from some form of measurement. Though effective for some applications, this method of representing numbers is a limitation of the analog computer. The accuracy of data used in analog computer is directly related to the precision of its measurement.

Digital Computers represents data as discrete numbers and process data using standard arithmetic operations. While an analog computer measures, a digital computer counts. Unlike analog computer, whose efficiency is subject of accuracy of measurements, the digital computer can accurately represent data using as many positions and numbers as necessary. Adding machines and pocket calculators are common devices based on the principles of digital computer.

Hybrid Computers combine the best features of analog and digital computers. They have speed of analog computers and accuracy of digital computers. They are usually used for special problems, in which data derived from measurements is converted into digits and processed by the computer. Hybrid Computers, for example, control national defense and passenger flight radar. These are also used in producing iron ore pellets for steel making.

EVOLUTION OF COMPUTERS

Generation/ Period	Circuitry	Input	Storage	Output	Language	Examples
1st (1951-58)	Vacuum Tubes	Punched Cards	Magnetic Drum	Punched Cards	Machine, Assembly	ENIAC EDVAC EDSAC UNIVAC-I Burroughs 220
2nd (1959-65)	Transistors	Punched Cards, Magnetic Tapes	Magnetic Core Storage	Punched Cards	FORTRAN, COBOL, BASIC, PL/1	IBM 700 ATLAS ICL 1901 Honeywell 200
3rd (1965-71)	Integrated Circuits (IC)	Key Boards	Magnetic Disks	Monitor	PASCAL, FORTRAN, COBOL, RPG	IBM 360 NCR 395 Burroughs B6500
4th (1971-present)	Very Large Scale Integration (VLSI) of Circuits	Mouse, Scanners, Sound etc.	Magnetic Disks with higher capacity	Monitor, Printer	RDBMS, Many programming languages	IBM 370 HP 3000
5th (Yet to come)	Artificial Intelligence					

(2) General-purpose and Special-purpose Computers

General-purpose computers are versatile and process business data as readily as they process complex mathematical formulae. These computers can store large amounts of data and the programs necessary to process them.

Special-purpose Computers are designed to solve specific problems. The program for solving the problem is built right into the computer. Special purpose computers are often used as training simulators.

Inter-relation between different types of Computers

Most of the digital computers are general-purpose computers and most analog computers are special-purpose computers. While General-purpose computers are mostly used in business and commercial data processing, Analog Computers are used in control applications like monitoring the distillation operation in a petroleum refinery. Our Home Computers are an example of General-purpose Digital Computer.

PARTS OF A COMPUTER

(1) **Input Devices.** The raw data is fed into computer through Input devices.

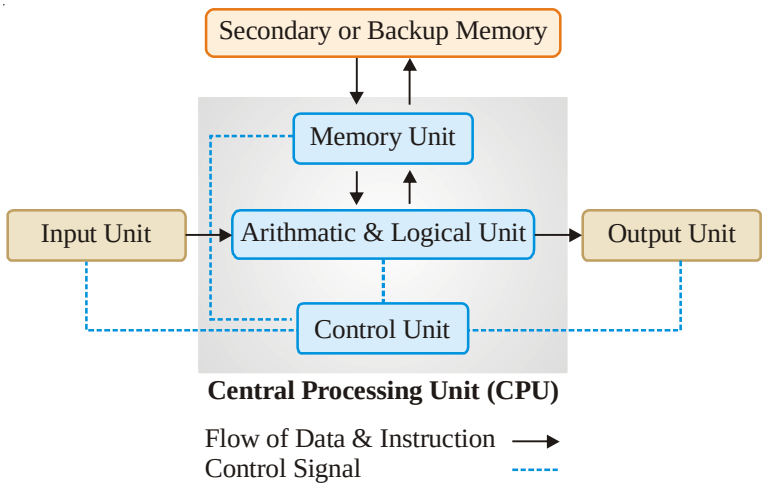
(2) **Central Processing Unit.** The raw data processed by the Central Processing Unit (CPU), as per the instructions given by the user. CPU has three parts *i.e.*

(*i*) **Memory Unit.** Data and instructions are stored on memory storage devices. The Primary or Main memory is supplemented by the Secondary or Backup memory.

(*ii*) **Arithmetic and Logical Unit (ALU).** Arithmetic and Logical operations on data are performed by ALU.

(*iii*) **Control Unit (CU).** It is the central nervous system of the computer system that control and coordinate the functioning of all the components of a computer.

(3) **Output Devices.** The useful information is made available by the Output devices.



Block Diagram of Computer Organisation

INPUT DEVICES

(1) Keyboard

Keyboard is the main input device to input data and commands into the computer. While the basic layout of Keyboard is similar to Typewriter Keyboard (QWERTY Type), it has some additional keys to perform computer specific functions, *i.e.*

Typing Keypad. It includes all Alphanumeric Keys (like a typewriter).

Numeric Keypad. It is like a Calculator Keypad, designed to perform calculations.

Function Keys. There are 12 Function Keys (F1 to F12) , to perform special tasks. Their function is different in different software packages.

Editing Keys. These comprise of Insert, Delete, Home, End, Page Up, Page Down keys etc.

Cursor Control Keys. Also known as Arrow keys, these keys are used for Up (↑), Down (↓), Left

Keyboard

Mouse

(←) and Right (→) movements of cursor.

Multimedia and Internet Keys. Modern Keyboards have Special keys for quick access to Multimedia and Internet functions.

(2) Mouse (*M*anually *O*perated *U*tility *S*election *E*quipment)

Mouse, which derives its name from its mouse-like shape, is the most widely used input and pointing device in Graphic User Interface (GUI) Software like Windows and LINUX, that lets you select and move items on the screen. The Mouse is held in one hand and moved across a flat surface. Its movement and the direction of movement is detected by two rotating wheels on the underside of the mouse, through its track ball at the bottom. The processing circuit sends the signal to the computer system through the mouse cable. A Mouse normally has :

Left Button. It is primarily used to select (single click) and execute (double click) the applications.

Right Button. It often displays a list of commands, program settings and properties.

Scroll Mouse. Scroll Mouse is an improvement over the normal Mouse and has a Scroll Button in the middle of Left and Right Button, to scroll through the text on the screen.

Optical Mouse. The normal Mouse has a track ball at the bottom, which enables the cursor movement, as we move the mouse on the mouse-pad. However, the modern Optical Mouse is without a track ball and instead works through optical light.

(3) Joystick

A Joystick is the control device for many video games. Just like a mouse, it detects motion in two directions and relates it with signals. The stick fits through a movable shaft into a cable. It is at right angle to the bottom. Two electronic devices send signals that make the cursor move. These signals vary with the positions of the shaft and the cable.

(4) Light Pen

This electronic pen is used to select the displayed options on the screen as also to enter the data by writing on the screen. The data you write is displayed on the Monitor. It has a light-sensing element, such as photo-diode or phototransistor, at the end of a pen or stylus like holder. A cable is attached on the other end to transmit the signal. The pen is positioned by hand to a desired screen location and the screen is touched with the tip of the pen, which causes the pen to get activated. A signal is sent to the system indicating the position of the pen. Thus, the graphic element can be identified. This is useful for graphic works, especially the Computer Aided Designing (CAD).

(5) Digitizer

A Digitizer converts graphical and pictorial data to the binary/digital form, which can be directly fed into a computer. It stores the coordinates of the image and displays them on the screen and thus the graphical image can be transmitted to the computer.

(6) Touch Screen

A Touch Screen is a special monitor that allows the user to input information by touching the icons or graphical buttons on the screen. You can enter a limited amount of data by using screen

technology. Touch screens are popular for interactive displays in museums, exhibitions, besides the modern **ATMs (Automated Teller Machines)**. They are also used in many supermarkets to give information about the products.

(7) Digital Camera

A Digital Camera is quite similar to a traditional camera. It allows you to take photograph that you can use on your computer. If you want to have the prints of the photos, you can take it through printer. Most digital cameras come with the image editing software that allows you to view and edit the photos taken by you.

(8) Web Camera

Web Camera allow us to capture all the surroundings around us and to send live videos over the Internet. With the advent of Web Camera, it is now possible to have face-to-face live chatting with people sitting at different places. This technique known as **Video Conferences** is also used in news channels for live telecast.

(9) Voice Input Devices

A Voice Input Device allows the user to control the computer using voice commands instead of a keyboard. The user would speak the command and his/her voice will be recorded. Computer will compare the voice pattern with the series of patterns stored in the computer and act accordingly. Microphones (Mikes) are becoming important as an input device to record sound. **Speech Recognition Software** is also available to give dictate text to the computer, instead of typing the same using keyboard.

(10) Scanners

Flatbed scanner

Scanners are the eyes of computer that read words, pictures or number directly from the page, convert them into the computer compatible form and display them on the Monitor. Scanners allow you to save pictures, text etc. as an image/text file on the computer. **Optical Character Reader (OCR)** technique is used to scan characters from the printed or hand-written paper into the computer. The shape of character is recognized by the OCR with the help of light source in conjunction with photoelectric cells. Two common character font sets used by OCRs are OCR-A (American Standard) and OCR-B (European Standard). The resolution of scanners is generally 1200, 4800 or 9600 DPI (Dots Per Inch). Scanners may be of three types :

Flatbed Scanner. It is much like a photocopy machine, where whole page is placed on a glass top and scanned.

Sheet-fed Scanner. It is used in fax machines, which uses mechanical rollers to move sheets of paper over the scan head.

Hand-held Scanner. It allows the user to move the scan head, over the material to be scanned. It is useful for copying small images like Signatures, Logos, Small Photographs, etc.

(11) Optical Mark Reader (OMR)

OMR is used for checking of documents and multiple-choice questions. OMRs are widely used in evaluating the objective types papers of competitive exams like IIT, AIEEE, Banking, etc. The candidates are required to darken the oval to mark the correct answer with a soft lead pencil. While evaluating the answer sheets, OMR directs a thin beam of light on the surface, due to which the computer recognizes the answer.

(12) Magnetic Ink Character Recognition (MICR)

It is used in Banks to process the Bank Drafts and Cheques. MICR Drafts and Cheques contain a number at the bottom. These numbers use a special magnetic ink and are scanned by a device called MICR. It changes these magnetic ink characters into code that computer processes to check the validity of cheque/draft.

(13) Bar Code Reader

A Bar Code is a pattern of black strips of varied thickness on a white background. It can be seen on various products. A Bar Code Reader throws a beam of light, which reflects off the Bar Code image. The light sensitive detector detects the bar code and converts into numeric code, which is processed by the computer. Bar Codes are used mainly by the traders for labeling the goods.

OUTPUT DEVICES

(1) Printer

A Printer produces a hard copy/printout of information displayed on the screen, which can be retained for a longer period of time. A computer can send data much faster than a printer can print. So the printer is equipped with a memory, called a *buffer*. The data is stored in the buffer till it is printed. Printers are of two types :

(*a*) **Impact Printers.** Impact Printers are the printers, where printing is done by the impact of dot wires on the paper. They are also called **character printers** and are classified as follows:

(*i*) **Daisy Wheel Printers.** These printers have good letter formations, but cannot produce graphics. Daisy Wheel printers produce letter quality documents. The print range of such printers varies from 60 to 120 CPS (Characters Per Second). They were being used for business letters and reports, but are outdated now for being slow and noisy.

