GOVERNMENT OF KARNATAKA

# COMPUTER SCIENCE

## PRESCRIBED

## TEXT BOOK FOR FIRST PUC

**Department of Pre - University Education**
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# *Preface*

*A new syllabus is introduced at the pre-University level after a number of fruitful deliberations. We now go ahead to widen our knowledge and to see brighter things. Adapting to new requirements has always been a difficult task of our lives, however we will have to look at things with a positive attitude and take things with a challenging approach. The new syllabus will provide the same feeling. It is however important to see that we prepare our students to face this world with a positive attitude and equip them with the latest knowledge.*

*The book is organized in such a way that it is useful to the knowledgeable teacher and the ever-willing learner. It allows the teacher to prepare the student for greater learning. The students are further ignited to explore into the field so that they are the torchbearers of tomorrow. The field of computer science is such that it always provides a challenge for those who want to do better.*

*The vast experience of the authors has allowed them to prepare this material so that it meets the exact requirement of the student. Greater importance is provided to the presentation, this has always helped the students in easily understanding the subject. Importance is given to programming methodology so that the student learns the correct technique of programming. Good programming techniques rather than smaller programs have always generated efficient solutions to problems. Thought provoking questions are included at the end of each chapter this allows the student to further improve his abilities.*

*An effort of this nature is not possible without the blessings of number of people. The authors would thank them and pray to provide them the strength to always travel in the right direction. Suggestions for the improvement of the book are always awaited with open hearts.*

*AUTHORS*

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# BLUE PRINT

## *FIRST PUC – COMPUTER SCIENCE FINAL EXAMINATION*

*GUIDANCE FOR DISTRIBUTION OF MARKS INCLUDING CHOICE QUESTIONS*

| | | |
|---|---|---|
| **Knowledge** | **30%** | **31** |
| **Understanding** | **40%** | **43** |
| **Application** | **20%** | **21** |
| **Skill** | **10%** | **10** |
| **Total** | **100%** | **105** |

## Question Paper Structure

10 Questions of one mark without choice out of 10 (Very Short Answers) (VSA) PART A
05 Questions of two marks each out of 08 ( Short Answers) (SA) PART B
05 Questions of three marks each out of 08 (Long Answers) (LA) PART C
07 Questions of five marks each out of 11 (Essay Type) (E) PART D

| Unit | Description | VSA(1 Mark) | SA(2 Marks) | LA(3 Marks) | E(5Marks) | **Total Marks** |
|---|---|---|---|---|---|---|
| **A** | Fundamentals of Computers | 2 | 3 | 2 | 2 | **24** |
| **B** | Problem solving Methodology | 1 | 1 | 2 | 2 | **19** |
| **C** | Programming in C++ | 5 | 3 | 4 | 5 | **48** |
| **D** | Elementary Concepts of Word Processing, Spreadsheets and wed designing (Commands should not be included) | 2 | 1 | ------- | 2 | **14** |
| | **Total Marks** | **10** | **16** | **24** | **55** | **105** |
| | **Total No of Questions in Question paper** | **10** | **08** | **08** | **11** | **37** |
| | ***Total No of Questions to be answered*** | ***1X10=10*** | ***2X5=10*** | ***3X5=15*** | ***5X7=35*** | ***70*** |

BLUE PRINT SUBJECT : COMPUTER SCIENCE(41)

| Unit | Description | VSA (1 Mark) | SA (2 Marks) | LA (3 Marks) | E (5Marks) | Total Marks |
|---|---|---|---|---|---|---|
| ***A*** | ***Fundamentals of Computers*** | *2* | *3* | *3* | *2* | *27* |
| Ch1 | Overview of Computers | 1 | 1 | ---- | 1 | 08 |
| Ch2 | Input Output and Memory units | 1 | 1 | 1 | ------- | 06 |
| Ch3 | Data representation | ------ | ------ | 1 | 1 | 08 |
| Ch4 | Software Concepts | ------ | 1 | 1 | ------- | 05 |
| ***B*** Ch5 | ***Problem solving Methodology*** | *1* | *1* | *1* | *1* | *11* |
| ***C*** | ***Programming in C++*** | *5* | *3* | *4* | *5* | *48* |
| Ch6 | Object Oriented Concepts | ------ | 1 | ------- | ------ | 02 |
| Ch7 | Introduction to c++ | 1 | ------- | 1 | 1 | 09 |
| Ch8 | Data types | ------ | 1 | ------- | ------ | 02 |
| Ch9 | Input output operators | 1 | ----- | 1 | ------ | 04 |
| Ch10 | Control Statements | 1 | ------ | ------ | 2 | 11 |
| Ch11 | Arrays | 1 | | 1 | 1 | 09 |
| Ch12 | Functions (Library functions) | ----- | 1 | ------ | ------ | 02 |
| Ch13 | User defined Functions | 1 | ------ | ----- | 1 | 06 |
| Ch14 | Structures | | | 1 | | 03 |
| ***D*** | ***Elementary Concepts of Word Processing, Spreadsheets and wed designing (Commands should not be included)*** | *2* | *1* | *-----* | *3* | *19* |
| Ch15 | Word Processing | 1 | 1 | ------ | ------ | 03 |
| Ch16 | Spreadsheets | 1 | ------ | ------ | 2 | 11 |
| Ch17 | Web designing | ------ | ------ | ------ | 1 | 05 |
| | Total Marks | 10 | 16 | 24 | 55 | 105 |
| | *Total No of Questions to be answered* | *1X10=10* | *2X5/8=10* | *3X5/8=15* | *5X7/11=35* | *70/37* |

## I PUC - Computer Science

## Practical's Syllabus

## BLUE PRINT

**The practical examination marks of 20 is distributed as follows :**

| | | |
|---|---|---|
| 1. | Writing one program from **Section A** and one problem from either **Section B** or **Section C** | 8 marks |
| 2. | Execution of any one ( Examiner choice ) | 6 marks |
| 3. | Formatting the output | 2 marks |
| 4. | Record writing | 4 marks |
| | **TOTAL** | **20 marks** |

## Practical List

### Section A

**List of practical programs for C++**

1. Write a program to interchange the values of two variables
   a. Using a third variable.
   b. Without using a third variable.
2. Write a program to find the area and circumference of a circle.
3. Write a program to find the area of a triangle given three sides.
4. Write a program to convert days into years, months and days (**Hint:** Assume all months have 30 days)
5. Write a program to find the largest, smallest and second largest of three numbers using simple if statement.
6. Write a program to input the total amount in a bill, if the amount is greater than 1000 the a discount of 8% is given otherwise no discount is given, output the total amount, the discount amount and the final amount, use simple if statement.
7. Write a program to check whether a given year is a leap year or not using if-else statement.

8. Write a program to input a character and find out whether it is a lower case or upper case character using if-else statement.

9. Write a program to input the number of units of electricity consumed in a house and calculate the final amount using nested-if statement. Use the following data for calculation

| **Units Consumed** | **Cost** |
|---|---|
| < 30 | Rs 3.50 / unit |
| >=30 and <50 | Rs 4.25 / unit |
| >=50 and < 100 | Rs 5.25 / unit |
| >=100 | Rs 5.85 /unit |

10. Write a program to input the marks of four subjects, calculate the total percentage and output the result as either "First class", or "Second class", or "Pass class" or "Fails" using switch statement.

| **Class** | **Range %** |
|---|---|
| First Class | Between 60 and 100% |
| Second Class | Between 50 and 59% |
| Pass Class | Between 40 and 49% |
| Fails | Less than 40% |

11. Write a program to find the sum of all the digits of a number using while statement.

12. Write a program to input principal amount, rate of interest and time period and calculate compound interest using while statement

    (**Hint:** CI = P * ( 1 + R / 100) $^{T}$).

13. Write a program to check whether a given number is a power of 2.

14. Write a program to check whether a given number is an Armstrong number using do-while statement (**Hint:** 153 = $1^3$ + $5^3$+ $3^3$).

15. Write a program to find the factorial of a number using for statement.

16. Write a program to generate the Fibonacci sequence up to a limit using for statement.

17. Write a program to find the sum and average of "N" numbers.

18. Write a program to find the second largest of "N" numbers.

19. Write a program to arrange a list of numbers in ascending order.

20. Write a program to find the position of a given number in an array.

21. Write a program to check whether a given matrix is scalar or not.

22. Write a program to sum of all the rows and the sum of all the columns of a matrix separately.

23. Write a program to find the sum of two compatible matrices.

24. Consider an array MARKS[20][5] which stores the marks obtained by 20 students in 5 subjects. Now write a program to:

a) Find the average marks obtained in each subject
b) Find the average marks obtained by every student
c) Find the number of students who have scored below 50 in their average

25. Write a program to check whether a given string is a palindrome or not.

26. Write a program to count the number of vowels and consonants in a string.

27. Write a program to find the GCD and LCM of two numbers using functions.

28. Write a program to find $X^Y$ using functions.

29. An industrial organization wants to computerize the Allowance calculations. Given the monthly Sales for the salesman, the rules for the calculations are as follows:

i. If the total sales is less than Rs. 10000/- there is no allowance.
ii. If the total sales is between Rs. 10000/- and Rs. 20,000/- then the Allowance is 10% of the sales amount or Rs. 1800/- whichever is minimum.
iii. If the total sales is greater than or equal to Rs. 20000/- then the allowance is 20% of the sales amount or Rs.6,000/- whichever is minimum.

Write a program using a function to calculate the allowance.

30. Write a program to input the register number, name and class of all the students in a class into a structure and output the data in a tabular manner with proper heading

## Section B

**Spreadsheet Practical List**

1. Eight salesmen sell three products for a week. Using a spreadsheet create a sales report. The report should include the name of the salesman, Amount of sales for each product and the salesman's total sales in the format given below.

| **Sales for the Month** | | | | |
|---|---|---|---|---|
| **Name** | **Total Amt. for** | **Total Amt. for** | **Total Amt.** | **Total sales** |
| | | | | |
| | | | | |

a) Type in all text and numbers in the spreadsheet.
b) Format all numbers as a currency.

c) Center the spreadsheet headings across the spreadsheet.

d) Format all text.

e) Create formulas to display a total for each sales rep.

f) Create formulas to display a total for each product.

g) Create a formula to calculate the total sales for all sales rep's for the month.

2. Enter the following details for 10 employees Employee Code, Employee name, Basic salary, DA, HRA, Loans, Total salary and Tax.

| **Salary for the Month** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Employee Code** | **Employee Name** | **Basic Salary** | **DA** | **HRA** | **Loan** | **Total Salary** | **Tax** |
| | | | | | | | |
| | | | | | | | |

a) Type the Employee Code, Employee Name, Basic Salary and Loan amount data for 10 employees in the spreadsheet.

b) Format all numbers as a currency.

c) Center the spreadsheet headings across the spreadsheet.

d) Format all text.

e) Create a formula to compute DA as 50% of the Basic salary and copy this to all the cells.

f) Create a formula to compute HRA as 12% of the Basic salary and copy this to all the cells.

g) Create a formula to compute Total salary and copy this to all the cells.

h) If Total salary is greater than 5,00,000, compute Tax as 20% of Total salary otherwise 10% of the Total salary using a formula.

3. Enter the following details for 10 Students Register Number, Name, Subject1 Marks, Subject2 Marks, Subject3 Marks, Subject4 Marks, Total Marks and Percentage.

| **Test Marks data of a Class** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Register Number** | **Name** | **Subject1 Marks** | **Subject2 Marks** | **Subject3 Marks** | **Subject4 Marks** | **Total Marks** | **Percentage** |
| | | | | | | | |
| | | | | | | | |

a) Type the Register Number, Name and marks of four subjects for 10students in the spreadsheet.

b) Format all text and numeric data appropriately.

e) Create a formula to compute Percentage and copy this to all the cells.

f) Create a formula to compute the highest and lowest score using a library function.

g) Draw a bar graph for Register Number against total marks.

h) Draw Pie chart for one student showing his marks in different subject from total score

4. A housewife maintains the budget expenditure in a spreadsheet under the headings Income and Expenses. Income includes husband's and Wife's income separately under different headings. Expenses include Rent, Bills, Household expenses and medical expenses.

| **Budget for the Month** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Income** | | | | **Expenses** | | **Total** | |
| **Husband** | **Wife** | **Rent** | **Bill** | **Household** | **Medical** | **Expenditure** | **Savings** |
| | | | | | | | |
| | | | | | | | |

a) Type the Income and Expenses data for the entire month in the spreadsheet.

b) Format all numbers as currency.

c) Center the spreadsheet headings across the spreadsheet.

d) Create a formula to compute the Total expenditure and copy this to all the cells.

e) Create a formula to compute the savings and copy this to all the cells.

f) Draw a bar graph to show expenditure under each heading.

g) Draw Pie chart to show the distribution of salary.

5. A Bank offers loan for housing and vehicle at an interest of 10.25% for housing and 14.2% for vehicle. For a loan applicants compute the monthly premium (EMI), given total installments as 24 months. Also compute the monthly interest and monthly principal amount and the total amount of principal and Interest paid using Financial library functions in a spreadsheet.

6. Implement five functions each for Arithmetic, Date and Time, Financial, Logical, text and statistical functions. Write the syntax, example and output for simple problems.

7. Create a data form to implement a student database and perform all related operations with the data form.

## Section C

### Web Designing Practical List

1. Create a Web page to display your details using different tags.
2. Create a model Web site for your college making using different tags.

# PRACTICAL EXAMINATION

## General instructions:

- *Duration of practical examination: 2 hours.*
- *Maximum marks allotted: 30 marks.*
- *The practical examination question paper should consists of two questions for writing (One program from C++ and One problem from either ESS or HTML )*
- *Each question carries 6 marks of writing ie 2X6=12 Marks.*
- *Only one experiment to be executed.*
- *Execution process carries 6(six ) marks.*
- *Generating the correct output for the executed problem carries two marks.*

### A. Weightage of marks

| Sl. No. | Particulars | Marks |
|---|---|---|
| I | Performing the Experiments | 20 |
| II | Viva -voce | 04 |
| III | Practical Record | 06 |
| | **TOTAL** | **30** |

### B. Distribution of marks

*I. Performing the Experiment*

*a) PROGRAMS ON C++*

| Sl. No. | Particulars | Marks |
|---|---|---|
| 1 | Including the necessary headers: | 1 |
| 2 | Declaration of correct identifiers | 1 |
| 3 | Input/Inputs commands | 1 |
| 4 | Logic | 2 |
| 5 | Output/Outputs commands | 1 |
| | Total | 6 |

### b) *PROBLEM on ESS*

| Sl. No. | Particulars | Marks |
|---|---|---|
| 1 | Including the necessary headers in ESS sheet : | 1 |
| 2 | Data entry | 1 |
| 3 | Using the correct Formula | 2 |
| 4 | Generating the correct output may include Graphs | 2 |
| | Total | 6 |

### c) *PROBLEM on HTML*

| Sl. No. | Particulars | Marks |
|---|---|---|
| 1 | Including the necessary basic tags of the HTML | 1 |
| 2 | Including the necessary basic tags of the Head & Title | 1 |
| 3 | Including the necessary basic tags of the Body | 1 |
| 4 | Including any other relevant tags | 3 |
| | Total | 6 |

***II. Viva- voce***

1. Four questions must be asked and each question carries 1 mark.
2. The questions in the *viva- voce* should be simple, direct and related to the experiment to be performed by the student.

***III. Practical Record***

| Sl. No. | Particulars | Marks |
|---|---|---|
| 1 | If the student has performed and recorded 27 programs or more 91% to 100% of the experiments prescribed for the practical examination or more. ) | 6 |
| 2 | If the student has performed and recorded 24 programs and below 27 programs (81% to 90% of the experiments prescribed for the practical examination.) | 5 |
| 3 | If the student has performed and recorded 21 programs and below 24 programs (71% to 80% of the experiments prescribed for the practical examination.) | 4 |
| 4 | If the student has performed and recorded below 21 and above 11 experiments (41% to 70% of the experiments prescribed for the practical examination) | 3 |
| 5 | If the student has performed and recorded below 10 or below 10 experiments (40% and below40% of the experiments prescribed for the practical examination) | 0 |

***NOTE : At least 30 experiments (21from C plus plus +7 from ESS +2 from HTML ) experiments have to be conducted in the Practical classes.***

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# CHAPTER 1

# FUNDAMENTALS OF COMPUTERS

## OBJECTIVES

- To Understand components
- History
- Generations of Computers

## 1.1 Introduction

Computers were invented to be an aid to the mankind in the field of calculations, the versatility of present day computers are giving rise to the modern society in the field of **information** and **technology**.

Computers are changing, the very being/area of communication, transport, trafficking, industry, government, education, medicine, scientific research, law, social service and even arts like music, movies, paintings, gaming or any filed which involves data and information.

Computers are becoming the bondage of reality in meeting the desires of communication and exploration of information. The distance of the world is sinking with the utilization of the computers with the help of email, chatting, online banking, booking tickets, audio, video etc.

Computer literates are well placed in the modern society in the field of career opportunities, workforce. The professionals can attain greater opportunity with the help of computers.

The application of computers is wide and expandable, without limitation of time and place.

This chapter will explain the evolution of computers, personalities who have involved in the field of computer, along with the functional units of the computer systems.

### 1.1.1 Definition

Computer is an automatic electronic machine that can store, recall and process data. Computers are electronic machines that perform tasks or complex calculations according to a set of instructions or **programs**.


Figure 1.1 COMPUTER SYSTEM

What can you do with computers? In the workplace, many people use computers to keep records, analyze data, do research, and manage projects. At home, you can use computers to find information, store pictures and music, track finances, play games, and communicate with others and these are just a few of the possibilities. A computer is used essentially as a data processor.

How does the computer work? Let's consider, your mother is asking you to prepare tea. The ingredients required may be ¾ cup of water, ½ teaspoon tealeaves, ½ teaspoon sugar and ½ cup of milk. You have to follow certain definite steps to prepare tea like boiling water/milk, adding tea-leaves, sugar and milk. Finally, you have prepared tea.

This Human being task/activity can be transformed into a computer environment in the following:

| | INPUT | PROCESS | OUTPUT |
|---|---|---|---|
| | **Ingredients required** | **The actual process** | **The result** |
| Preparation of tea | ¾ cup of water, ½ teaspoon tealeaves, ½ teaspoon sugar and ½ cup of milk. | Boiling water/milk, adding tea-leaves, sugar and milk | Obtain the prepared tea. |

### 1.1.2 Characteristics of Computers

#### i. Speed

The ability to get answers fast enough so that one has time to take action.

Electrical pulses travel at incredible speeds, because the computer is an electronic machine, its internal speed is virtually instantaneous. We do not talk in terms of seconds or even milliseconds. Our units of speed are the microsecond (millionths), the nanosecond (thousand- millionths) and latterly even the Picosecond (million-millionths). A powerful computer is capable of adding together two 18-digit number in 300 to 400 nanoseconds, even the non-numerical environments. The indexing of the complete students name in the college will consume less time with the help of computer.

#### ii. Memory

As a human acquires new knowledge, the brain subconsciously selects what it feels to be important and worth retaining in its memory, and relegates unimportant details to the back of the mind or just forgets them. Similarly in computers, the primary memory RAM is used to store the data temporarily.

#### iii. Storage

After processing, the data and information must be stored in the secondary storage device, so that the data or information can be used later. The data and information can be stored permanently in secondary storage devices (or auxiliary storage).

The computer memory is measured using BITS and Bytes.

#### iv. Accuracy

The computer generated results are exact and without any mistakes with high rate of consistency.

**v. Versatility**

Computers seem capable of performing almost any task, provided that the task can be reduced to series of logical steps.

**vi. Automation**

A computer is much more than an adding machine, calculator or check-in/out system, all of which require human operators to press the necessary keys for the operations to be performed. Once a program is in the computer's memory, the individual instructions are then transferred, one after the other, to the control unit for execution. The processor/CPU follows these instructions until it meets a last instruction which says stop program execution.

**vii. Diligence**

Being a machine, a computer does not suffer from the human traits of tiredness and lack of concentration. For example, if 3 million calculations have to be performed, it will perform the 3 millionth with exactly the same accuracy and speed as the first.

**viii. Cost effectiveness**

Computers reduce the amount of paper work and human effort, thereby reducing costs.

### 1.1.3 Data and Information

The term data and information are common terminology in the field of computers. Computers process data into information.

**Data** is collection of unprocessed items, which can include text, numbers, images, audio and video. We can also define data as collection of raw facts, figures, statistics which requires to be processed.

For example, "PARAM" 16.

The computer processed data is called the information, which conveys meaning and is useful to people to take future decisions on the information.

For example, Name = "PARAM" AGE=16.

- Computers work through an interaction between hardware and software.
- The machine parts (physical parts) of the computer is called as hardware.
- The programs that tell computer what to do, how to do etc. is called as software.

**Hardware** refers to the parts of a computer that you can see and touch (physical components) including the case and everything inside it. This part translates instructions and performs calculations.

Hardware items such as monitor, keyboard, mouse, printer, and other items are often called **hardware devices**, or **devices.**


Figure 1.2 **HARDWARE COMPONENTS**

Common computer hardware components include a keyboard, mouse, microphone, scanner, Web cam, printer, monitor, speakers, system unit, hard disk drive, external hard disk, optical disc drive(s), USB flash drive, card reader/writer, memory cards, and modem.

### Software

Software refers to the instructions, or programs, that tell the hardware what to do.

The two categories of software are **system software** and **application software**.

**1. System software** consists of the programs that control or maintain the operations of the computer and its devices. System software serves as the interface between the user, the application software, and the computer's hardware.

**2. Application software** consists of programs designed to make users more productive and/or assist them with personal tasks.

## 1.2 Functional components of a computer (working of each unit)

Basically any computer is supposed to carry out the following functions.

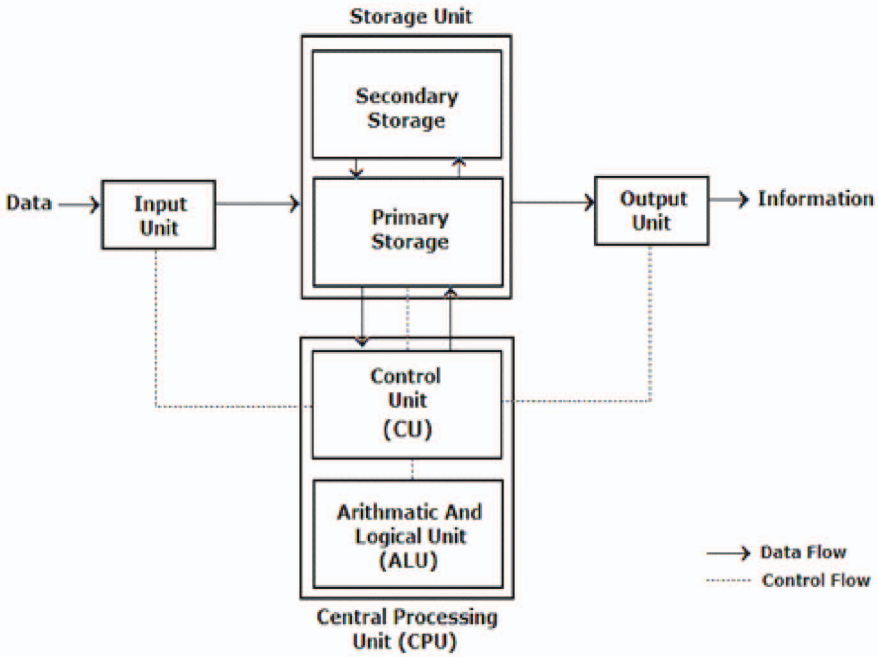
- Accept the data and program as input
- Store the data, program and retrieve as and when required.
- Process the data as per instructions given by the program and convert it into useful information
- Communicate the information as output

Based on the functionalities of the computer, the hardware components can be classified into four main units, namely input unit, processing unit, output unit, memory unit.

These units are interconnected by minute electrical wires to permit communication between them. This allows the computer to function as a system.

## Input Devices

An **input device** is any hardware component that allows you to enter data and instructions into a computer. Some of the widely used input devices are the keyboard, mouse, microphone, scanner, and Webcam.