(*ii*) **Dot Matrix Printers (DMPs)**. These are the only Impact Printers in use these days. These printers have printer head with pins (generally 9 or 24 pins) on it, which prints dots on the paper to form characters. The speed of matrix ranges from 50 to 500 CPS. Besides printing near letter quality text (with 24 pin print head), they can also print graphics and charts. They have very low operational cost. But, they are noisy and do not have good printing quality. Thus, they are losing popularity.

Inkjet Printer

Colour Laser Printer

(*iii*) **Line Printers (LPs)**. A Line Printer prints one complete line at a time. Its printing speed is 150 to 2500 lines per minute with 96 to 160 characters on a 15-inch line. These printers are available in different scripts. The codes of all the characters to be printed on one line

are transmitted from the memory of the computer to a storage unit (buffer) on a printer. These printers are also noisy and are commonly used with mainframes for high-speed printing.

(*b*) **Non-Impact Printers.** Non-Impact Printers do not strike against the inked ribbon or paper on which they are printing. Generally, with non-impact printers, the only thing that touches the paper at all is the ink that is used. Non-impact printers are becoming very popular because they are virtually no-noise printers, providing crisp and clear quality printouts. In addition, they also have the capability of producing high-resolution graphics in greyscale and color modes. There are three main types of non-impact printers :

(*i*) **Thermal Printers.** These printers offer the highest quality of graphics and text vis-à-vis all other printers. These printers use heat to produce an image on the special thermal paper. These printers are quite expensive.

(*ii*) **Ink Jet Printers.** These printers produce images by spraying tiny droplets of ink on the paper. They have very high quality output and can also produce graphics and color. Their printing speed is measured in Pages Per Minutes (PPM) say 4, 8, 12 ppm etc. and printing quality *i.e.* resolution is measured in Dots Per Inch (DPI) say 300, 600, 1200 dpi etc. The per page printing cost of Ink Jet Printer is about 10 times higher than the laser printer.

(*iii*) **Laser Printers.** These printers use photocopy technology to print. An electronically controller laser beam traces out the desired character to be printed on photoconductive drum. These are very high-speed printers, producing very high image quality and color. These printers also offer excellent graphics quality and mostly used for DTP (Desk Top Publishing) purposes. While the Color Laser Printers are very expensive, the monochrome Laser Printers are now affordable and are slowly replacing the Ink Jet Printers, on account of their lower operational cost, better speed and high image quality.

(2) Monitor or Visual Display Unit (VDU)

Monitor is a Soft copy output device attached to the computer system, which displays text and images generated by the video card. A VDU is similar to a television screen. Whatever we input through the keyboard is displayed on the screen. In Character User Interface (CUI), a monitor normally displays 25 lines, each consisting of maximum 80 characters. In Graphic User Interface (GUI), the monitor screen is divided into a number of dots arranged in rows and columns, which are called **Pixels** (acronym for Picture Elements). A monitor with more pixels will have higher resolution and thus the picture will have more clarity. Monitor may be Monochrome or Color.

Monitors

While a Monochrome monitor can show only one color, a Color monitor can show up to

approximately 16 million colors. Since a monitor displays both the Input and Output information it is called an **Input-Output (I/O) device**. The other examples of I/O devices are floppy, Hard Disk etc., as they too can handle both input and output data through their read and write capabilities.

(3) Computer Output on Microfilm (COM) and Microfilche

In COM, the output from the computer is displayed on a high resolution Cathode Ray Tube (CRT), which is photographed on a 35 mm film. A microfilm reader is used to read the output. In some systems, the microfilm is converted to a microfilche form, which is a 4" × 6" sheet of film capable of holding 98 frames of 8" × 11" page images reduced 24 times. A microfilche reader is used to read the microfilche. COM systems being expensive are suited for archival applications, where volume of output is large and the data must be stored for long periods with occasional references to it.

(4) Audio Response Unit (ARU)

An ARU converts the computer data output into sound, which may take many forms like speech, musical notes or even beeps. When ARU is used to produce speech, it is known as Speech Synthesizer. A Speech Synthesizer is commonly used while communicating with computer using phone lines. A user dials the computer through the phone and makes an inquiry, the computer output is passed through the speech synthesizer, and the output is converted to spoken reply, which is sent to the user over the telephone line. Another similar technology is **Interactive Voice Response System (IVRS)**, which is commonly used in Automated Telephone Complaint Booking System and Computerised Railway Enquiry, wherein the processing/response is based on the phone keys pressed by the user.

MEMORY UNIT

Memory refers to the storage space, where the instructions and data are stored before execution and where the results are placed after execution. The amount of memory determines the number of programs a computer can run at once and how fast the programs will operate.

Units of Memory

Since computer is an electronic device, it understands only two states of current *i.e.* ON and OFF. While the presence of current in a circuit (*i.e.* ON state) indicates 1, its absence (*i.e.* OFF state) indicates 0. Therefore, computer understands only two digits *i.e.* 0 and 1, called **Binary Digits**. Thus, the basic unit of memory is **BIT** (**BI**nary digi**T**), which represents either **0** or **1.** The other units of memory are :

Nibble	=	Group of 4 Bits
Byte	=	Group of 8 Bits, which represents one character.
Kilo Byte (KB)	=	1024 Bytes
Mega Byte (MB)	=	1024 KB
Giga Byte (GB)	=	1024 MB
Tera Byte (TB)	=	1024 GB
Peta Byte (PB)	=	1024 TB
Exa Byte (HB)	=	1024 PB

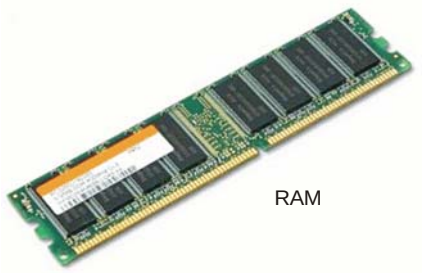
Types of Memory

Basically, there are two types of memory in the computer system :

(*a*) **Primary Memory.** Every computer comes with a certain amount of memory usually referred to as Primary Memory. It is also known as **Main Memory** or **Internal Memory**. Primary Memory is a place, where data and programs are stored for execution. It is very fast but has limited storage capacity. Main memory of computer is divided into number of memory locations, each having a unique address. Main Memory is further classified into two types :

(*i*) **Read Only Memory (ROM)**. It is a called Read Only memory, because user can only read from and can not write into it. It is a nonvolatile memory, as it stores information permanently. ROM has a small storage capacity. The primary use of ROM is during booting procedure. It holds special instructions like programs that perform **Power On Self Test (POST)**, when the computer is switched on.

(*ii*) **Random Access Memory (RAM).** It is a volatile, read-write memory, having random access and storage capacity larger than ROM. It is working memory of the computer. While RAM has great advantage of being very fast, its main disadvantage is its volatile nature, due to which its contents are erased as soon as the electricity supply to the computer is switched off. That is why, we frequently save our work (*i.e.* we transfer the contents from RAM - the working memory, to the secondary storage memory, say hard disk or floppy).



RAM

(*iii*) **Cache Memory.** Cache (Pronounced as "cash") memory is special high-speed memory, which stores frequently used instructions, so that the CPU can access them quickly and easily. It is a physical memory other than RAM, which is either inserted on the motherboard or can be part of CPU.

(*b*) **Secondary Memory.** Also known as **External Memory** or **Auxiliary Memory**, the secondary memory is used to supplement the storage capacity of the computer. It is needed because main memory is volatile, expensive and insufficient to store huge amount of data. The data required for processing is being transferred from secondary memory to primary memory, as and when required. It stores the data permanently, that can be recalled any time when needed. However, the speed of secondary memory is much slower as compared to primary memory.

SECONDARY MEMORY/STORAGE DEVICES

(1) Magnetic Tape

Magnetic tape is a sequential access storage device. Tape Drive is used for read write operation from magnetic tape. It is best suited for taking backups, but not for on-line applications. Magnetic Tape is made up of a plastic ribbon usually ½ inch wide. It is coated on one side with iron-oxide material, which can be magnetized. The tape is divided into frames and tracks. Frames are vertical strips and tracks are horizontal strips. There are generally 7 to 9 tracks in a magnetic tape, each having separate read/write heads for recording. A character is recorded across the tape in a frame. Magnetic tape has low data transfer rate.

(2) Magnetic Disk

Magnetic Disk is just like a gramophone record that can store large amount of data. It is a direct access storage device, having sequential access. It consists of disk pack comprising of disks made up of ferromagnetic material and having coating of thin film of magnetic material on both sides. The collection of disks is placed one above the other, on a vertical spindle, connected to a motor that enables it to rotate. Each disk is divided into number of tracks, which is further sub-divided into number of sectors. Same tracks on all disks of disk pack constitute a cylinder. Thus, total number of cylinders is equivalent to number of tracks per disk. A read/write head is attached to disk pack for read and write operation. Data Transfer rate of Magnetic Disk is higher than the magnetic tape.

(3) Hard Disk


Hard Disk

Also known as **Winchester Disk** or **Fixed Disk**, it is the most common storage medium for storing huge amount of data. It is fixed inside the computer and is not easily portable. Like its name, it is hard and inflexible. Hard Disk is made up of collection of circular magnetic disks known as platters, which are spun about their centre. A hard disk consists of 5 to 50 disks of about 5.50" to 20" in diameter mounted about 0.5" apart on a common spindle. The Read/Write head is used to read from and write onto the hard disk. The rotating speed of hard disk is as large as 2400, 3600, 5600, 7200 RPM (Revolutions per Minute). It has large storage capacity (hard disks common these days can store up to 40, 80 GB of data) and higher data access rate as compared to floppy disks.

(4) Floppy Disk


3.5" Floppy Disk

Floppy Disk is small, flexible and portable storage device, which is commonly used in Personal Computers. The floppy is made up of flexible plastic, which is coated with magnetic oxide. The hole in the centre of the floppy, which permits it to rotate, is called HUB. Read and Write operation from floppy are carried out using Read/Write sensor, when Read/Write head comes in contact with the floppy. Data can be read from and written onto the floppy. The floppy has a write protect notch, which can be either open or close. If open, data can only be read from the floppy (*i.e.* write protected) and if closed, data can be both read from and written into floppy. The floppies are available in two sizes *i.e.* 5.25" (which are virtually outdated now) and 3.5". Small amount of data can be stored on a floppy - *i.e.* 640 KB/1.2 MB (on 5.25" floppy) and 1.44 MB/2.8 MB (on 3.5" floppy).

(5) Zip Disk

Zip Disk has a shape similar to a 3.5" floppy disk with slightly bigger size, but large storage capacities of 100, 250, 500 MB etc. We need to have a Zip Drive to use a Zip Disk.