## Central Processing Unit

**CPU** is the part of the computer that carries out the instructions of a computer program. It is the unit that reads and executes program instructions. Hence it is known as the brain of the computer. It takes all major decisions, makes all sorts of calculations and directs different parts of the computer function by activating and controlling the operation. It consists of arithmetic and logic units, control unit and internal memory (registers). The CPU controls and coordinates all the actions of the entire system. Programs (software) provide the CPU, a set of instructions to follow and perform a specific task and communicate between two or more components of the computer system. There is a pathway called as **bus** which allows the data transfer between them. The CPU consists of storage or memory unit, Arithmetic Logic Unit (ALU) and control unit.

a. **Memory Unit:** Memory unit is also known as the primary storage or main memory(RAM). It stores data, program instructions, internal results and final output temporarily before it is sent to an appropriate output device. It consists of thousands of cells called storage locations. These cells activate with off-on or binary digits(0,1) mechanism. These bits are used to store instructions and data by their combinations. The main memory holds data and program only

temporarily(volatile-data/information will be lost when power off). Hence there is a need for storage devices to provide backup storage.

b. **Arithmetic and Logical Unit(ALU):** ALU is the unit where all Arithmetic operations (addition, subtraction, multiplication, division etc.) and logical functions such as AND, OR NOT are performed. Non-numeric data results in true or false along with logical functions. Once data are fed into the main memory from input devices, they are held and transferred as needed to ALU where processing takes place. No process occurs in primary storage. Intermediately generated results in ALU are temporarily placed in memory until needed at later time. Data may move from primary memory to ALU and back again to storage many times before the process is finalized.

c. **Control Unit:** It acts as a central nervous system and ensures that the information is stored correctly and the program instructions are followed in proper sequence as well as the data are selected from the memory as necessary. It also coordinates all the input and output devices of a system. Control unit controls all the hardware operations i.e., those of input units, output units, memory unit and the processor.

### Storage Unit

Results obtained after processing will be in the primary memory, these data or information can be stored in the storage device/secondary memory units. Secondary storage devices are called as auxiliary memory devices. Secondary storage devices can hold more storage data than main memory and is less expensive. This result or information can be copies to any storage medium and used in future.

### Output Unit

An **output device** is any hardware component that conveys information to one or more people.in user understandable form. Commonly used output devices are printer, monitor and speakers.

## 1.3 Evolution of Computers

Evolution of man and mankind has helped to invent a calculating tool. Early man used stones, sticks, fingers, pebbles and cowries to count. Even today we calculate using our fingers. The limitations of the ten fingers and ten toes apparently caused early man to construct a tool for calculations .Every civilization have contributed calculating tool in their own methods/design. Mechanical counting devices were made.

## 2500 BC – The Abacus

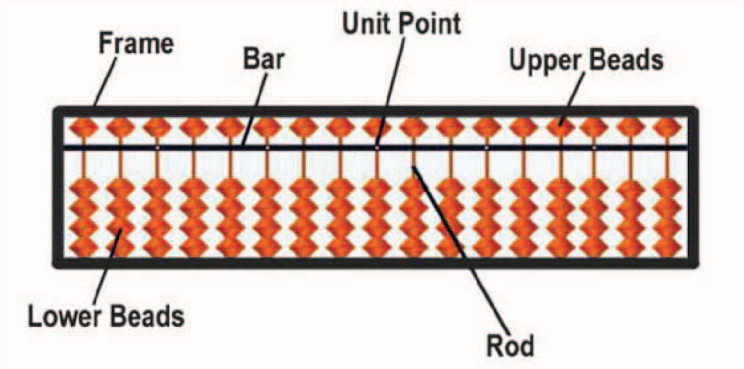



Figure 1.4 Abacus

Abacus is the first known calculating machine used for counting. It is made of beads strung on cords and is used for simple arithmetic calculations. The cords correspond to positions of decimal digits. The beads represent digits. Numbers are represented by beads close to the crossbar (heaven and earth), Abacus was mainly used for addition, subtraction and later for division and multiplication. The reason for studying about abacus is, even today the complex calculations which are performed by advanced computers are calculated using abacus.

## 1614 AD – Napier's bones

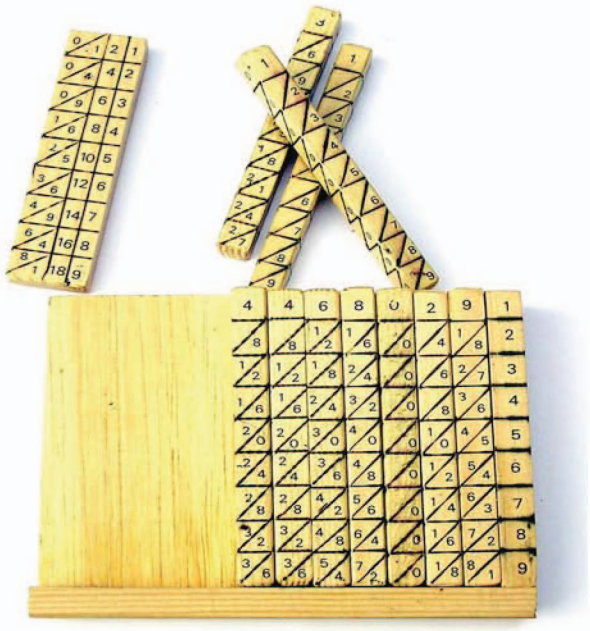


Figure1.5 Napier's bones

The Napier's bones was invented by John Napier, a Scottish mathematician as an aid to multiplication. A set of bones consisted of nine rods, one for each digit 1 through 9 and a constant rod for the digit '0'. A rod is similar to one column of a multiplication table.

### 1633 AD – The Slide Rule

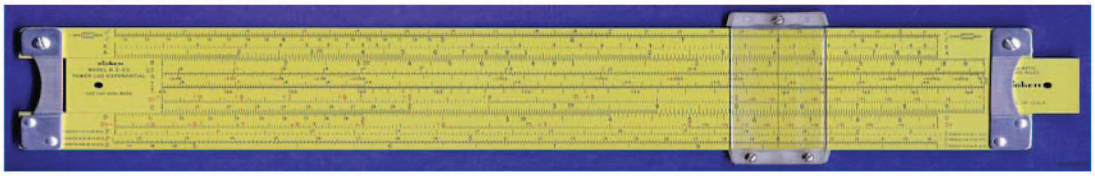


Figure 1.6 Slide Rule

The Slide Rule was invented by William Oughtred. It is based on the principle that actual distance from the starting point of the rule is directly proportional to the logarithm of the numbers printed on the rule. The slide rule is embodied by the two sets of scales that are joined together, with a marginal space between them. The suitable alliance of two scales enabled the slide rule to perform multiplication and division by a method of addition and subtraction.

### 1642 AD – Adding Machine-Pascaline

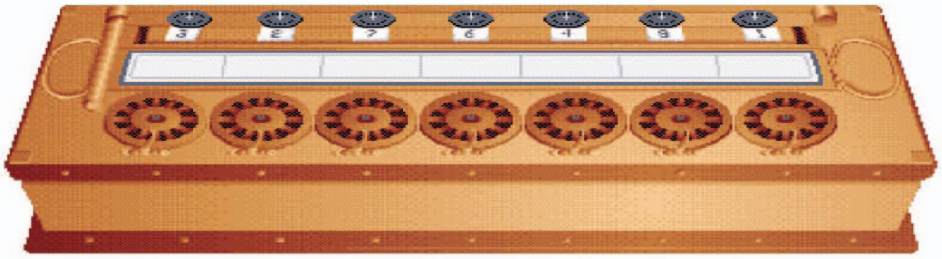


Figure1.7 Adding machine

The Rotating Wheel Calculator was developed by a French philosopher, Blaise Pascal invented the first mechanical calculator in 1641. It was named Pascaline. It had a box with eight movable wheels called dials. The numbers for calculations were entered with dials. It could add, subtract, divide and multiply the numbers as big as thousands. It was using simple components such as gears and levers. This is a predecessor to today's electronic calculator. He was inspired by the computation work of his father's job and devised the model. He was only 19 years old, when he devised this model.

### Leibniz Calculator

Mathematician Gottfried Leibniz built a calculator in 1650 that could add, subtract, multiply and divide the numbers.

Figure1.8 Rotating wheel calculator

## 1801- Jacquard's Loom

In 1801, Joseph Mary Jacquard invented a powered loom that used punched wooden cards to automatically weave incredibly detailed patterns including pictures and text. This can be taken as the first "**read only memory**" device.

Figure 1.9 Power loom calculator

## 1822 –Charles Babbage: The Difference Engine

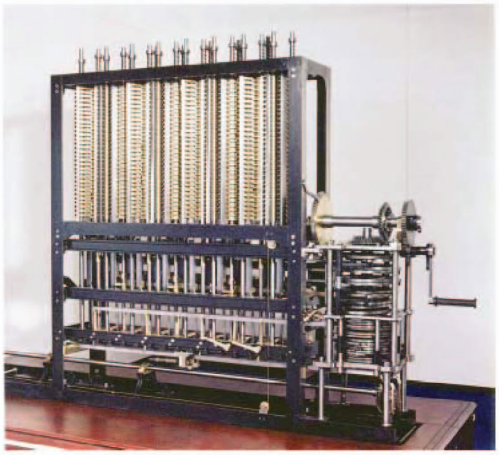


Figure 1.10 Difference Engine

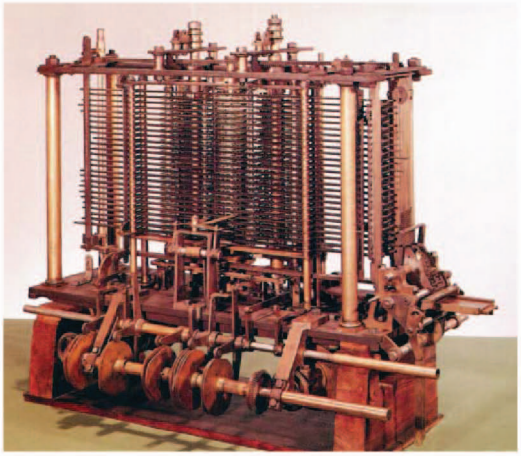


Figure 1.11 The Analytical Engine

Charles Babbage, British mathematician and engineer, designed an automatic calculating machine in 1822. He called it a Difference Engine. Later he thought of a mechanical construction which was known as a mechanical-digital computer. Babbage called this Analytical engine. This analytical engine consisted five units, which became the basic principles for the development of modern computer. Hence Charles Babbage is rightly called the "**Father of Computers**".

### 1833-First Programmer

Figure 1.12 Lady Ada Lovelace

Lady Ada Lovelace, her mathematical genius came to light most strikingly in her work with Charles Babbage. Babbage was pathway into the process of designing the first mechanical computer ("Analytical Engine"). She started writing the first computer algorithm, and she predicted that later computers' will have the abilities to do more than mathematical calculations. Lovelace realized that the Analytical Engine was in essence, a machine for manipulating symbols and music notations .Ada called herself ("an Analyst & Metaphysician),"

Lady Ada Lovelace is the first programmer.

### 1890 AD - Hollerith Tabulating Machine

Fig. 1.13 Hollerith Tabulating Machine

In 1889, an American named Herman Hollerith invented a counting machine to count the population of USA. This electronic machine is able to read the information on the punched cards and process it electronically. It was one of the main electronic counting devices. It was based on punch cards. Herman Hollerith was the founder of the company that became famous as IBM.

## 1.4 Generations of Computers

The evolution of electronic computers, over a period of time can be traced effectively by dividing this period into various generations. Each generation is characterized by a major technological development

that fundamentally, changed the way computers operated. These helped to develop smaller, economical , powerful, efficient and reliable devices.

## First Generation - 1940-1956: Vacuum Tubes

Figure 1.14 Vacuum Tube

The first generation of computers used vacuum tubes for switching circuits and magnetic drums for memory. They were large in size, occupied a lot of space and produced enormous amount of heat. They were very expensive to operate and consumed large amount of electricity. Most of the times the heat generated caused the computer to malfunction. First generation computers operated only on machine language. Input was based on punched cards, paper tapes and output was obtained as print out. First generation computers could solve only one problem at a time.

In America, with the success of Aiken's, Harvard Mark-I as the first major American development in the computing race, work was proceeding on the next great break through by the Americans. Their second contribution was the development of the giant ENIAC machine by John W Mauchly and J Presper Eckert at the University of Pennsylvania.