(6) CD-ROM (Compact Disk - Read Only Memory)

CD-ROM is an Optical storage device that can store large amount of information. It is made up of reflective metal coating usually aluminum, enclosed between two protective polycarbon layers. In the top layer, label and description of the contents of the disk is printed and in the bottom layer data is being read. This bottom layer comprises of millions of tiny depressions (Pits) and flat surfaces (Lands). A high power laser beam is used to read data from the CD-ROM. The speed of CD-ROM varies from quad speed (4X) to 52X. Modern CD-ROMs have storage capacity of 700 MB of data (equivalent of approximately 480 floppy disks) or 80 Minutes of video recording. The incredible use of CD has increased its popularity as it can hold large volume of text, graphics, audio and video, at a very low cost. Now-a-days, almost all the application softwares are available on CDs. A CD drive is used to read information on CD-ROM. We need a CD-Writer to write(store) data on to CDs. CDs are available in two variants :


CD Rom

(*i*) **CD-R (Compact Disk Recordable)** disks allow you to permanently store data on to it. Data once recorded on it cannot be changed.

(*ii*) **CD-RW (Compact Disk Re-Writable)** disks allow you to change data you record on CD-RW disks.

DVD Drive

(7) DVD-ROM (Digital Versatile Disk - Read Only Memory)

These days, DVDs are becoming a standard for storage of data. These are also an optical storage devices that looks similar in size and shape to CD-ROM, but they have much large storage capacity that the CD. Commonly available DVDs offer 4.5 GB of disk space, which is about six times the storage capacity of a CD. The transmission rate of DVD is much faster than that of CD (approximately 15 times faster). DVD is called versatile, because it can be used in a number of ways. The DVD-ROM drive is used to play both DVDs and CDs.

(8) Memory Sticks

Memory Sticks are very sleek, reliable and easily portable storage devices. It is becoming a common medium to share data between Lap-Tops, PDAs, Personal Organisers, PCs, LCD Projectors and Digital Cameras. It is available in different storage capacities like 512MB, 1GB, 2GB, 4GB etc.

Pen Drives

HARDWARE AND SOFTWARE

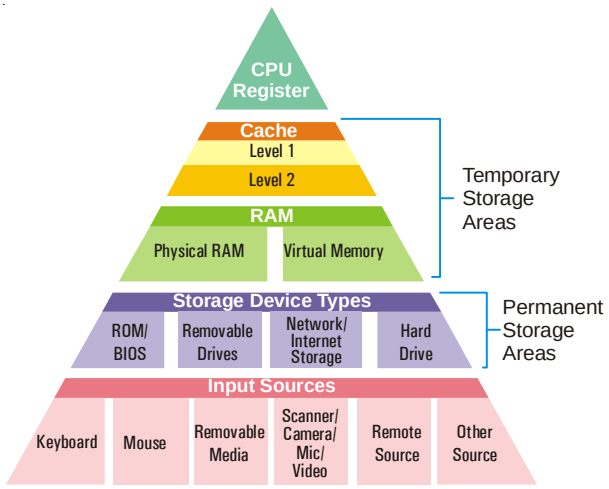
Hardware

Hardware refers to the tangible components of a computer *i.e.* all the parts of computers, which can see and touch. The parts/peripherals of computer, which we have discussed till now, constitute the computer hardware.

Software

Software refers to set of computer programs used to process the data. It is the software, which differentiates one computer hardware from another. The computers may have similar looks, but they perform different functions at different places, say, railways, airlines, banks, hospitals and schools, because of different set of software being used at different places. Software is generally divided into two categories, namely :

(1) **System Software.** We know that the computer understands only binary language, whereas the user works in an English like language. It is the System Software, which acts as a bridge between the user, hardware and application software. It comprises of **Language Translators** (further categorized as Compiler, Interpreters and Assemblers), which translates the English like commands to computer understandable binary language and vice-versa, so as to facilitate the communication between the user and the computer. Thus, System Software is the first thing to be loaded on to a computer system to make it functional. System Software also manages the computer resources, automate its operations and facilitate writing, testing and debugging of user programs. The **Editor**, enables the user to write programs and create files in computer. The most important System Software is the **Operating System (OS)**, which consists of a number of programs designed to ensure smooth working of a computer system.



Popular Operating Systems

(*a*) **DOS (Disk Operating System).** This Operating System was launched by Microsoft in 1981, for the Personal Computers. The user has to give text-based command for all the operations (like copy, edit, delete, rename etc.). The commands have to be given in a specified format (called 'Syntax'); otherwise an error is reported by the system. Since the interface is through character-based commands, it is called **Character User Interface (CUI).**

(*b*) **WINDOWS.** Introduced by Microsoft, it a very simple and user-friendly operating system, based on **Point and Click** technology. The commands were replaced by graphical ICONs (**I**mages on the **CON**sole) and user has to click at these ICONs to perform various tasks. There is no need for him to cram the commands or their syntax. Since the interface in Windows is through Graphics, it is called **Graphics User Interface (GUI)**. The credit of bringing computers to our homes goes to GUI Operating systems, whose ease of use have led to virtual revolution in usage of home computers. The popular versions of Windows Operating System these days are Windows 98, Windows Millennium, Windows XP, Windows Vista (Home and Professional Editions).

(*c*) **UNIX.** It is a very powerful CUI based operating system with a wide spectrum of powerful features. High level of security and regulated access to data are the key features of this operating system. It is organized as a layered Operating System. The innermost layer is called **Kernel**, which provides low-level services such as device drivers and memory management. The next layer is called the **Shell**, which is Command Interpreter. The outermost layer provides

miscellaneous services. The user interacts with the Kernel using commands and utilities. Most of the medium and high-level organizations use this operating system on their computers.

(*d*) **XENIX.** XENIX is replica of UNIX Operating System. While UNIX is primarily used on mainframes, XENIX is mainly used on PCs.

(*e*) **LINUX.** It is another powerful operating system, originally created by Linus Torvalds with the assistance of developers around the world. Linux is an independent POSIX implementation and includes true multi-tasking, virtual memory, shared libraries, demand loading, proper memory management, TCP/IP networking and other features consistent with UNIX type systems. Developed under the GNU (General Public Licence), the source code for LINUX is freely available to everyone. LINUX is gaining popularity and is offering great competition to Windows Operating System due to many reasons. Firstly, it is available free of cost. You can simply download and install it. Secondly, it has been developed as an open architecture *i.e.* the users can contribute source code, for further value addition in the operating system. Thirdly, it is an operating system having dual capability *i.e.* it can work like UNIX in its CUI form and also like WINDOWS in its GUI form.

(*f*) **Micro Kernel Operating Systems.** A Micro Kernel is a very small machine dependent part of the operating system, which coordinates the activities of other services within operating system, providing services such as memory management, device management and file management. Micro Kernel based operating systems are easily portable and are the latest development in the design of operating systems.

(2) **Application Software.** Application software are developed to solve different end-user problems, which include :

Graphics Software. Corel Draw, Adobe Photoshop, Adobe Illustrator, Visio, Macromedia Free Hand, Write Image, Fractal Design Painter, SuperGOO etc.

Desk Top Publishing (DTP) Software. Adobe Page Maker, Microsoft Publisher, Quark Xpress, Print Shop Ensemble, Frame Maker, Interleaf, etc.

Word Processing Software. Microsoft Word, Word Perfect, Word Pro, etc.

Spreadsheet Programs. Microsoft Excel, Lotus 1-2-3, Quattro Pro, etc.

Database Programs. Microsoft Access, Foxpro, Oracle, etc.

Multimedia Programs. 3D Studio Max, Extreme 3D, Morpher, Animation Master, etc.

Architectural Software. AutoCAD, Planix Home Designer 3D, Softplan, etc.

Chemistry Software. Hyperchem 7.5, Chemistry 3D draw, ChemSuite, Chem-X, ChemCalc, ChemSW, Molesearch Pro, Molecular Modelling Pro, AutoNom 4.0, Babel, CrystalMaker etc.

HTML/Web Designing Software. Microsoft Front Page, Home Page, AOL press, Netscape Composer, etc.

E-mail Software. Outlook Express, Microsoft Outlook, Netscape Messenger, Eudora Pro, Z-Mail Pro, etc.

Software Suites. Microsoft Office, Lotus Smart Suite, Word Perfect Suite etc.

Library Management Software. Library Manager

Financial Accounting Software. Tally, Ex, etc,

Banking Software. Bankmaster, Finacle, B@nc 24, Kapiti, etc.

Anti-virus Software. Norton Antivirus, Mcafee Anti-virus, Dr. Solomon's Anti virus, PC-Cilin, Smartdog, AVG Antivirus, etc.

Problem Solving in Computer

It involves following steps :

1. Define the Problem
2. Analyze the Problem
3. Develop an algorithm to solve the problem
4. Translate the algorithm into a Computer Program
5. Test and Debug the program
6. Document the Program

Algorithm

An algorithm refers to the sequence of steps (method) to be followed to solve a problem. It facilitates the problem solving process in a computer and forms the basis for coding a program.

Flow Chart

While algorithm is representation of sequence of steps in English-like language, Flow Chart is diagrammatic representation of steps to be taken to solve a problem. It uses various flow chart symbols connected by arrows.

Flowchart Symbol	Meaning
	Start or Stop
	Input or Output Operation
	Process
	Condition Box
	Connector
	Arrows to represent flow of instructions

Program

A program is a set of instructions, written in a programming language, to convert the raw data into desired useful information.

Programming Languages

Programming Languages are divided into two major categories *i.e.* Low-level and High-level. **Low-level languages** comprise machine languages and assembly level languages. **High-level languages** are English-like and used by programmers to write computer programs. These are divided into four classes :

(*i*) **Scientific Languages** - ALGOL, APL, FORTRAN, PASCAL, PL/1

(*ii*) **Business Languages** - COBOL, PL/1

(*iii*) **Specialized Languages** - ADA, APT, CORAL 66, LISP, PROLOG, RPG, SIMULA, SNOBOL

(*iv*) **Interactive Languages** - APL, BASIC, JOSS, Interactive FORTRAN, RTL/2

As the computer understands only machine language, the programs written in Assembly language and High-level language need to be converted into Machine language, before execution.

Assembler converts the program written in Assembly language to Machine language.

Translator converts the program written in High Level language to Machine language.

NUMBER SYSTEM

In early days, when there were no means to count, people used various methods to count the objects like fingers, stones, pebbles, sticks etc., but these methods were not adequate and had their limitations. Various other number systems were introduced with the passage of time like :

Decimal Number System

Binary Number System

Octal Number System

Hexadecimal Number System

Base or Radix of a Number System

The Base of the number system is the number of digits used in it. For *e.g.*, Since the Decimal Number System uses 10 digits, its Base or Radix is 10.

Decimal Number System

It consists of basically 10 digits *i.e.* 0 to 9 with the Base 10. Each digit may be used individually or the digits may be grouped to form a numeric value. For *e.g.*, 7, 32, -786, 72.32 are Decimal Numbers. The value of each digit in a number depends upon the following :

The **Face value** of the system

The **Base** of the System

The **Position** of the digit in a number

For *e.g.*, the number 786 can be understood in powers of its base :

6×10^0 Units	=	6
8×10^1 Tens	=	80
7×10^2 Hundreds	=	700
		786

We observe that the positional value of each digit increases 10 folds, as we move from right to left. In the above given number 7, 8 and 6, each digit has its face value and their place value is 6 ones, 8 tens and 7 hundreds, which depends on the position of the digit in a number.

Binary Number System

The Binary Number System consists of only two digits *i.e.* 0 and 1 to represent any number. Since this system uses only two digits, its Base or Radix is 2. **All our computer systems use this Binary Number System and convert the data input from its Decimal form into Binary equivalent.**

Decimal to Binary Conversion

The Decimal to Binary Conversion is based on the fact that any decimal integer may be expressed as a sum of the powers of 2.

Steps to convert a Decimal integer to its Binary equivalent :

(*i*) Divide the given Decimal Number with the Base 2.

(*ii*) Write down the Remainder and divide the Quotient again by 2.

(*iii*) Repeat Step 2, till the Quotient becomes Zero.

(*iv*) Write down the sequence of remainders obtained during division from bottom to top *i.e.* from **Most Significant Bit** (*i.e.* the Last Remainder) to the **Least Significant Bit** (*i.e.* the First Remainder)

SOLVED PROBLEM 1. Find the Binary equivalent of $(72)_{10}$.

SOLUTION $(72)_{10} = (\ ?\ )_2$

2	72 - Remainder
2	36 - 0
2	18 - 0
2	9 - 0
2	4 - 1
2	2 - 0
2	1 - 0
	0 - 1

LSB (Least Significant Bit)

↑ Bottom to Top

MSB (Most Significant Bit)

Thus, $\mathbf{(72)_{10} = (1001000)_2}$

Verification : $(1001000)_2 = 1 \times 2^6 + 0 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 0 \times 2^0$

$= 64 + 0 + 0 + 8 + 0 + 0 + 0$

$= \mathbf{(72)_{10}}$

Conversion of Decimal Fractions to its Binary

Steps to convert a Decimal Fractions to its Binary equivalent :

(*i*) Multiply the fraction part by 2 to obtain the integer part.

(*ii*) Continue multiplying the fraction part by 2 until the fractional product becomes Zero.

(*iii*) The carries generated by each Multiplication form the Binary Number. Write down the sequence of carries obtained during multiplication from bottom to top *i.e.* from **Most Significant Bit** (*i.e.* the First Carry produced) to the **Least Significant Bit** (*i.e.* the Last Carry produced)

SOLVED PROBLEM 2. Find the Binary equivalent of $(0.625)_{10}$

SOLUTION $(0.625)_{10} = (\ ?\ )_2$

	Carry	
$0.625 \times 2 = 1.250$	1	(MSB)
$0.250 \times 2 = 0.500$	0	↓
$0.500 \times 2 = 1.000$	1	(LSB)

Thus, $\mathbf{(0.625)_{10} = (0.101)_2}$

SOLVED PROBLEM 3. Find the Binary equivalent of $(14.4375)_{10}$

SOLUTION $(14.4375)_{10} = (\ ?\ )_2$

First, convert the whole number part :

2	14 - Remainder
2	7 - 0
2	3 - 1
2	1 - 1
	0 - 1

LSB (Least Significant Bit)

↑

MSB (Most Significant Bit)

Now, convert the fractional part :

		Carry	
0.4375×2	$= 0.8750$	0	**(MSB)**
0.8750×2	$= 1.7500$	1	↓
0.7500×2	$= 1.5000$	1	↓
0.5000×2	$= 1.0000$	1	**(LSB)**

Thus, $\mathbf{(14.4375)_{10} = (1110.0111)_2}$

Binary to Decimal Conversion

Steps to convert a Binary number to its Decimal equivalent :

(*i*) Multiply the **Least Significant Bit** (LSB) *i.e.* the extreme right most digit of the given Binary Number with 2 having the power 0 *i.e.* 2^0 (*i.e.* 1).

(*ii*) Repeat Step 1 for all the binary digits, by increasing the power one by one, but keeping the base 2 fixed, as you move from Right (LSB) to Left (MSB) *i.e.* Multiply the bit next to the LSB by 2^1 (*i.e.* 2) and other successive bits to the left by 2^2 (*i.e.* 4), 2^3 (*i.e.* 8) and so on.

(*iii*) Finally, Sum up all the products to get the Decimal Number.

SOLVED PROBLEM 4. Find the Decimal equivalent of $(11001)_2$.

SOLUTION

$$(11001)_2 = (?)_{10}$$
$$= (1 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (0 \times 2^1) + (1 \times 2^0)$$

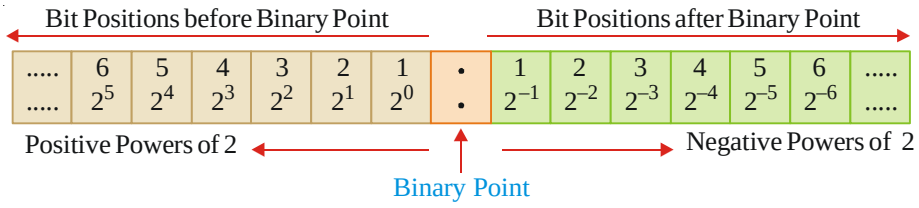
Power increases as we move from right (LSB) to left (MSB)

$$= 16 + 8 + 0 + 0 + 1$$
$$= 25$$

Thus, $\mathbf{(11001)_2 = (25)_{10}}$

Conversion of Binary Fractions to Decimal

Like in Decimal Number System, the fractions can also be represented in Binary by placing the bits to the right of Binary Point. All the bits on the left side of the Binary Point have positive powers of 2 (from 2^0 to 2^n) and all bits to the right of Binary Point have negative powers of 2 (from 2^{-1} to 2^{-n}). Thus the powers for the Binary Number System are :



SOLVED PROBLEM 5. Find the Decimal equivalent of $(0.1001)_2$.

SOLUTION

$$(0.1001)_2 = (?)_{10}$$
$$= (1 \times 2^{-1}) + (0 \times 2^{-2}) + (1 \times 2^{-3})$$
$$= {}^1/_2 + 0 + {}^1/_8$$
$$= 0.5 + 0 + 0.125$$
$$= 0.625$$
$$= \mathbf{(0.625)_{10}}$$

SOLVED PROBLEM 6. Find the Decimal equivalent of $(1110.0111)_2$.

SOLUTION

$$(1110.0111)_2 = (?)_{10}$$
$$= (1\times2^3) + (1\times2^2) + (1\times2^1) + (0\times2^0) + (0\times2^{-1}) + (1\times2^{-2}) + (1\times2^{-3}) + (1\times2^{-4})$$
$$= 8 + 4 + 2 + 0 + 0 + {}^1/_4 + {}^1/_8 + {}^1/_{16}$$
$$= 8 + 4 + 2 + 0 + 0 + 0.25 + 0.125 + 0.0625$$
$$= 14.4375$$

Thus, $\mathbf{(1110.0111)_2 = (14.4375)_{10}}$

Octal Number System

The Octal Number System consists of 8 digits *i.e.* 0 to 7, with the Base 8. The counting in the octal system is same as in decimal system except that any number with 8 or 9 is omitted.

Like decimal and binary number systems, it is also a positional systems, consisting of an integer part and a fractional part. The procedure of Octal to Decimal conversion is similar to Binary to Decimal conversion. The only difference is that of Base.

The octal system is **used in microcomputers for direct input/output operation**.

Octal to Decimal Conversion

Steps to convert a Octal number to its Decimal equivalent :

(*i*) Multiply the Least Significant Bit (LSB) *i.e.* the extreme right most digit of the given Octal Number, with 8 having the power 0 i.e. 8^0 (*i.e.* 1).

(*ii*) Repeat Step 1 for all the Octal numbers, by increasing the power one by one, but keeping the base 8 fixed, as you move from Right (LSB) to Left (MSB) *i.e.* Multiply the bit next to the LSB by 8^1 (*i.e.* 8) and other successive bits to the left by 8^2 (*i.e.* 64), 8^3 (*i.e.* 512) and so on.

(*iii*) Finally, Sum up all the products to get the Decimal Number.

SOLVED PROBLEM 7. Find the Decimal equivalent of $(3156)_8$.

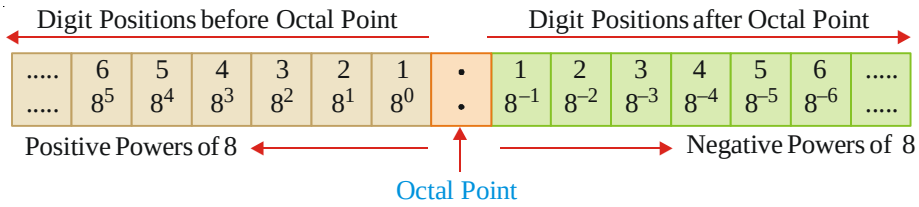
SOLUTION

$$(3156)_8 = (?)_{10}$$
$$= (3\times8^3) + (1\times8^2) + (5\times8^1) + (6\times8^0)$$
$$= 1536 + 64 + 40 + 6$$
$$= 1646$$

Thus, $\mathbf{(3156)_8 = (1646)_{10}}$

Conversion of Octal fractional number to its Decimal equivalent :

Like in Decimal Number System, the fractions can also be represented in Octal by placing the digits to the right of Octal Point. All the digits on the left side of the Octal Point have positive powers of 8 (from 8^0 to 8^n) and all digits to the right of Octal Point have negative powers of 8 (from 8^{-1} to 8^{-n}). Thus the powers for the Octal Number System are :



SOLVED PROBLEM 8. Find the Decimal equivalent of $(72.32)_8$.

SOLUTION

$$(72.32)_8 = (\,?\,)_{10}$$
$$= (7 \times 8^1) + (2 \times 8^0) + (3 \times 8^{-1}) + (2 \times 8^{-2})$$
$$= 56 + 2 + 3 \times 0.125 + 2 \times 0.0156$$
$$= 56 + 2 + 0.375 + 0.0313$$
$$= 58.4063$$

Thus, $\mathbf{(72.32)_8 = (58.406)_{10}}$

Decimal to Octal Conversion

Steps to convert a Decimal integer to its Octal equivalent :

(*i*) Divide the given Decimal Number with the Base 8.

(*ii*) Write down the Remainder and divide the Quotient again by 8.

(*iii*) Repeat Step 2, till the Quotient becomes Zero.

(*iv*) Write down the sequence of remainders obtained during division from bottom to top *i.e.* from **Most Significant Bit** (*i.e.* the Last Remainder) to the **Least Significant Bit** (*i.e.* the First Remainder).

SOLVED PROBLEM 9. Find the Octal equivalent of $(590)_{10}$

SOLUTION

$$(590)_{10} = (\,?\,)_8$$

8	590	Remainder
8	73	6
8	9	1
8	1	1
	0	1

LSB (Least Significant Bit)

↑

MSB (Most Significant Bit)

Thus, $\mathbf{(590)_{10} = (1116)_8}$

Conversion of Decimal Fractions to Octal

Steps to convert a Decimal Fractions to its Octal equivalent :

(*i*) Multiply the fraction part by 8 to obtain the integer part.

(*ii*) Continue multiplying the fraction part by 8 until the fractional product becomes Zero or up to 6 decimal places (in case the fractional product does not become Zero in 6 steps).