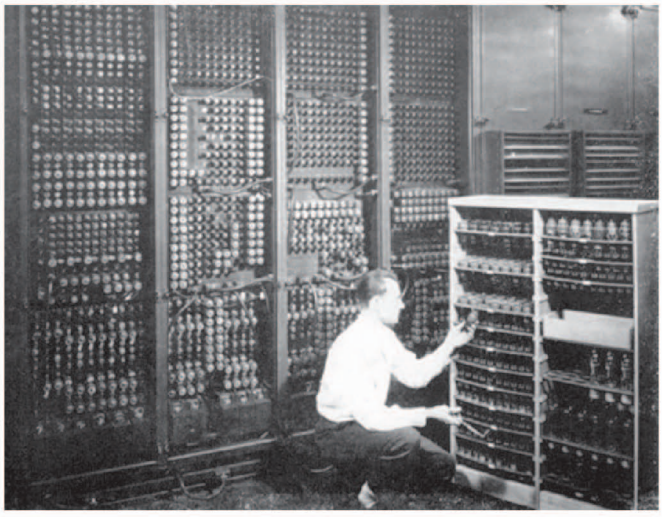


Figure1.15 ENIAC

**ENIAC** (Electrical Numerical Integrator and Computer) used a word of 10 decimal digits instead of binary ones like previous automated calculators/computers. ENIAC also was the first machine to use more than 2,000 vacuum tubes, using nearly 18,000 kms of wires. Space for all those vacuum tubes and the machinery required to be keep cool and occupied up more than 167 square meters of floor space. Nonetheless, it had punched-card input and output and arithmetically had 1 multiplier, 1 divider-square rooter, and 20 adders employing decimal "ring counters", which served as adders and also as quick-access (0.0002 seconds) read-write register storage.

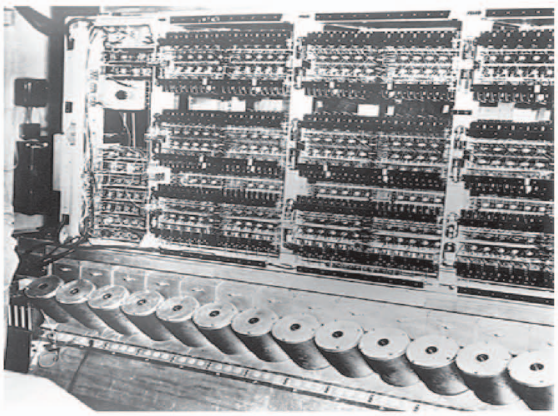


Figure1.16 EDVAC

**EDVAC** (Electronic Discrete Variable Automatic Computer) was to be a vast improvement upon ENIAC. Mauchly and Eckert started working on it two years before ENIAC even went into operation. Their idea was to have the program for the computer stored inside the computer. This would be possible because EDVAC was going to have more internal memory than any other computing device to date. Memory was to be provided through the use of mercury delay lines. The idea being that given a tube of mercury, an electronic pulse could be bounced back and forth to be retrieved at will another two state device for storing 0's and 1's. This on/off switch ability for the memory was required because EDVAC was to use binary rather than decimal numbers, thus simplifying the construction of the arithmetic units.

UNIVAC (**UNIV**ersal **A**utomatic **C**omputer) was the first commercial computer produced in the United States.

## Second Generation - 1956-1963: Transistors

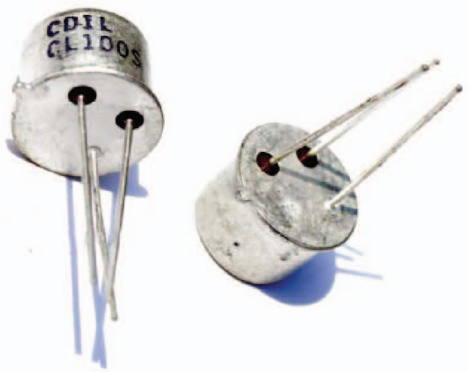


Figure1.17 Transistor

The second generation of computers witnessed the vacuum tubes being replaced by transistors. The transistor was far superior to the vacuum tube, allowing computers to become smaller, faster, economical energy-efficient and more reliable than their first-generation computers. The transistors also generated considerable heat that sometimes caused the computer to malfunction. But it was a vast improvement over the vacuum tube. Second-generation computers used punched cards for input and printouts for output.

Second-generation computers moved from the use of machine language to assembly languages, which allowed programmers to specify instructions in words. High-level programming languages were also being developed at this time, such as early versions of COBOL and FORTRAN. The computers stored their instructions in their memory, which moved from a magnetic drum to magnetic core technology.

## Third Generation - 1964-1971: Integrated Circuits

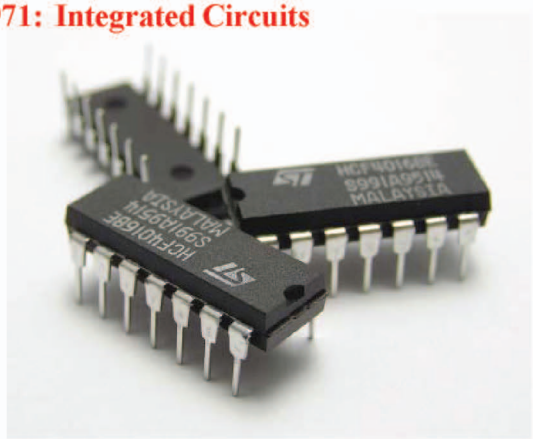


Figure1.18 Integrated Circuit

The development of the integrated circuit(IC's) left its mark in the third generation of computers. **Transistors were made smaller in size and placed into silicon chips**, which dramatically increased the speed and efficiency of computers. In this generation, keyboards and monitors were used instead of punched cards and printouts. The computers were interfaced with an operating system which allowed to solve many problems at a time. Some of the LSIC's and VLSIC's were used.

## Fourth Generation - 1971-Present: Microprocessors


Figure 1.19 Microprocessor

The microprocessor brought forth the fourth generation of computers, as thousands of integrated circuits were built onto a single silicon chip. As these small computers became more powerful, they could be linked together to form networks, which eventually led to the development of the Internet.

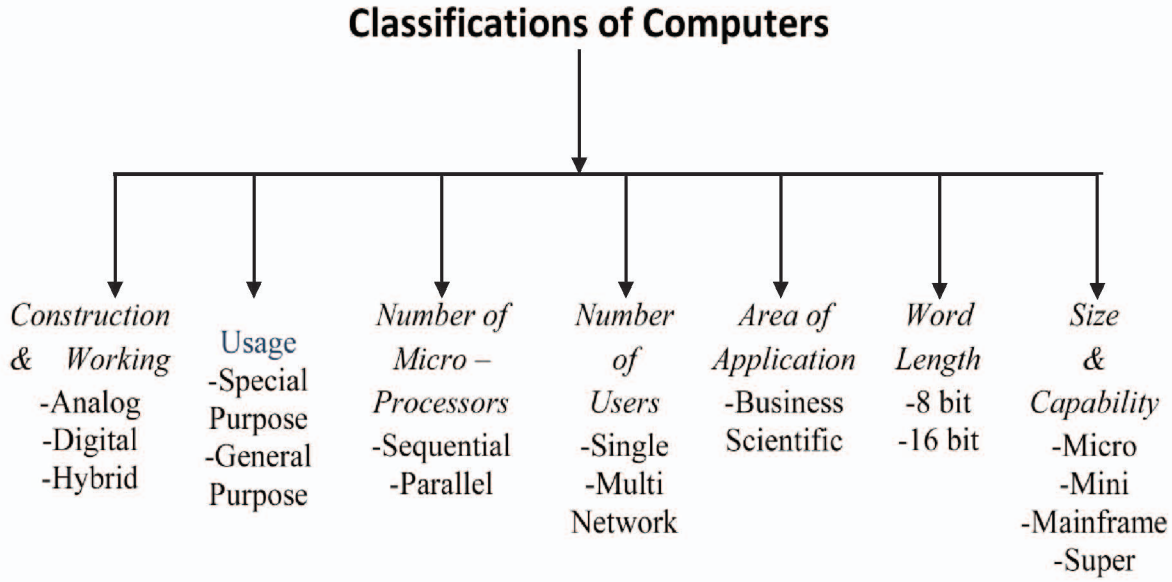
## Fifth Generation - Present and Beyond: Artificial Intelligence (ROBOTICS)

Figure1.20 Robotics

Fifth generation computing devices, based on artificial intelligence, are still in their developmental stage. Fifth generation computers will come close to bridge the gap between computing and thinking.

## 1.5 Classifications of Computers

Classification of the electronic computers may be based on either their principles of operation or their configuration, by configuration; we mean the size, speed of doing computation and storage capacity of a computer.




### 1.5.1 Classification based on Principles of Operation

Based on the principles of data handling, computers are classified analog, digital or hybrid.

Analog Computer is a computing device that works on continuous range of values, with a minimum value and maximum value. At a given point of time any value can be attained which is dependent on the pervious value .The analog computers give **approximate results** since they deal with quantities that vary continuously. To represent an analog graph there must be two quantities.

Digital computers are those that operate with information, numerical or otherwise, represented in a digital form. Such computers process data into a digital value (in 0s and 1s). They give the results with more accuracy and at a faster rate.

Hybrid computers incorporate the measuring feature of an analog computer and counting feature of a digital computer. For computational purposes, these computers use analog components and for storage, digital memories are used.

## Analog Computers

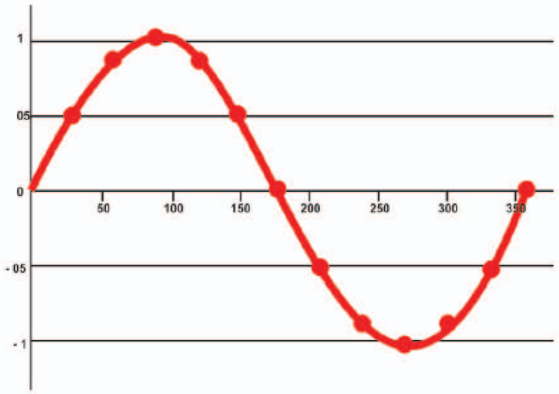



Figure1.21 Analog Graph with two parameters time and temperature

Analog computers work on the principle of measuring, in which the measurements obtained are translated into data rather than counting. The analog computers are that all calculations take place in parallel, hence faster. Modern analog computers usually employ electrical parameters, such as voltages, resistances or currents, to represent the quantities being manipulated. Such computers do not deal directly with the numbers. They measure continuous physical magnitudes. It generally deals with physical variables such as voltage, pressure, temperature, speed etc.,

## Digital Computers

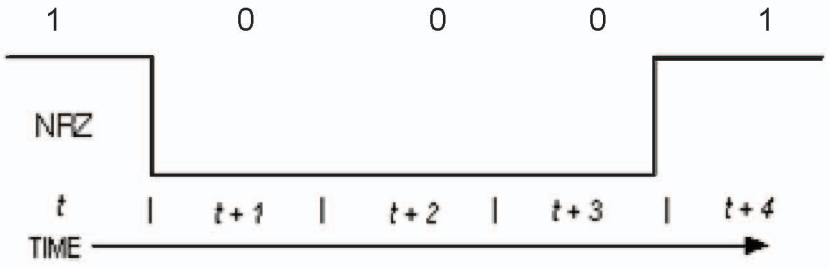



Figure1.22 Digital Graph with 0's and 1's

Digital computers are those that operate with information, numerical or otherwise, represented in a digital form. Such computers process data into a digital value (in 0s and 1s). They give the results with accuracy and at a faster rate, On the other hand a digital computer operates on digital data such as numbers. It uses binary number system in which there are only two digits 0 and 1. Each one is called a bit. All the data representation will be in the series of 0's and 1's. Not dependent of time of other values. Digital computers are unique. The digital computer is made for both general purpose and special purpose. Special purpose computer is one that is built for a specific application.

General purpose computers are used for any type of applications. It can store different programs and do the jobs as per the instructions specified on those programs. Most of the computers used are digital computers.

### Hybrid Computer (Analog + Digital)

A combination of computers those are capable of accepting inputs and outputs in both digital and analog signals. A hybrid computer system setup offers a cost effective method of performing complex simulations.

A hybrid computing system is a combination of desirable features of analog and digital computers. It is mostly used for automatic operations of complicated physical processes and machines. Now-a-days analog-to-digital and digital-to-analog converters are used for transforming the data into suitable form for either type of computation.