(*iii*) The carries generated by each Multiplication form the Octal Number. Write down the sequence of carries obtained during multiplication from top to bottom *i.e.* from **Most Significant Bit** (*i.e.* the First Carry produced) to the **Least Significant Bit** (*i.e.* the Last Carry produced).

SOLVED PROBLEM 10. Find the Octal equivalent of $(0.675)_{10}$

SOLUTION

$$(0.675)_{10} = (\,?\,)_8$$

	Carry	
$0.675 \times 8 = 5.400$	5	**(MSB)**
$0.400 \times 8 = 3.200$	3	↓
$0.200 \times 8 = 1.600$	1	
$0.600 \times 8 = 4.800$	4	
$0.800 \times 8 = 6.400$	6	
$0.400 \times 8 = 3.200$	3	**(LSB)** - Up to 6 decimal places

Thus, $\mathbf{(0.675)_{10} = (0.531463)_8}$

SOLVED PROBLEM 11. Find the Octal equivalent of $(590.6875)_{10}$

SOLUTION $(590.6875)_{10} = (?)_8$

First, convert the whole number part :

8	590	-	Remainder
8	73	-	6
8	9	-	1
8	1	-	1
	0	-	1

LSB (Least Significant Bit)

↑

MSB (Most Significant Bit)

Now, convert the fractional part :

		Carry	
0.6875×8	$= 5.5000$	5	**(MSB)**
0.5000×8	$= 4.0000$	4 ↓	**(LSB)**

Thus, $\mathbf{(590.6875)_{10} = (1116.54)_8}$

Octal to Binary Conversion

To convert an octal number into a binary number, each octal digit is converted into its equivalent binary notation. Since all the three bit binary numbers are required to represent the eight octal digits, it takes only one octal digit to represent three bits. Thus, conversion from Octal to Binary and vice-versa is very easy.

To convert an Octal number to its Binary equivalent, we simply replace each octal digit by its appropriate binary bits, given in the following table (Table 33.1).

TABLE 33.1. OCTAL NUMBERS AND THEIR BINARY EQUIVALENTS

Octal Number	Binary Equivalent
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

SOLVED PROBLEM 12. Find the Binary equivalent of $(72.3541)_8$.

SOLUTION $(72.3541)_8 = (?)_2$

$(72.3541)_8 =$	7	2	.	3	5	4	1
	↓	↓		↓	↓	↓	↓
	111	010	.	011	101	100	001

Thus, $\mathbf{(72.3541)_8 = (111010.011101100001)_2}$

Binary to Octal Conversion

The steps to convert a Binary number into an Octal number, are as under :

(*i*) Divide the Binary number into groups of three bits each, starting at **Least Significant Bit (LSB).**

(*ii*) Separate the integer part of the binary number in groups of three bits, starting from the Binary Point and proceeding to the left.

(*iii*) Also, Separate the fractional part in groups of three bits, starting from the Binary Point and proceeding to the right.

(*iv*) Then, express each group as the octal equivalent, according to conversion table. (Table 33.1)

SOLVED PROBLEM 13. Find the Octal equivalent of $(100111101.011011)_2$.

SOLUTION

$(100111101.011011)_2 = (?)_8$

$(100111101.011011)_2 = 100 \quad 111 \quad 101 \cdot 011 \quad 011$

$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow$

$4 \quad 7 \quad 5 \cdot 3 \quad 3$

Thus, $(100111101.011011)_2 = (475.33)_8$

Hexadecimal Number System

The Hexadecimal Number System consists of 16 symbols *i.e.* Ten Digits (0 to 9) and Six alphabets (A, B, C, D, E, F), with the Base 16.

This is the most popular number system, **used for expressing binary numbers concisely**. Most of the popular microprocessors like INTEL (8085 and 8088) use Hexadecimal Number System.

TABLE 33.2. RELATIONSHIP BETWEEN BINARY, DECIMAL, OCTAL AND HEXADECIMAL NUMBER SYSTEMS

Binary	Decimal	Octal	Hexadecimal
0000	0	0	0
0001	1	1	1
0010	2	2	2
0011	3	3	3
0100	4	4	4
0101	5	5	5
0110	6	6	6
0111	7	7	7
1000	8	10	8
1001	9	11	9
1010	10	12	A
1011	11	13	B
1100	12	14	C
1101	13	15	D
1110	14	16	E
1111	15	17	F

Hexadecimal to Binary Conversion

For Hexadecimal to Binary Conversion :

Convert each Hexadecimal Number into its 4-bit Binary equivalent, according to Table 33.2.

SOLVED PROBLEM 14. Find the Binary equivalent of $(F2E.74)_{16}$.

SOLUTION

$(F2E.74)_{16} = (?)_2$

$(F2E.74)_{16} = F \quad 2 \quad E \quad . \quad 7 \quad 4$

$\downarrow \quad \downarrow \quad \downarrow \quad \quad \downarrow \quad \downarrow$

$1111 \quad 0010 \quad 1110 \quad . \quad 0111 \quad 0100$ (As per Table 33.2)

Thus, $\mathbf{(F2E.74)_{16} = (111100101110.01110100)_2}$

Binary to Hexadecimal Conversion

The steps to convert a Binary number into an Octal number, are as under :

(*i*) Divide the Binary number into groups of four bits each, starting at Least Significant Bit (LSB).

(*ii*) Separate the integer part of the binary number in groups of four bits, starting from the Binary Point and proceeding to the left.

(*iii*) Also, Separate the fractional part in groups of four bits, starting from the Binary Point and proceeding to the right.

(*iv*) Then, express each binary group into its the hexadecimal equivalent, according to Table 33.2.

SOLVED PROBLEM 15. Find the Hexadecimal equivalent of $(110100101011)_2$.

SOLUTION

$(110100101011)_2 = (?)_{16}$

$(110100101011)_2 = 1101 \quad 0010 \quad 1011$

$\downarrow \quad \downarrow \quad \downarrow$

$D \quad 2 \quad B$ (As per Table 33.2)

Thus, $\mathbf{(110100101011)_2 = (D2B)_{16}}$

SOLVED PROBLEM 16. Find the Hexadecimal equivalent of $(10011110.01101111)_2$.

SOLUTION

$(10011110.01101111)_2 = (?)_{16}$

$(10011110.01101111)_2 = 1001 \quad 1110 \quad . \quad 0110 \quad 1111$

$\downarrow \quad \downarrow \quad \quad \downarrow \quad \downarrow$

$9 \quad E \quad . \quad 6 \quad F$ (As per Table 33.2)

Thus, $\mathbf{(10011110.01101111)_2 = (9E.6F)_{16}}$

Hexadecimal to Decimal Conversion

Steps to convert a Hexadecimal number to its Decimal equivalent :

(*i*) Multiply the Least Significant Bit (LSB) *i.e.* the extreme right most digit of the given Hexadecimal Number, with 16 having the power 0 *i.e.* 16^0 (*i.e.* 1).

(*ii*) Repeat Step 1 for all the Hexadecimal numbers, by increasing the power one by one, but keeping the base 16 fixed, as you move from Right (LSB) to Left (MSB) *i.e.* Multiply the bit next to the LSB by 16^1 (*i.e.* 16) and other successive bits to the left by 16^2 (*i.e.* 256), 16^3 (*i.e.* 4096) and so on. While doing multiplication, take decimal equivalent of Hexadecimal numbers *i.e.* A, B, C, D, E and F should be taken as 10, 11, 12, 13, 14 and 15 respectively.

(*iii*) Finally, Sum up all the products to get the Decimal Number.

SOLVED PROBLEM 17. Find the Decimal equivalent of $(C7F2)_{16}$.

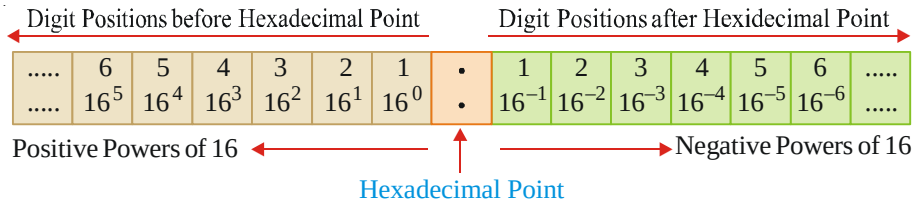
SOLUTION

$$(C7F2)_{16} = (?)_{10}$$
$$= (C \times 16^3) + (7 \times 16^2) + (F \times 16^1) + (2 \times 16^0)$$
$$= 12 \times 4096 + 7 \times 256 + 15 \times 16 + 2 \times 1$$
$$= 49152 + 1792 + 240 + 2$$
$$= 51186$$

Thus, $\mathbf{(C7F2)_{16} = (51186)_{10}}$

Conversion of Hexadecimal fractional number to its Decimal equivalent :

Like in Decimal Number System, the fractions can also be represented in Hexadecimal by placing the digits to the right of Hexadecimal Point. All the digits on the left side of the Hexadecimal Point have positive powers of 16 (from 16^0 to 16^n) and all digits to the right of Hexadecimal Point have negative powers of 16 (from 16^{-1} to 16^{-n}). Thus the powers for the Hexadecimal Number System are :



SOLVED PROBLEM 18. Find the Decimal equivalent of $(A1.3C)_{16}$.

SOLUTION

$$(A1.3C)_{16} = (?)_{10}$$
$$= (A \times 16^1) + (1 \times 16^0) + (3 \times 16^{-1}) + (C \times 16^{-2})$$
$$= 10 \times 16 + 1 \times 1 + {}^3/_{16} + {}^{12}/_{256}$$
$$= 160 + 1 + 0.1875 + 0.0469$$
$$= 161.2344$$

Thus, $\mathbf{(A1.3C)_{16} = (161.2344)_{10}}$

Alternatively, the Hexadecimal numbers can be converted to their decimal equivalents by first converting the Hexadecimal number to its binary equivalent and then converting the binary to decimal.

SOLVED PROBLEM 19. Find the Decimal equivalent of $(F2)_{16}$.

SOLUTION

$$(F2)_{16} = (?)_{10}$$
$$= F \quad 2$$
$$\downarrow \quad \downarrow$$
$$1111 \quad 0010 \quad \text{(As per Table 33.2)}$$
$$= (11110010)_2$$
$$= 1 \times 2^7 + 1 \times 2^6 + 1 \times 2^5 + 1 \times 2^4 + 0 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$$
$$= 128 + 64 + 32 + 16 + 0 + 0 + 2 + 0$$
$$= 242$$

Thus, $\mathbf{(F2)_{16} = (242)_{10}}$

Decimal to Hexadecimal Conversion

Steps to convert a Decimal integer to its Hexadecimal equivalent :

(*i*) Divide the given Decimal Number with the Base 16.
(*ii*) Write down the Remainder and divide the Quotient again by 16.
(*iii*) Repeat Step 2, till the Quotient becomes Zero.
(*iv*) Write down the sequence of remainders obtained during division from bottom to top *i.e.* from **Most Significant Bit** (*i.e.* the Last Remainder) to the **Least Significant Bit** (*i.e.* the First Remainder). While doing so, take hexadecimal equivalents of decimal remainders 10, 11, 12, 13, 14 and 15 as A, B, C, D, E and F respectively.