For example, in hospital's automated intensive care unit, analog devices might measure the patient's temperature, blood pressure and other vital signs. These measurements which are in analog might then be converted into numbers and supplied to digital components in the system. These components are used to monitor the patient's vital sign and send signals if any abnormal readings are detected. Hybrid computers are mainly used for specialized tasks.

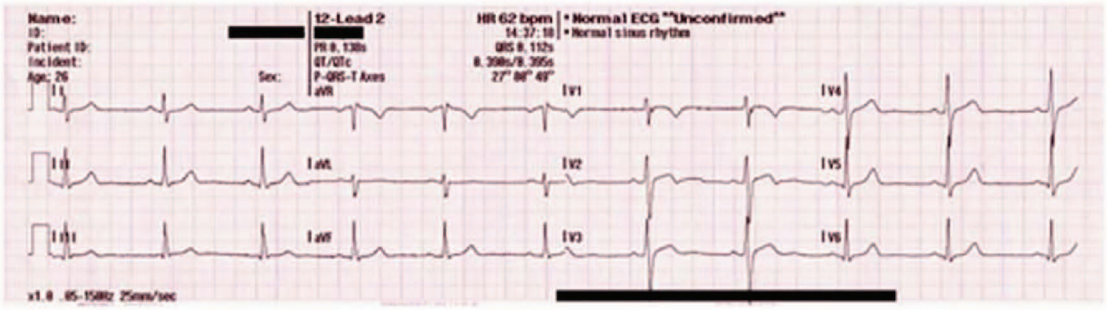



Figure1.23 Hybrid with Analog and Digital signal ECG of a person

### 1.5.2 Classification of Computers based on Configuration

Based on performance, size, cost and capacity, the digital computers are classified into four different types: Microprocessor, Minicomputer, Mainframe computer and Super computers.

#### 1.5.2.1 Micro Computers

**Fig. 1.24** Desktop Model computer

Micro computer is also called personal computer. It was introduced in 1970. The number of processors in microcomputers will be one or two processors. It contains input devices, output device, storage device, memory and processor. It is used by one person at a time. Examples of personal computers are PC and Apple Macintosh. The major types of personal computers are desktop computer and portable computer.

## Desktop computers

These computers can easily fit on a table or desktop, hence the name. These computers come in two models or casings. In Desktop model, the system unit is placed on the desktop or table. Monitor is placed on the system unit. In Tower model, both monitor and system unit are placed on the table.

Figure 1.25Tower Model computer

## Portable Computers

Portable is a personal computer that can be carried from one place to other easily. Notebook computer and handheld computer (smart phone) are examples of portable computers. Notebook computer is also called laptop computer. Laptop computers are very small in size and can be placed easily on lap.

Figure 1.26 Lap top computer or notebook computer

### Hand held computer

Figure. 1.27Hand held computer

Handheld Computers (like smart phone) are also portable. Handheld computer is also known as palmtop computer. It easily fits in the hand of the user.

**Uses of Micro Computer** The PC is the most common type of computer used in the office. It is now widely used in many homes. These are also used for business and engineering application.

### 1.5.2.2. Mini Computers

Mini computers were introduced in the 1960s. Minicomputer is larger and more powerful computer than personal computer. It can execute five million instructions per second. It generally consists of two or more processors.

Figure1.28Mini Computers

Mini computer can serve up to 4000 connected users simultaneously. It is normally accessed by users via personal computer or terminal. A device with a monitor and keyboard is called terminal. It is also known as dumb terminal. It has no processing power and cannot work as stand-alone computer. Examples of mini computers are: VAX-8800, AS 400.

### Uses of Mini Computers:

Mini computers are often used by small and medium-sized companies to provide centralized store of information.

## 1.5.2.3. Mainframe Computers

Mainframe computers were introduced in 1975. A mainframe computer is a very large computer in size. It is more powerful than minicomputer. It consists of multiple processors. It is designed to perform multiple tasks for multiple users at the same time. Mainframe computers can serve up to 50,000 users at the same time.

**Fig. 1.29** Mainframe Computers

The users access a mainframe computer through terminal or personal computer. A typical main frame computer can execute 16 million instructions per second. Examples of mainframe computers are NEC610, DEC 10.

### Uses of Mainframe Computers

Mainframe computers are used in large organizations. For example, airlines use these computers for ticket reservation system. IBM's offering z-series mainframe. The server-dominated have presented its own challenges of cost, complexity and security. Indian companies are looking for a more responsive and dynamic environment and mainframe are increasingly being considered. This company machines are used by RBI, HDFC, TCS, HCL, Wipro, NSDL are come of clients. Clients face rising energy and cooling cost, limited floor space and manpower concerns required to man servers. NADRA - The Computerized National Identity Card Issuer in Pakistan - uses mainframe computers to maintain the information of population.

### 1.5.3.4. Super Computers

**Made in India Super Computers**


Figure 1.30 Super computer

Super computers were introduced in 1980s. Super computer is the fastest computer. Super computer is the biggest in size and the most expensive in price than any other computers.

Tata's **Eka** supercomputer in Pune's **Computational Research Laboratories** (CRL) remains the fastest Indian supercomputer, its top performance of 132.8 teraflops remaining unchanged. However, shifting goal posts in high performance computing technology sees the Eka slip from no. 18 to no. 26 in the list.

The government-run **Centre For Development of Advanced Computing** (C-DAC) also headquartered in Pune, sees its **Param Figure 1.30. Super c**omputers **Yuva** machine at no. 137 in the latest ratings announced November 17. Its speed is in fact a bit faster than before — 38.1 teraflops — but its rank is now 137, down from 109 in June.

Super computer is the most sophisticated, complex and advanced computer. It has a very large storage capacity. It can process trillions of instructions in one second. Super Computer is the fastest and most powerful computer of a time. Super computers are very expensive. Super computers are used for highly calculation intensive tasks. Super computers are used for specialized applications that require immense amounts of mathematical calculations. Super computers were designed primarily by computer scientist - **Seymour Cray at Control Data Corporation** (CDC).

Uses of Super Computers include:

1. Weather forecasting
2. Animated graphics like in Hollywood movies
3. Fluid dynamic calculations
4. Nuclear energy research
5. Space science
6. Weapon and missile design
7. Petroleum exploration etc.

Today, supercomputers are produced by traditional companies such as Cray, IBM and Hewlett-Packard, who had purchased many of the 1980s companies to gain their experience. Since October 2010, the Tianhe-1A super computer has been the fastest in the world; it is located in China.

The main difference between a Supercomputer and a mainframe is that a Supercomputer channels all its power into executing a single program as fast as possible, whereas a mainframe uses its power to execute many programs concurrently. The modern super computer consists of thousands of microprocessors. Super computer uses high-speed facilities such as satellite for online processing. Examples of Super computers are CRAY-XP, ETA-10, and Deep Blue and above all today's number one super computer is Tianhe-1A supercomputer of China. Aircraft companies use super computer to simulate aircraft and check its performance. Computers differ based on their data processing abilities. They are classified according to purpose, data handling and functionality.

## 1.6 Applications of computers

The uses of computers can be classified into the area of usage.

**Schools and colleges**: Computers are implemented in the schools for the creation of school ID card, (some schools have smart card with the IC's embedded) which contains the details of the student. The creation of marks card, attendance, learning the subject with audio and video and fees collection so on are the few examples.

**Banks** : The computers are used in the creation of account in the bank, transactions, transfer of funds, alert messages, transaction messages, used of banking with ATM (Automatic Teller Machine) card which can be accessed any part of the globe, Online banking etc.

**Office**: Used in documentation of the transactions, events that are carried out every day along with the money, funds transactions, payroll for all the events either in the form of letters or specific application software are used, payroll for employee, audit etc.,

**Stock control in business firms:** Computers are used in the shops and business for the stock account of the movements of the items in business and the money transactions along with the shipping of the items with the quantity price and quality expiry date ,the tracing of the product at any given point of time etc.,

**Stock Exchange:** To check the stock exchange globally, transaction of sell and buying of the stock can be done with the help of computers, stock exchange members carry out the transactions only with the help of computers, and online trading is carried throughout the world, sitting at one place.

**Research and developments :** The new invention are designed and implemented with the animated virtual viewed with scientific and mathematical equations in the labs , with the help of computers and models are implemented in the real world which saves time, resource, money etc.,

**Entertainment and NEWS :** The audio and video are created in the studio after the pictures is taken the editing process(cloning, merging of sound and images, super impose etc.,) is carried out simultaneously. NEWS are telecasted live and immediately.

**Governments office:** All the transactions of the government, law and information are been obtained in the websites of the government.

**Satellite Communications:** With the venture of satellite the communication are made available to the entire world. This have led to the growth of the information and technological globally and every country is implementing the standardized, so that the communication is at its ease.

Figure 1.31. Internet Communications

**Usage:** Browsing, Surfing, Chatting, email, Messaging, online gaming are some of the area of communications.

**Publishing:** Publishing is the process of making works available to the public. These works include books, magazines, newspapers, music, film, and video. Special software assists graphic designers in developing pages that include text, graphics, and photos; artists in composing and enhancing songs; filmmakers in creating and editing film; and journalists and mobile users in capturing and modifying video clips. Many publishers make their works available online. Some Web sites allow you to copy the work, such as a book or music, to your desktop computer, mobile computer, smart phone, or other mobile device.

**Travel:** Whether traveling by car or airplane, your goal is to arrive safely at your destination. As you make the journey, you may interact with some of the latest technology. Vehicles manufactured today often include some type of onboard navigation system, such as INDIAMAP. Many mobile devices such as smart phones have built-in navigation systems. Some mobile users prefer to carry specialized hand held navigation devices. In preparing for a trip, you may need to reserve a car, hotel, or flight. Many Web sites offer these services to the public. For example, you can order airline tickets on the Web. If you plan to drive somewhere and are unsure of the road to take to your destination, you can print directions and a map from the Web.


Figure 1.32. Travel Karnataka Map

**Computer-aided manufacturing (*CAM*)** refers to the use of computers to assist with manufacturing processes such as fabrication and assembly. Industries use CAM to reduce product development costs, shorten a product's time to market, and stay ahead of the competition. Often, robots carry out processes in a CAM environment. CAM is used by a variety of industries, including oil drilling, power generation, food production, and automobile manufacturing. Automobile plants, for example, have an entire line of industrial robots that assemble a car and special computers on the shop floor record actual labor, material, machine, and computer time used to manufacture a product. The computers process this data and automatically update inventory, production, payroll, and accounting records on the company's network.

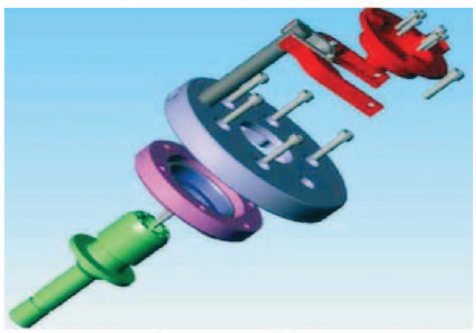


Figure 1.33 CAM

**Hospitals:** The patients id card, details, help in diagnosing (MICR, CEG, Scanning etc.), medication and history of patients are maintained. These are few areas were data and information are obtained with the help of computers, have made the right impression for the betterment of man and mankind.