SOLVED PROBLEM 20. Find the Hexadecimal equivalent of $(7232)_{10}$.

SOLUTION $(7232)_{10} = (?)_{16}$

16	7232	-	Remainder
16	452	-	0
16	28	-	4
16	1	-	12 (C)
	0	-	1

LSB (Least Significant Bit)

MSB (Most Significant Bit)

Thus, $\mathbf{(590)_{10} = (1C40)_{16}}$

Conversion of Decimal Fractions to Hexadecimal

Steps to convert a Decimal Fractions to its Hexadecimal equivalent :

(*i*) Multiply the fraction part by 16 to obtain the integer part.
(*ii*) Continue multiplying the fraction part by 16 until the fractional product becomes Zero or up to 6 decimal places (in case the fractional product does not become Zero in 6 steps).
(*iii*) The carries generated by each Multiplication form the Hexadecimal Number. Write down the sequence of carries obtained during multiplication from top to bottom *i.e.* from **Most Significant Bit** (*i.e.* the First Carry produced) to the **Least Significant Bit** (*i.e.* the Last Carry produced)

SOLVED PROBLEM 21. Find the Hexadecimal equivalent of $(7232.625)_{10}$.

SOLUTION $(7232.625)_{10} = (\,?\,)_{16}$

First, convert the whole number part :

16	7232	-	Remainder
16	452	-	0
16	28	-	4
16	1	-	12 (C)
	0	-	1

LSB (Least Significant Bit)

MSB (Most Significant Bit)

Now, convert the fractional part :

	Carry
$0.625 \times 16 = 10.000$	A

Thus, $\mathbf{(7232.625)_{10} = (1C40.A)_{16}}$

Hexadecimal to Octal Conversion

Steps to convert a Hexadecimal Number to its Octal equivalent :

(*i*) Convert the Hexadecimal number to its 4-bit binary equivalents. (As per Table 33.2)
(*ii*) Group the 4 bit binary equivalents into 3 bit groups, starting from the LSB and moving left

towards MSB for the integer part.

(*iii*) For the fractional part, groupings of three bits are made starting from the Binary point and moving towards right.

(*iv*) Then replace each 3-bit group by its octal equivalent.

SOLVED PROBLEM 22. Find the Octal equivalent of $(F2)_{16}$.

SOLUTION

$(F2)_{16} = (?)_8$

$= F \quad 2$

$\quad \downarrow \quad \downarrow$

$\quad 1111 \quad 0010$ (As per Table 33.2)

$= (011 \quad 110 \quad 010)_2$

$= 011 \quad 110 \quad 110$

$\quad \downarrow \quad \downarrow \quad \downarrow$

$= 3 \quad 6 \quad 2$

Thus, $\mathbf{(F2)_{16} = (362)_8}$

SOLVED PROBLEM 23. Find the Octal equivalent of $(6C.43)_{16}$.

SOLUTION

$(6C.43)_{16} = (?)_8$

$= 6 \quad C \quad . \quad 4 \quad 3$

$\quad \downarrow \quad \downarrow \quad \quad \downarrow \quad \downarrow$

$\quad 0110 \quad 1100 \quad . \quad 1100 \quad 0011$

$= (001 \quad 101 \quad 100 \quad . \quad 010 \quad 000 \quad 110)_2$

$= 001 \quad 101 \quad 100 \quad . \quad 010 \quad 000 \quad 110$

$\quad \downarrow \quad \downarrow \quad \downarrow \quad \quad \downarrow \quad \downarrow \quad \downarrow$

$= 1 \quad 5 \quad 4 \quad . \quad 2 \quad 0 \quad 6$

Thus, $\mathbf{(6C.43)_{16} = (154.206)_8}$

Octal to Hexadecimal Conversion

Steps to convert a Octal Number to its Hexadecimal equivalent :

(*i*) Convert the Octal number to its 3-bit binary equivalents. (As per Table 33.2)

(*ii*) Group the 3 bit binary equivalents into 4 bit groups, starting from the LSB and moving left towards MSB for the integer part.

(*iii*) For the fractional part, groupings of four bits are made starting from the Binary point and moving towards right.

(*iv*) Then replace each 4-bit group by its hexadecimal equivalent.

SOLVED PROBLEM 24. Find the Hexadecimal equivalent of $(154.206)_8$.

SOLUTION

$(154.206)_8 = (?)_{16}$

$(154.206)_8 = 1 \quad 5 \quad 4 \quad \cdot \quad 2 \quad 0 \quad 6$

$\quad \downarrow \quad \downarrow \quad \downarrow \quad \quad \downarrow \quad \downarrow \quad \downarrow$

$= (001 \quad 101 \quad 100 \quad \cdot \quad 010 \quad 000 \quad 110)_2$

$= 0 \quad 0110 \quad 1100 \quad \cdot \quad 0100 \quad 0011 \quad 0$

$= 0000 \quad 0110 \quad 1100 \quad \cdot \quad 0100 \quad 0011 \quad 0000$

$\quad \downarrow \quad \downarrow \quad \downarrow \quad \quad \downarrow \quad \downarrow \quad \downarrow$

$= 0 \quad 6 \quad C \quad \cdot \quad 4 \quad 3 \quad 0$

Thus, $\mathbf{(154.206)_8 = (6C.43)_{16}}$

Binary Arithmetic

As computer understands only Binary language, the data which is input by the user is converted into binary language for its processing. The processing may involve various kinds of arithmetic operations such as addition, subtraction, multiplication, division etc. on the Binary numbers.

Binary Addition

The technique used to add the binary numbers inside the computers is very easy and simple. This is performed in the same way as we perform addition with Decimal numbers. The following table illustrates the addition of two Binary numbers.

Number(Input)		Result (Output)	
A	*B*	*Sum = A + B*	*Carry*
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

SOLVED PROBLEM 25. Compute $(1010)_2 + (1101)_2$.

SOLUTION $(1010)_2 + (1101)_2 = (?)_2$

Augend		1	0	1	0
Addend	+	1	1	0	1
Carry Bit ←	1	0	1	1	1

Thus, $\mathbf{(1010)_2 + (1101)_2 = (10111)_2}$

SOLVED PROBLEM 26. Compute $(11111)_2 + (1011)_2$.

SOLUTION $(11111)_2 + (1011)_2 = (?)_2$

		1	1	1	1	→ Carry
Augend		1	1	1	1	1
Addend	+	0	1	0	1	1
Sum	1	0	1	0	1	0

Thus, $\mathbf{(11111)_2 + (1011)_2 = (101010)_2}$

Binary Subtraction

Binary Subtraction is also performed in the same way as we perform Decimal subtraction. The following table illustrates the subtraction of two Binary numbers.

While subtracting the numbers, a borrow is required while subtracting 1 from 0. In such a case, when a 1 is borrowed from the next higher column, the difference is also 1.

Number(Input)		Result (Output)	
A	*B*	*Difference =A-B*	*Borrow*
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

To represent the Negative numbers, we may use either a **Sign Magnitude** or **Complement Representation.**

In the *Sign Magnitude representation*, while 0 is used to represent positive (+) sign, 1 is used to represent negative (–) sign.

In the *Complement Representation*, 2s complement of an n-bit number x is (2n – x). To subtract a number y from a number x, the 2s complement of y is added to x and the overflow bit is ignored. This method simplified the subtraction of negative numbers.

SOLVED PROBLEM 27. Compute $(1111)_2 - (1010)_2$.

SOLUTION $(1111)_2 - (1010)_2 = (?)_2$

Minuend		1	1	1	1
Subtrahend	–	1	0	1	0
Difference		0	1	0	1

Thus, $\mathbf{(1111)_2 - (1010)_2 = (0101)_2}$

SOLVED PROBLEM 28. Compute $(1100)_2 - (11)_2$.

SOLUTION $(1100)_2 - (11)_2 = (?)_2$

				(10 – 1 = 1)	Borrow in Step 2
			(0)	(10)	(10) Borrow in Step 1
Minuend		1	1	0	0
Subtrahend	–	0	0	1	1
Difference		1	0	0	1

Thus, $\mathbf{(1111)_2 - (11)_2 = (1001)_2}$

Binary Multiplication

Binary Multiplication is also similar to Decimal multiplication. The following table illustrates the multiplication of two Binary numbers.

Number(Input)		Result (Output)
A	*B*	*Product* = *A* × *B*
0	0	0
0	1	0
1	0	0
1	1	1

Multiplication of two numbers is performed by successive addition of multiplicand to itself, after shifting it.

SOLVED PROBLEM 29. Compute $(1111)_2 \times (101)_2$.

SOLUTION $(1111)_2 \times (101)_2 = (?)_2$

Multiplicand				1	1	1	1
Multiplier	×				1	0	1
				1	1	1	1
			0	0	0	0	×
		1	1	1	1	×	×
Product	1	0	0	1	0	1	1

Thus, $\mathbf{(1111)_2 \times (101)_2 = (1001011)_2}$

Binary Division

The method to perform Binary Division is also similar to Division to Decimal numbers. Binary Division is performed by successive subtraction of the divisor from the dividend and developing the quotient bits. The Rules for Division are :

$0 \div 1 = 0$

$1 \div 1 = 1$

Division by 0 is meaningless.

SOLVED PROBLEM 30. Compute $(110)_2 \div (10)_2$.

SOLUTION $(110)_2 \div (10)_2 = (?)_2$

```
                    1   1   <-- Quotient
Divisor  1   0  ) 1   1   0   <-- Dividend
                  1   0
                  ---------
                      1   0
                      1   0
                  ---------
                      0   0   <-- Remainder
```

Thus, $(110)_2 \div (10)_2 = (11)_2$

SOLVED PROBLEM 31. Compute $(10000111)_2 \div (1001)_2$.

SOLUTION $(10000111)_2 \div (1001)_2 = (?)_2$

```
Quotient                0 1 1 1 1
Divisor      1 0 0 1 ) 1 0 0 0 0 1 1 1
                       1 0 0 1
                       ---------
                         1 1 1 1
                         1 0 0 1
                       ---------
                         1 0 0 1
                         1 0 0 1
                       ---------
                           1 0 0 1
                           1 0 0 1
                         ---------
Remainder                  0 0 0 0
```

Thus, $(10000111)_2 \div (1001)_2 = (01111)_2$

Binary Arithmetic for Real Numbers

Floating Point Representation is used for Real Numbers (*i.e.* Numbers with a fractional part), which uses a mantissa and exponent representation. To preserve the maximum number of significant digits, the mantissa is normalized with leading bit as 1.

The Rules to perform Binary Arithmetic on Floating Point Numbers are :

(1) **Addition and subtraction of floating point number.** It is performed by first making the exponents of two operands equal. The mantissa is appropriately shifted. The mantissas are then added or subtracted.

(2) **Multiplication of floating point numbers**. It is carried out by multiplying the mantissas and adding the exponents.

(3) **Division of two floating point numbers.** Here, the mantissas are divided and the exponent of the divisor is subtracted from that of the dividend.

If at first you don't succeed, blame your computer.

EXAMINATION QUESTIONS

1. Explain the functions of different parts of computer using Computer Block Diagram.
2. Describe briefly the advancements made in computer systems during different generations.
3. Differentiate between Computer Hardware and Software.
4. Differentiate between Primary Memory and Secondary Memory.
5. Differentiate between Cache Memory and Buffer.
6. What are the advantages of Non-impact Printers over the Impact Printers ?
7. What do you understand by DVD. How it is an improvement over CD ?
8. Why do we need an Operating System. Compare Windows and Linux Operating Systems.
9. What is an Application Software? Explain the application of computers in Chemistry, stating some specific application software, you are familiar with.
10. What is Number System? Explain different types of Number Systems used in Computers.
11. Convert the following decimal numbers to their desired equivalents.

    (*a*) $(214.75)_{10} = (?)_2$ (*b*) $(0.121)_{10} = (?)_8$

    (*c*) $(9172)_{10} = (?)_{16}$
12. Convert the following octal numbers to their desired equivalents.

    (*a*) $(121)_8 = (?)_2$ (*b*) $(21.7)_8 = (?)_{10}$
13. Convert the following hexadecimal numbers to their desired equivalents.

    (*a*) $(F2C)_{16} = (?)_2$ (*b*) $(C4F)_{16} = (?)_8$

    (*c*) $(D2C6.C3)_{16} = (?)_{10}$
14. Convert the following binary numbers to their desired equivalents.

    (*a*) $(1010101.1100)_2 = (?)_{10}$ (*b*) $(111010110.100)_2 = (?)_8$

    (*c*) $(10101111.1100)_2 = (?)_{16}$
15. Perform the following Binary Calculations.

    (*a*) $(10100011)_2 + (11100111)_2$ (*b*) $(111010)_2 - (101011)_2$

    (*c*) $(110101)_2 \times (101)_2$ (*d*) $(10101100)_2 \div (11001)_2$

MULTIPLE CHOICE QUESTIONS

1. _____ is the product of data processing.

(*a*) Data (*b*) Information

(*c*) Software (*d*) Computer

(*e*) None of these

Answer. (*b*)

2. The CPU (Central Processing Unit) consists of :

(*a*) Input, Output and Processing

(*b*) Control Unit, Primary Storage and Secondary Storage

(*c*) Primary Storage, Arithmetic-Logical Unit and Control Unit

(*d*) Input Processing and Storage

(*e*) None of the above

Answer. (*c*)

3. Advances in computer hardware and software are generally classified into generations. We are currently in which generation.

(*a*) First (*b*) Second

(*c*) Third (*d*) Fourth

(*e*) Fifth

Answer. (*d*)

4. Which of the following pieces of hardware is used the most in the input phase of a computer based information system.

(*a*) Printer (*b*) Diskette

(*c*) Monitor (*d*) Keyboard

(*e*) Main Memory

Answer. (*d*)

5. Monitor is an _____ device

(*a*) Input (*b*) Output

(*c*) Input Output (I/O) (*d*) Processing

(*e*) None of the these

Answer. (*c*)

6. Compared with secondary storage, primary storage is :

(*a*) Slow and inexpensive (*b*) Fast and inexpensive

(*c*) Fast and expensive (*d*) Slow and expensive

(*e*) None of the these

Answer. (*c*)

7. Software intended to satisfy a user's specific processing needs is called _____

(*a*) System Software (*b*) Utility Software

(*c*) Operating Software (*d*) Application Software

(*e*) All of the these

Answer. (*d*)

8. Which of the following is commonly used in academic testing ?

(*a*) MICR (*b*) POS

(*c*) OCR (*d*) OMR

(*e*) CRT

Answer. (*d*)

9. _____ is a non impact printer, which can produce high quality, letter-perfect printing.

(*a*) Dot Matrix Printer (*b*) Daisy Wheel Printer

(*c*) Line Printer (*d*) Ink Jet Printer

(*e*) Laser Printer

Answer. (*e*)

10. ROM stands for _____

(*a*) Read Only Method (*b*) Read On Memory

(*c*) Read Only Memory (*d*) Remember Only Memory

(*e*) None of these

Answer. (*c*)

11. ICON stands for _____

(*a*) Integrated Circuit Of Networks (*b*) Image Creation On Network

(*c*) Images on Computer Network (*d*) Images on CONsole

(*e*) None of the these

Answer. (*d*)

12. MICR stands for _____

(*a*) Many Inks Character Recognition (*b*) Multiple Inks Code Recognition

(*c*) Magnetic Ink Code Recognition (*d*) Magnetic Ink Character Recognition

(*e*) None of the these

Answer. (*d*)

13. DVD stands for

(*a*) Direct Video Disk (*b*) Digital Video Disk

(*c*) Digital Versatile Disk (*d*) Developed Video Disk

(*e*) None of the these

Answer. (*c*)

14. CASE stands for

(*a*) Computer Aided Software Engineering

(*b*) Computer Applications Software Engineering

(*c*) Computer Architecture and Software Engineering

(*d*) Computer Applied Software Engineering

(*e*) None of the these

Answer. (*a*)

15. Nibble is group of ___ bytes

(*a*) 2 (*b*) 4

(*c*) 6 (*d*) 8

(*e*) None of the these

Answer. (*b*)

16. 1 GB = _____ KB

(*a*) 1000 (*b*) 1024

(*c*) 1000000 (*d*) 1048576

(*e*) None of the these

Answer. (*d*)

17. What is the storage capacity of a CD-ROM

(*a*) 500 MB (*b*) 500 GB
(*c*) 700 MB (*d*) 700 GB
(*e*) None of these

Answer. (*c*)

18. Which of the following is not a GUI based software ?
(*a*) Windows (*b*) UNIX
(*c*) MS-Office (*d*) Corel Draw
(*e*) Pagemaker

Answer. (*b*)

19. The number of digits used in a number system is known as its _____
(*a*) Power (*b*) Weight
(*c*) Radix (*d*) Base
(*e*) Either (*c*) or (*d*)

Answer. (*e*)

20. _____ Number System is used by the computer systems.
(*a*) Decimal (*b*) Binary
(*c*) Octal (*d*) Hexadecimal
(*e*) None of the these

Answer. (*b*)

21. Hexadecimal Number System has a base of _____
(*a*) 2 (*b*) 4
(*c*) 8 (*d*) 10
(*e*) 16

Answer. (*e*)

22. _____ Number System has a base of 8
(*a*) Binary (*b*) Decimal
(*c*) Octal (*d*) Hexadecimal
(*e*) None of the these

Answer. (*c*)

23. The octal equivalent of $(111)_2$ is _____
(*a*) 4 (*b*) 5
(*c*) 6 (*d*) 7
(*e*) None of the these

Answer. (*d*)

24. The hexadecimal equivalent of $(1111)_2$ is _____
(*a*) 7 (*b*) A
(*c*) C (*d*) F
(*e*) None of the these

Answer. (*d*)

25. In Binary Addition, 1 + 1 is equal to _____
(*a*) 0 (*b*) 1
(*c*) 0 with carry 1 (*d*) 1 with carry 1
(*e*) None of the these

Answer. (*c*)

Top

Appendix A

Physical Constants

Quantity	Symbol	Traditional units	SI units
Atomic mass unit ($\frac{1}{12}$th mass of ^{12}C atom)	amu	1.6606×10^{-2} g	1.6606×10^{-27} kg
Avogadro's number	N	6.022×10^{23}	6.022×10^{23} particles/mol particles/mol
Bohr radius	a_0	0.52918 Å	5.2918×10^{-13} m
Boltzmann constant	k	1.3807×10^{-16} erg/K	1.3807×10^{-23} J/K
Charge-to-mass ratio of electron	e/m	1.7588×10^{8} Coulomb/g	1.7588×10^{11} C/kg
Electron rest mass	m_e	9.1095×10^{-28} g	9.1095×10^{-31} kg 0.00054859 amu
Faraday constant	F	96,487 coulombs/mole^{-1}	96,487 J/V mol^{-1}
Gas constant	R	$0.08206 \frac{\text{L atm}}{\text{mol K}}$	$8.3145 \frac{\text{Pa dm}^3}{\text{mol K}}$
Gravitational acceleration	g	980.6 cm/s	9.906 m/s
Molar volume (STP)	V_m	22.414 L/mol	22.414×10^{-3} m^3/mol
Neutron rest mass	m_n	1.67495×10^{-24} g	1.67495×10^{-27} kg 1.008665 amu
Planck's constant	h	6.6262×10^{-27} erg sec	6.6262×10^{-27}
Proton rest mass	m_p	1.6726×10^{-27} erg sec	1.6726×10^{-27} kg 1.0077277 amu
Velocity of ligh (in vaccum)	c	2.9979×10^{10} cm/s 186,281 miles/s	2.9979×10^{8} m/s
Rydberg constant	R_z	3.289×101^{5} cycles/s 2.1799×10^{-11} erg	1.0974×10^{7} m^{-1} 2.1799×10^{-18} J

Conversion Factors

cm → in : $\frac{1\text{ in}}{2.54\text{ cm}}$

cm^3 → in^3 : $\frac{1\text{ in}^3}{2.54\text{ cm}^3}$

cm → in ($\frac{1\text{ in}}{2.54\text{ cm}}$) → ft ($\frac{1\text{ ft}}{12\text{ in}}$)

in → cm : $\frac{2.54\text{ cm}}{1\text{ in}}$

in^2 → cm^2 : $\frac{(2.54\text{ cm})^2}{(1\text{ in})^2}$

km^2 → m^2 : $\frac{(1000)^2}{(1\text{ km})^2}$

km → mi : $\frac{0.6214\text{ m}}{1\text{ km}}$

km → mi ($\frac{0.6214\text{ mi}}{1\text{ km}}$) → laps ($\frac{1\text{ lap}}{0.250\text{ mi}}$)

m → mm : $\frac{1\text{ mm}}{0.001\text{ m}}$

ft → in ($\frac{12\text{ in}}{1\text{ ft}}$) → m ($\frac{1\text{ m}}{39.37\text{ in}}$)

in → cm : $\frac{2.54\text{ cm}}{1\text{ in}}$

dm^3 → m^3 ($\frac{(0.1\text{ m})^3}{(1\text{ dm})^3}$) → cm^3 ($\frac{(1\text{ cm})^3}{(0.01\text{ m})^3}$) → in^3 ($\frac{(1\text{ in})^3}{(2.54\text{ cm})^3}$)

L → (1.057 qt / 1 L) → qt → (4 cu / 1 qt) → cu

g → (1 mL / 0.84 g) → mL → (1 L / 1000 mL) → L

g → (1 cm^3 / 1.32 g) → cm^3 → (1 mL / 1 cm^3) → mL

kg → (1000 g / 1 kg) → g → (1 cm^3 / 0.752) → cm^3

kg → (1000 g / 1 kg) → g → (1 cm^3 / 0.789 g) → cm^3 → (1 mL / 1 cm^3) → mL → (1 L / 100 mL) → L