Figure 1.34. Hospital with Life saving computer controls

## Area of usage and specifications of hardware and software

| Area of usage | Hardware | Software |
|---|---|---|
| **Home** | Desktop or notebook computer Smart phone or other mobile device Game consoles | Business (e.g., word processing) Personal information manager Personal finance, online banking, tax preparation Web browser E-mail, blogging, instant messaging, chat rooms, and online social networking Internet telephone calls Photo and video editing Reference (e.g., encyclopedias, medical dictionaries, road atlas) Entertainment (e.g., games, music composition, greeting cards) Education (e.g., tutorials, children's math and reading software) |
| **Small Office/ Home Office** | Desktop or notebook computer Smart phone or other mobile device Shared network printer | Business (e.g., word processing, spreadsheet, database) Personal information manager Company specific (e.g., accounting, legal reference) Network management Web browser E-mail Internet telephone calls |
| **Enterprise** | Server or mainframe Desktop or notebook computer Industry-specific handheld computer Smart phone or other mobile device | Business (e.g., word processing, spreadsheet, database)Personal information manager Accounting Network management, Web browser E-mail, Blogging, Specific database |
| **SCHOOLS & COLLEGES** | Desktop or notebook computer Smart phone or other mobile device Shared network printer | Business (e.g., word processing, spreadsheet, database)Personal information manager Accounting Network management Web browser, E-mail, Blogging |
| **Hospitals** | Desktop or notebook computer Smart phone or other mobile device Shared network printer | Business (e.g., word processing, spreadsheet, database) Personal information manager Company specific (e.g., accounting, legal reference) Network management Web browser E-mail Internet telephone calls |

| **Area of usage** | Hardware | Software |
|---|---|---|
| **Traffic Network** | Desktop or notebook computer Smart phone or other mobile device Shared network printer | Business (e.g., word processing, spreadsheet, database)Personal information manager Accounting Network management Web browser E-mail Blogging Specific database – fine details |

## Review Questions

**One mark questions :**

1. What is a computer ?
2. What are advantages of learning computers?
3. Which is the earliest computing machine?
4. Who invented the Pascaline?
5. What are the advantages of the machine by Leibnitz over the Pascaline?
6. What is Charles baggage known as?
7. What is the machine proposed by Babbage, to perform differential equations called as?
8. Who is the father of computers?
9. What concept of computing did Herman Hollerith to find a faster way to compute U.S. census.
10. Who developed the first all-electronic computer?
11. What us the electronic relay computer Mark-I also called as?
12. Expand the term ENIAC?
13. Expand the term EDVAC.
14. What is the Von Neumann concept also called as?
15. Expand the term UNIVAC.
16. Which is the basic electronic component of the first generation systems?
17. Which is the basic electronic component of the second generation systems?
18. What does IC stand for?
19. How internet is used ?
20. How computer help in publishing?

**Two Marks Questions:**

1. What are the fields where computers are used today?
2. Write a note on Abacus?
3. Write a note on Pascaline?
4. Explain the important features of difference engine.
5. Explain Charles Babbage's role in the history of modern computers?
6. Mention any two features of ENIAC?
7. Mention any two features of EDVAC?
8. What are the importance features of the III generation computers?
9. Explain the role of computers in education?
10. Why are computer used in the industry?
11. How are computers important in communication?

**Three marks questions:**

1. Briefly explain the history of computers
2. Give the features of the Generations
3. Explain the importance and usage of computers in education and industry
4. Discuss the characteristics of a computer in detail.
5. Explain the functional units of a computer with a neat block diagram?
6. Explain the role of computers in science and engineering?
7. Explain the latest implementation of computers?
8. How does the computer help mankind?
9. What is the concept of e-governance?
10. Explain the use of computer in the email?

**Five marks questions:**

12. Explain generations of computers in details.
13. Which are the areas computer have proved its effective?
14. In the field of communication computer are the best? Why?
15. What are the latest development in the file of computers list the areas and explain.
16. Explain the robotics in detail.
17. Compare the features of micro and mini computers?
18. Compare mainframe and supercomputers

**Activities:** a. Collect the images of personalities in the fields of computers.

b. Area where computer are not used.

c. Making charts for the known area.

# CHAPTER 2

# INPUT OUTPUT MEMORY DEVICES

## OBJECTIVES

- To identify the types and purposes of specialized input devices
- Output devices
- Memory devices
- Storage devices
- Cache Memory

## 2.1 Input Devices

An input device is used to feed data into a computer. The human understandable form (usually English/Kannada or any other language) is converted into machine understandable form 0's and 1's (digital or analog signals). Input devices are capable of converting data into a form which can be recognized by computer. A computer can have several input devices. Namely Keyboard, Mouse, Joystick, OCR, MICR etc.

Ø Input and output devices connect the external world to the computer system.

### 2.1.1 Keyboard

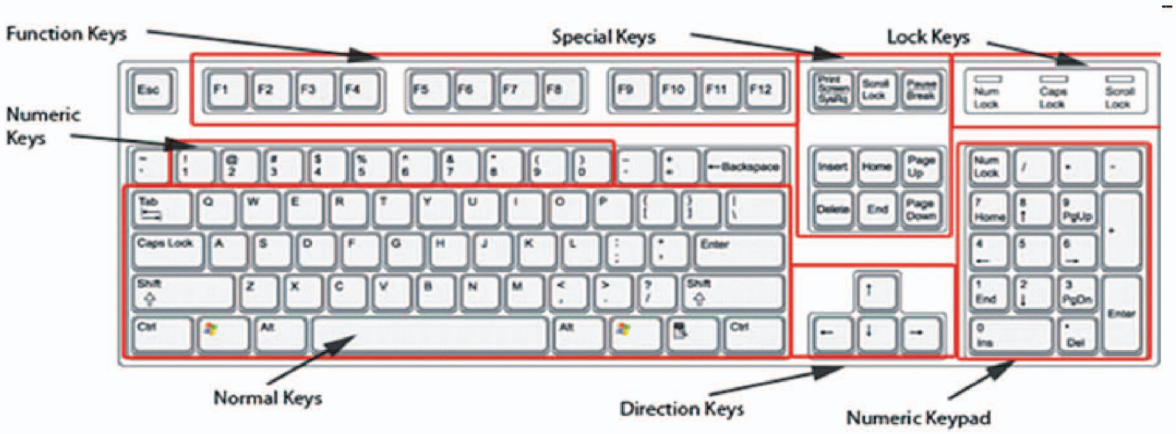



Figure 2.1 Keyboard

The most common input device is the keyboard. Keyboard consists of a set of typewriter like keys that enable you to enter data into a computer. They have **alphabetic keys** to enter letters, **numeric keys** to enter numbers, **punctuation keys** to enter comma, period, and semicolon etc., **functional keys** to perform some specific functions. The keyboard detects the key pressed and generates the corresponding ASCII codes which can be recognized by the computer.


Figure 2.2 Types of keyboard

**Standard keyboards** have their basic layout. The average number of keys on a regular keyboard is 105/108, though range of 95-108 slight variations, especially in the manner the keys are placed. QWERTY keyboards are the most common and have the six alphabets Q, W, E, R, T, and Y in the first row.

**Ergonomics** refers to the study of methods that can reduce stress on muscles to avoid repetitive strain injury. It mostly deals with optimizing posture and technique while working, so the work can be carried out in the easiest manner with the least possible strain on any muscle joint or organ. Ergonomic keyboards are designed in such a way that typing can be done putting the least amount of stress on the fingers and wrist. This is a radical type of keyboard designed to prevent Carpal Tunnel Syndrome.

**Wireless Keyboard** is a keyboard that does not need to be connected to the computer via a wire. This makes it very convenient for the user to use the keyboard comfortably. Wireless keyboard use Bluetooth, Infrared (IR), and Radio Frequency to connect to the computer with the help of batteries and transmitted and receiver with the range 1 to 40 feet distance contact between the computer and the keyboard type very ineffective.

**Virtual keyboards** are software devices that let you input data just like a hardware keyboard. They open up as an application and can be controlled by a mouse or via a touch screen. They are mainly used in devices which do not necessarily require a keyboard, like a tablet or a smart-phone. They are useful as they aid in making the size of the device smaller. Virtual keyboards are also used in situations concerning security, as anything entered on an ordinary keyboard is recorded in a key log, leading to security risks associated with passwords or PIN numbers. This is the reason many banks provide the facility of a virtual keyboard in their online banking operations.

**Compact keyboards** are slim and usually do not have the numeric keypad that is present on the right side of other keyboards. These are typically used in laptops, where sizing issues make it difficult to accommodate a standard keyboard. To make up for the small size, these keyboards rely on the use of multiple keys to carry out functions that would only use a single key on a standard-sized keyboard. Some models also include a touch-pad that can be used instead of the mouse. These are not extremely small in size, but offer portability during travel and storage. Another benefit of compact keyboards is that they can be used by people with certain disabilities that hinder them from effectively using hand and finger movements.

### 2.1.2 Mouse

Mouse is an input device that controls the movement of the cursor on the display screen. The display screen is map in the form of graphical points dot is called pixels. The number of pixels differs depending upon the resolution of the screen. Mouse is a small device; you can roll/navigate along a flat surface. In a mouse, a small ball/ IR rays is kept inside and touches the pad through a hole at the bottom of the mouse. When the mouse is moved, the ball rolls/position on the screen. This movement of the ball/position is converted into signals and sent to the computer. You will need to click the button at the top of the mouse to select the option. Mouse pad is a pad over which you can move a mouse. Mouse is very popular in modern computers.

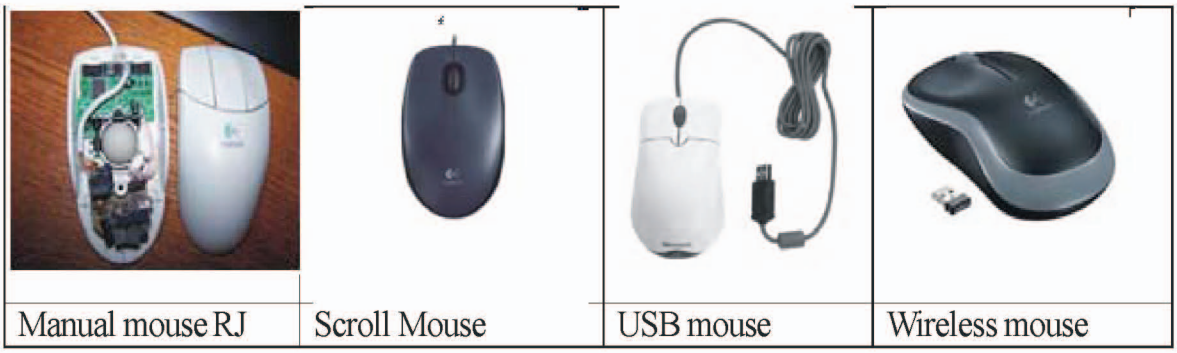



Figure 2.3 Types of Mouse

### 2.1.3 Joystick

A **joystick** is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling.


Video game joystick elements:
1. Stick 2. Base 3.Trigger 4. Extra buttons 5. Auto fires switch 6. Throttle 7. Tat switch (POV hat)


The movements of the joystick is been identified with the axis form x, y and z with three

Figure 2.4 Joystick

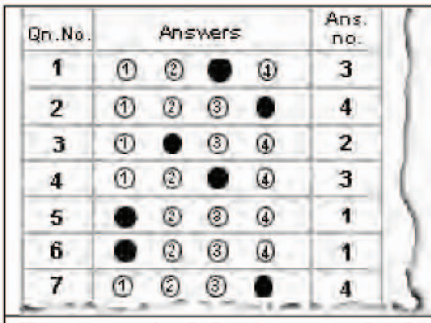
Joysticks are often used to control video games, simulated programs, usually have one or more push-buttons whose state can also be read by the computer. A popular variation of the joystick used on modern video game consoles is the analog stick. Joysticks are also used for controlling machines such as cranes, trucks, underwater unmanned vehicles, surveillance cameras and zero turning radius lawn mowers. Miniature finger-operated joysticks have been adopted as input devices for smaller electronic equipment.

### 2.1.4 OMR, OCR and MICR

Optical reading of the pictures, symbols and shapes are scanned with the help of laser beam, usually the position is pre-programmed, accessed and documented instantly.

## i. Optical Mark Reading and Recognition (OMR)

Special pre-printed forms are designed with boxes which can be marked with a dark pencil or ink. Such documents are read by a reader, which transcribes the marks into electrical pulses which are transmitted to the computer. They are widely used in applications like objective type answer papers evaluation in which large number of candidates appear, time sheets of factory employees etc.




**Every marked dot is recognized based on the position which is programmed.**

**OMR- Optical Mark Reading and Recognition**

## ii. Optical Character Recognition (OCR)

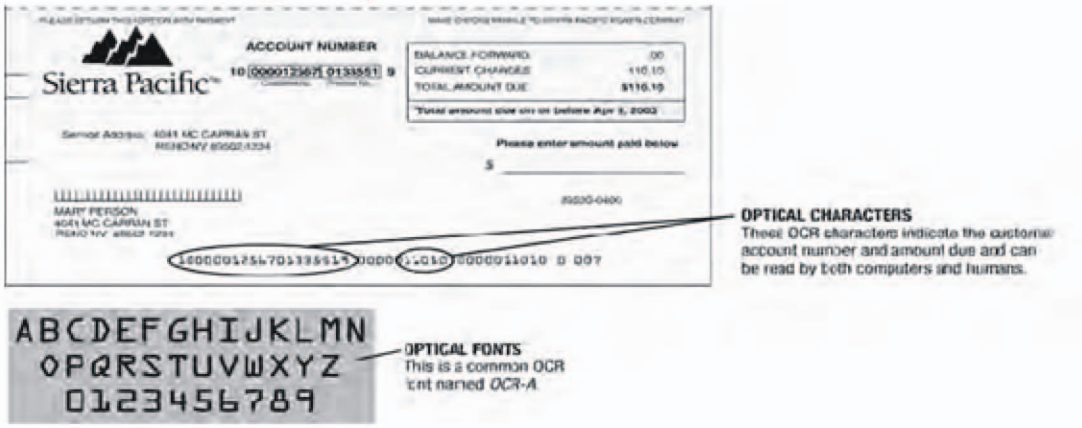



Figure 2.6 OCR Sheet

The OCR technique permits the direct reading of any printed character without any special ink. With OCR, a user can scan a page from a book. The computer will recognize the characters in the page as letters and punctuation marks, and stores. This can be edited using a word processor the size (width, height and depth) of the scanned.

### iii. Magnetic Ink Character Recognition (MICR)


Figure2.7 MICR Cheque

MICR is widely used by banks to process cheques. Human readable numbers are printed on documents such as cheque using a special magnetic ink. The cheque can be read using a special input unit, which can recognize magnetic ink characters. This method eliminates the manual errors. It also saves time, ensures security and accuracy of data.

## 2.2 Introduction to output devices

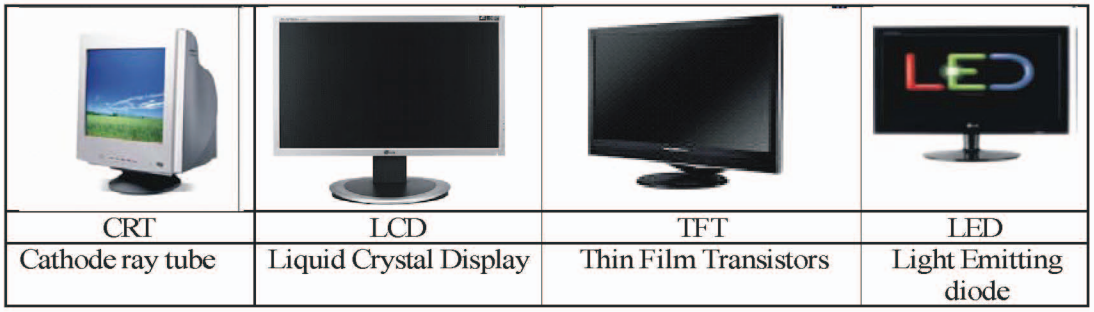
Output is the result/information that is obtained after processing. The information must be presented in the human understandable form (usually from 0's and 1's to English/Kannada or any other language) is capable of presenting information on to the output devices. There are many output devices attached with the computers. The monitors and printers are commonly used output devices.

### 2.2.1 Monitors

Monitor is a commonly used output device, sometimes called as display screen/Visual display unit (VDU). It provides a visual display of data. Monitors are connected with the computer and are similar in appearance to a television set.

Figure 2.8 Monitor

Initially there were only monochrome monitors. But gradually, we have monitors that display colour. Monitors display images and text. The smallest dot that can be displayed is called a pixel (picture element). The resolution of the screen improves as the number of pixels is increased. Most of the monitors have a 4:3 width to height ratio. This is called '**aspect ratio**'. The number of pixels that can be displayed vertically and horizontally gives the resolution of the monitor. The resolution of the monitor determines the quality of the display. Some popular resolutions are 640x480 pixels, 800x600 pixels and 1024x768 pixels. A resolution of 1024x768 pixels will produce sharper image than 640x480 pixels. The size of the monitor is measured diagonally may be 12",14",17",19", 21" and based on technology.




| CRT | LCD | TFT | LED |
|---|---|---|---|
| Cathode ray tube | Liquid Crystal Display | Thin Film Transistors | Light Emitting diode |

Figure 2.9 Types of Monitors

### 2.2.2 Printers

Printer is an output device that **prints** text or **images** on paper or other media (like transparencies). By printing you create what is known as a **'hard copy'**. There are different kinds of printers, which vary in their speed and print quality.

The two main types of printers are impact printers and non-impact printers.

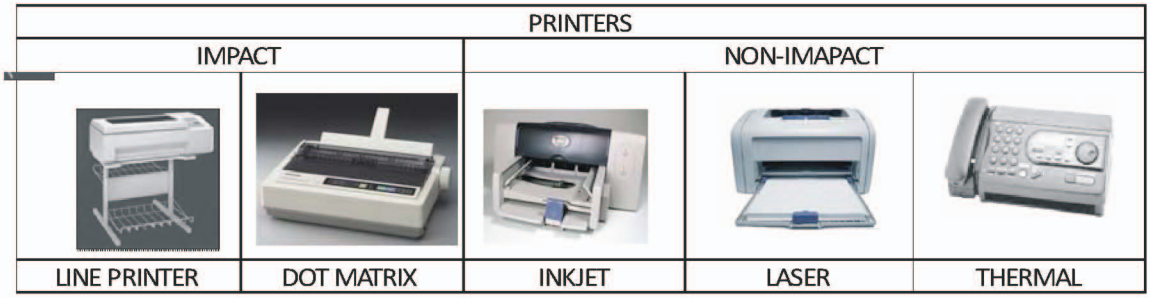



Figure2.10 Types of Printers

Impact printers include printers that print by **striking** device against inked ribbon. Impact printers use a print head containing a number of metal pins, which strike an inked ribbon placed between the print head and the paper. Line printers, dot-matrix printers are some of the impact printers.

- Ø The programs and data present in the memory is called as soft copy.
- Ø The programs and data present on the paper is called as hard copy.

### 2.2.2.1 Characteristics of impact printers

- Ø In impact printers, there is physical contact with the paper to produce an image. Due to being robust and low cost, they are useful for bulk printing.
- Ø Impact printers are ideal for printing multiple copies (that is, carbon copies) because they can easily print through many layers of paper.
- Ø Due to its striking activity, impact printers are very noisy.
- Ø Since they are mechanical in nature, they tend to be slow.
- Ø Impact printers do not support transparencies.
- Ø Measured with characters per seconds (cps).

### 2.2.2.2 Characteristics of Non-impact printers

Non-impact printers do not use striking device, the ink or semi-solid ink is stored in the printer cartridges and the flow of ink is controlled by the processors which is much faster and can print colour, different font and size also.

- Ø They are quiet than impact printers because there is no striking mechanism involved.
- Ø They possess the ability to change type faces automatically.
- Ø These printers produce high-quality graphics
- Ø These printers usually support the transparencies
- Ø These printers cannot print multi part forms because no impact is being made on the paper.
- Ø Measured in dots per inches (dpi)
- Ø The speed is calculated by the number of pages per minute (ppm)
- Ø The size of the printing various A4, A3, A2, A0 and Jumbo size.

### 2.2.2.3 Line Printer

Line printers are high-speed printers capable of printing an entire line at a time. A line printer can print 150 lines to 3000 lines per minute. The limitations of line printer are they can print only one font, they cannot print graphics, the print quality is low and they are noisy to operate. But it can print large volume of text data very fast compared to the other printers. It is also used to print on multi part stationeries to prepare copies of a document.

Figure 2.11 Line Printer

### 2.2.2.4 Dot Matrix Printer

The most popular serial printer is the dot matrix printer. It prints one line of 8 or 14 points at a time, with print head moving across a line. They are similar to typewriters. They are normally slow. The printing speed is around 300 characters per second. It uses multi part stationeries to prepare copies of a document.

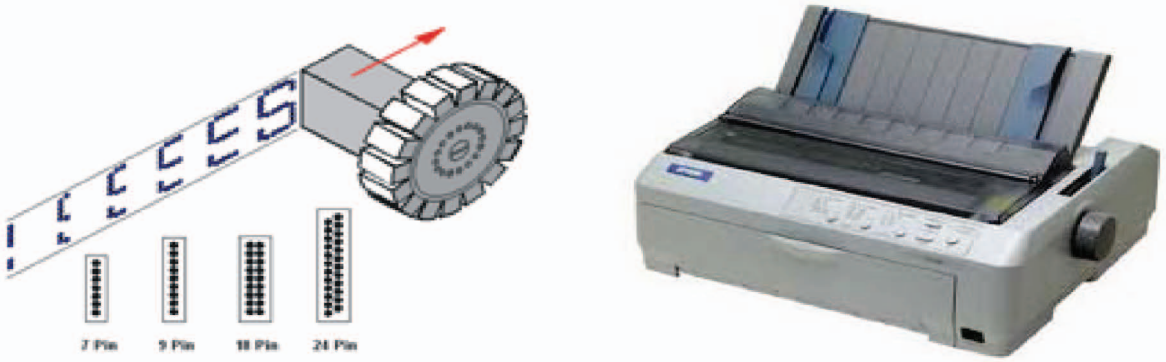



Figure 2.12 Dot Matrix Printers

### 2.2.2.5 Thermal Printer

Thermal printers are printers that produce images by pushing electrically heated pins against special heat-sensitive paper. They are inexpensive and used widely in fax machines and calculators.

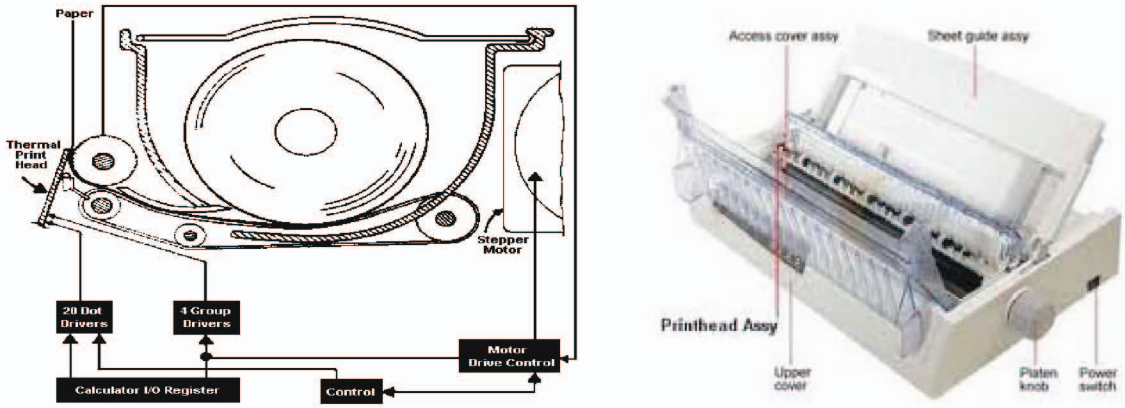



Figure 2.13 Thermal Printer

Thermal printer paper tends to darken over time due to exposure to sunlight and heat. So the printed matters on the paper fade after a week or two. It also produces a poor quality print.

### 2.2.2.6 Laser Printers

Laser printers use a laser beam and dry powdered ink to produce a fine dot matrix pattern. It can produce very good quality of graphic images. One of the chief characteristics of laser printers is their resolution – how many dots per inch (dpi) they lay down. The available resolutions range from 300 dpi at the low end to around 1200 dpi at the high end.