K → °C $K = °C + 273$

°C → K $K = °C + 273$

°F → °C $°C = \frac{[°F - 32]}{1.8}$

°C → °F $°C = \frac{[°F - 32]}{1.8}$

K → °C → °F

$K = °C + 273$ $°C = \frac{[°F - 32]}{1.8}$

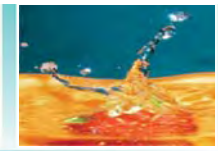
m, V → d $d = \frac{m}{v}$

Cal → (1000 cal / 1 Cal) → cal → (4.184 J / 1 cal) → J

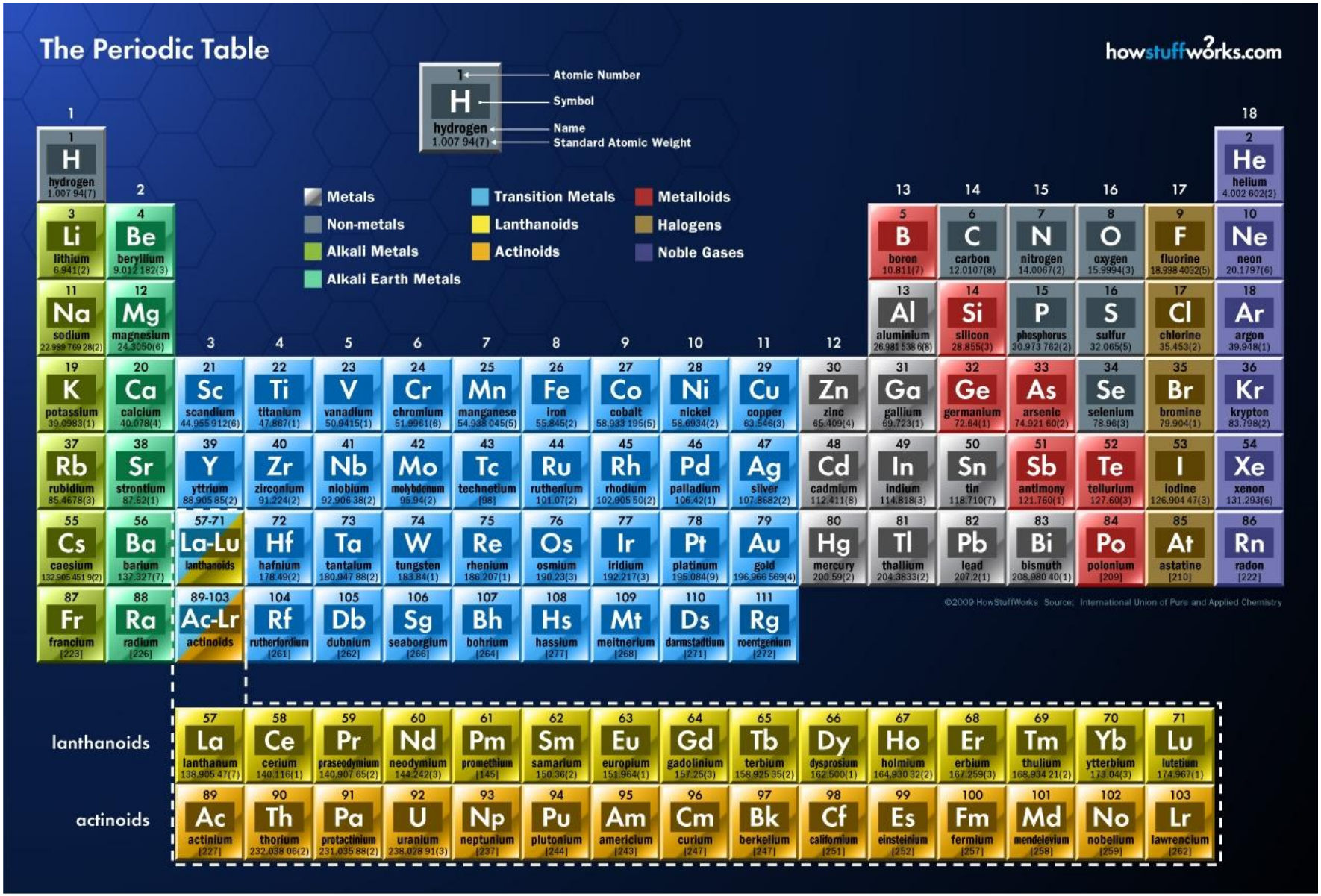
Dissociation constants of acids at 25°C

Name	Formula	Ka_1	Ka_2	Ka_3
Acetic acid	CH_3COOH	1.8×10^{-5}		
Arsenic acid	H_3AsO_4	5.6×10^{-3}	1.0×10^{-7}	3.0×10^{-12}
Arsenious acid	H_3AsO_3	6.0×10^{-10}		
Benzoic acid	C_6H_5COOH	6.5×10^{-5}		
Boric acid	H_3BO_3	5.8×10^{-10}		
Carbonic acid	H_2CO_3	4.3×10^{-7}	5.6×10^{-11}	
Chloroacetic acid	$ClCH_2COOH$	1.4×10^{-3}		
Formic acid	$HCOOH$	1.8×10^{-4}		
Hydrocyanic acid	HCN	4.9×10^{-10}		
Hydrofluoric acid	HF	6.8×10^{-4}		
Hydrogen peroxide	H_2O_2	2.4×10^{-12}		
Hydrogen sulphate ion	HSO_4^-	1.2×10^{-2}		
Hydrogen sulphide	H_2S	5.7×10^{-8}		
Hypobromous acid	$HBrO$	2.0×10^{-9}		
Hypochlorous acid	$HClO$	3.0×10^{-8}		
Hypoiodous acid	HIO	2.0×10^{-11}		
Lactic acid	$CH_3(OH)COOH$	1.4×10^{-4}		
Malonic acid	$CH_3(OH)COOH$	1.4×10^{-4}		
Malonic acid	$CH_2(COOH)_2$	1.5×10^{-3}	2.0×10^{-6}	
Nitrous acid	HNO_2	4.5×10^{-4}		
Oxalic acid	$(COOH)_2$	5.9×10^{-2}	6.4×10^{-5}	
Phenol	C_6H_5OH	1.3×10^{-10}		
Phosphoric acid	H_3PO_4	7.5×10^{-3}	6.2×10^{-8}	4.2×10^{-13}
Propionic acid	CH_3CH_2COOH	1.3×10^{-5}		
Sulphuric acid	H_2SO_4	strong acid	1.2×10^{-2}	
Sulphurous acid	H_2SO_3	$1.7 \times 1^{0-2}$	6.4×10^{-8}	
Tartaric acid	$(CHOHCOOH)_2$	1.0×10^{-3}	4.6×10^{-5}	

Top



Index


The Periodic Table
howstuffworks.com
1
H
hydrogen
1.007 94(7)
Atomic Number
Symbol
Name
Standard Atomic Weight
Metals
Non-metals
Alkali Metals
Alkali Earth Metals
Transition Metals
Lanthanoids
Actinoids
Metalloids
Halogens
Noble Gases
1 H hydrogen 1.007 94(7)
2 He helium 4.002 602(2)
3 Li lithium 6.941(2)
4 Be beryllium 9.012 182(3)
5 B boron 10.811(7)
6 C carbon 12.0107(8)
7 N nitrogen 14.0067(2)
8 O oxygen 15.9994(3)
9 F fluorine 18.998 4032(5)
10 Ne neon 20.1797(6)
11 Na sodium 22.989 769 28(2)
12 Mg magnesium 24.3050(6)
13 Al aluminium 26.981 538 6(8)
14 Si silicon 28.855(3)
15 P phosphorus 30.973 762(2)
16 S sulfur 32.065(5)
17 Cl chlorine 35.453(2)
18 Ar argon 39.948(1)
19 K potassium 39.0983(1)
20 Ca calcium 40.078(4)
21 Sc scandium 44.955 912(6)
22 Ti titanium 47.867(1)
23 V vanadium 50.9415(1)
24 Cr chromium 51.9961(6)
25 Mn manganese 54.938 045(5)
26 Fe iron 55.845(2)
27 Co cobalt 58.933 195(5)
28 Ni nickel 58.6934(2)
29 Cu copper 63.546(3)
30 Zn zinc 65.409(4)
31 Ga gallium 69.723(1)
32 Ge germanium 72.64(1)
33 As arsenic 74.921 60(2)
34 Se selenium 78.96(3)
35 Br bromine 79.904(1)
36 Kr krypton 83.798(2)
37 Rb rubidium 85.4678(3)
38 Sr strontium 87.62(1)
39 Y yttrium 88.905 85(2)
40 Zr zirconium 91.224(2)
41 Nb niobium 92.906 38(2)
42 Mo molybdenum 95.94(2)
43 Tc technetium [98]
44 Ru ruthenium 101.07(2)
45 Rh rhodium 102.905 50(2)
46 Pd palladium 106.42(1)
47 Ag silver 107.8682(2)
48 Cd cadmium 112.411(8)
49 In indium 114.818(3)
50 Sn tin 118.710(7)
51 Sb antimony 121.760(1)
52 Te tellurium 127.60(3)
53 I iodine 126.904 47(3)
54 Xe xenon 131.293(6)
55 Cs caesium 132.905 451 9(2)
56 Ba barium 137.327(7)
57-71 La-Lu lanthanoids
72 Hf hafnium 178.49(2)
73 Ta tantalum 180.947 88(2)
74 W tungsten 183.84(1)
75 Re rhenium 186.207(1)
76 Os osmium 190.23(3)
77 Ir iridium 192.217(3)
78 Pt platinum 195.084(9)
79 Au gold 196.966 569(4)
80 Hg mercury 200.59(2)
81 Tl thallium 204.3833(2)
82 Pb lead 207.2(1)
83 Bi bismuth 208.980 40(1)
84 Po polonium [209]
85 At astatine [210]
86 Rn radon [222]
87 Fr francium [223]
88 Ra radium [226]
89-103 Ac-Lr actinoids
104 Rf rutherfordium [261]
105 Db dubnium [262]
106 Sg seaborgium [266]
107 Bh bohrium [264]
108 Hs hassium [277]
109 Mt meitnerium [268]
110 Ds darmstadtium [271]
111 Rg roentgenium [272]
©2009 HowStuffWorks Source: International Union of Pure and Applied Chemistry
lanthanoids
57 La lanthanum 138.905 47(7)
58 Ce cerium 140.116(1)
59 Pr praseodymium 140.907 65(2)
60 Nd neodymium 144.242(3)
61 Pm promethium [145]
62 Sm samarium 150.36(2)
63 Eu europium 151.964(1)
64 Gd gadolinium 157.25(3)
65 Tb terbium 158.925 35(2)
66 Dy dysprosium 162.500(1)
67 Ho holmium 164.930 32(2)
68 Er erbium 167.259(3)
69 Tm thulium 168.934 21(2)
70 Yb ytterbium 173.04(3)
71 Lu lutetium 174.967(1)
actinoids
89 Ac actinium [227]
90 Th thorium 232.038 06(2)
91 Pa protactinium 231.035 88(2)
92 U uranium 238.028 91(3)
93 Np neptunium [237]
94 Pu plutonium [244]
95 Am americium [243]
96 Cm curium [247]
97 Bk berkelium [247]
98 Cf californium [251]
99 Es einsteinium [252]
100 Fm fermium [257]
101 Md mendelevium [258]
102 No nobelium [259]
103 Lr lawrencium [262]