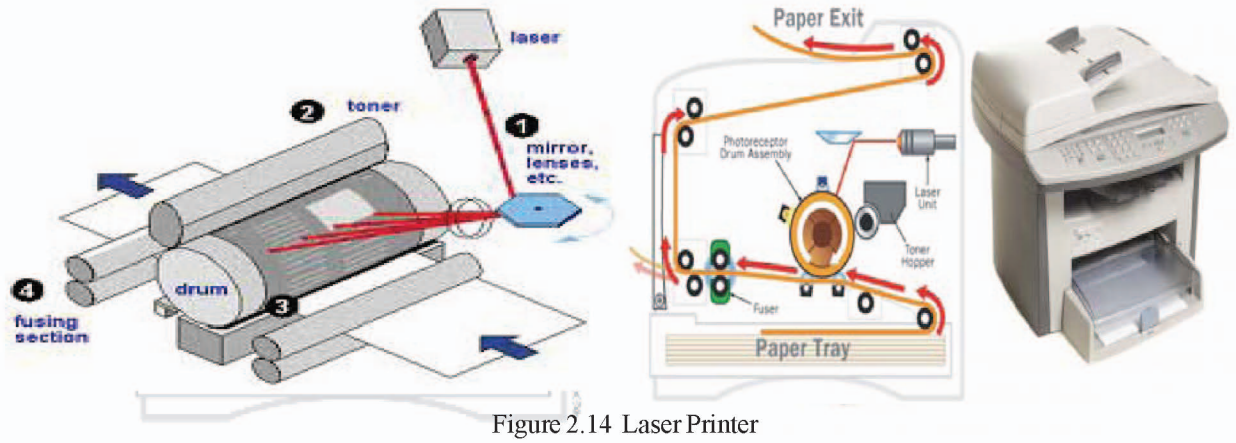



Figure 2.14 Laser Printer

### 2.2.2.7 Inkjet Printers

Inkjet printers use colour cartridges which combine magenta, yellow and cyan inks to create colour tones. A black cartridge is also used for crisp monochrome output. Inkjet printers work by spraying ionizing ink at a sheet of paper. Magnetized plates in the ink's path direct the ink onto the paper in the described shape.

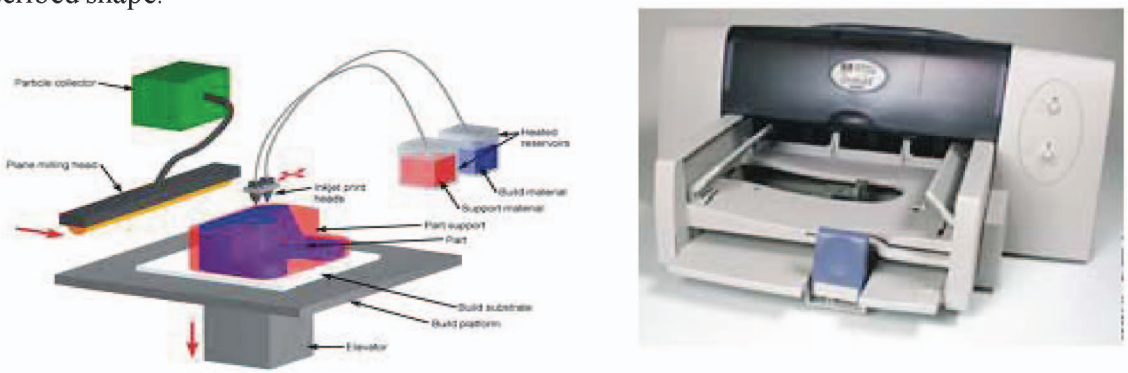


Figure2.15 Inkjet Printer

### 2.2.2.8 Plotter Printers

Plotter is an output device that draws pictures on paper based on commands from a computer. Plotters differ from printers in that they draw lines using a pen. As a result, they can produce continuous lines, whereas printers can only simulate lines by printing a closely spaced series of dots. Multicolor plotters use different-colored pens to draw different colors.

In general, plotters are considerably more expensive than printers. They are used in engineering applications where precision is mandatory.

### 2.2.3 Speakers

The speakers are the output units. The sound signals from analog/digital are converted into audible frequency in the speakers and produce voice output (audio data). Using speakers along with speech synthesizer software, the computer can provide voice output. Voice output has become very common in many places like airlines, banks, automatic telephone enquiry system etc. Users can also hear music/ songs using the voice output system. The advance in the development of the speakers are given rise to the track system of output sound based on the position of the speakers and the numbers of tracks output. Namely 2.1 or 5.1 which indicates the position of the speakers and tracking systems. The latest speakers are crystal clear audio. Walkman speakers are smaller in size with less watts and disables. Today the speakers are with the subwoofer and 2/3/4 speakers

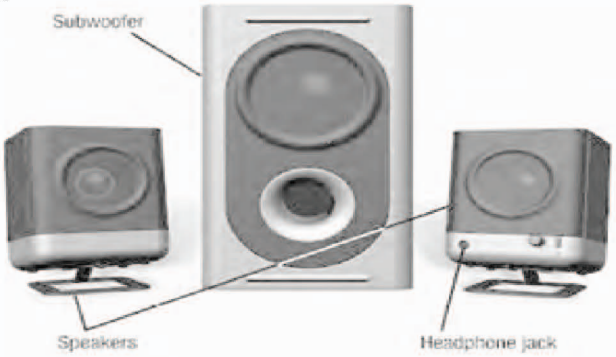



Figure 2.16 Speakers

## 2.3 Introduction to Memory devices

Memory is the most essential part of the computer. Memory is storage part of the computer. We need memory to store the data. This storage enables us to use the stored data to in future. Computer memory is mainly divided as primary memory and secondary memory.

The memory and storage devices are measured in terms of bits and bytes, the measurements in used are 0 ,1 binary digit (bit).

8 bits make a byte.2*2*2*2*2*2*2*2*2*2=1024. $2^{10}$

| | | |
|---|---|---|
| $2^{10}$bytes | 1024 bytes | 1 Kilo byte |
| $2^{20}$bytes | 1024 Kilo bytes | 1 Mega byte |
| $2^{30}$bytes | 1024 Mega bytes | 1 Giga byte |
| $2^{40}$bytes | 1024 Giga bytes | 1 Terra byte |
| $2^{50}$bytes | 1024 Terra bytes | 1 Peta byte |
| $2^{60}$ bytes | 1024 Peta bytes | 1 Exa byte |
| $2^{70}$bytes | 1024 Exa bytes | 1 Zeta byte |
| $2^{80}$bytes | 1024 Zeta bytes | 1 Yotta byte |
| $2^{90}$bytes | 1024 Yotta bytes | 1 Bronto byte |
| $2^{100}$bytes | 1024 Bronto bytes | 1 Geop byte |

Table 1.0

Units of Measurements in computer for Primary Memory and secondary memory

### 2.3.1 Primary Memory

Memory units are the storage areas in the computer. The term "memory" usually refers to the main memory of the computer, whereas the word "storage" is used for the memory that exists on disks, CD's, floppies or tapes. The main memory is usually called a physical memory which refers to the 'chip' (Integrated Circuit) capable of holding data and instruction.

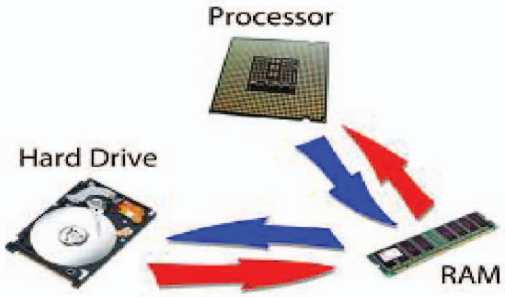
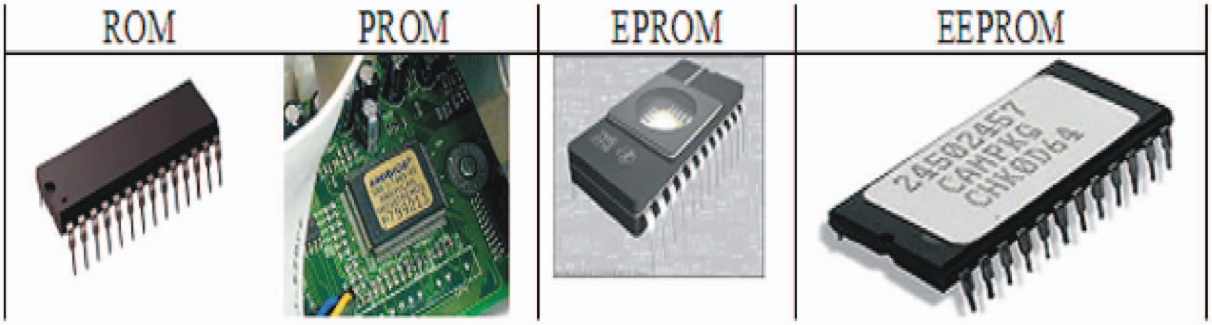



Figure 2.17 Memory Unit

There are different types of memories: ROM and RAM




They are Read Only Memory (ROM), Programmable Read-Only Memory (PROM), Erasable Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM).

#### Read Only Memory - ROM

In ROM, the information is burnt (pre-recorded) into the ROM chip at manufacturing time. Once data has been written into a ROM chip, it cannot be erased but you can read it. When we switch OFF the computer, the contents of the ROM are not erased, but remain stored permanently. ROM is a non-volatile memory. ROM stores critical programs such as the program that boots the computer.

#### Programmable Read Only Memory - PROM

PROM is a memory on which data can be written only once. A variation of the PROM chip is that it is not burnt at the manufacturing time, but can be programmed using PROM programmer or a PROM burner. PROM is also a non-volatile memory.

#### Erasable Programmable Read Only Memory – EPROM

In EPROM, the information can be erased and re-programmed using a special PROM – programmer. EPROM is non-volatile memory. A n EPROM differs from a PROM in that a PROM can be written to only once and cannot be erased. But an ultraviolet light is used to erase the contents of the EPROM.

## Electrically Erasable Programmable Read Only Memory – EEPROM

EEPROM is a recently developed type of memory. This is equivalent to EPROM, but does not require ultraviolet light to erase its content. It can be erased by exposing it to an electrical charge. It is also non-volatile in nature. EEPROM is not as fast as RAM or other types of ROM. A flash memory is a special type of EEPROM that can be erased and re-programmed.

## Random Access Memory - RAM

RAM is the most common type of memory found in the modern computers. This is really the main store and is the place where the program gets stored temporary. When the CPU runs a program, it fetches the program instructions from the RAM and carries them out. If the CPU needs to store the results of the calculations it can store them in RAM. When we switch OFF a computer, whatever is stored in the RAM gets erased. It is a volatile form of memory.

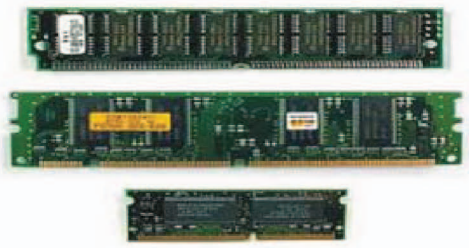


Figure 2.19 RAM

The main memory must store many data items and have some way of retrieving them when they are needed. The memory can be compared to the boxes at a post office. Each box-holder has a box with a unique number which is called its **address**. This address serves to identify the box. The memory has a number of locations in its store. Each location in a memory has a unique number called its memory address. This serves to identify it for storage and retrieval.

Operations on memories are called **reads and writes**, defined from the perspective of a processor or other device that uses a memory: A write instruction transfers information from other device to memory and a read instruction transfers information from the memory to other devices. A memory that performs both reads and writes is often called a RAM.

In a computer system, the clock signal is an oscillating frequency used to coordinate interaction between digital circuits. Simply put, it synchronizes communication. Digital circuits designed to operate on the clock signal may respond at the rising or falling edge of the signal. SDRAM memory chips used only the rising edge of the signal to transfer data, while DDRRAM transfers data on both the rising and falling edges of the clock signal, making it essentially twice as fast as SDRAM. RAM speed works in conjunction with the front side bus (FSB) of a computer system. The FSB is the two-way data channel that sends information from the central processing unit (CPU) throughout the motherboard to the various components, including the RAM, BIOS chips, hard drives and PCI slots.

Types of RAM

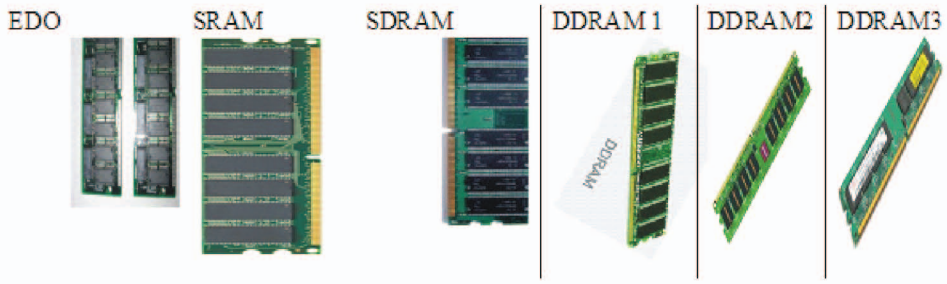



Figure 2.20 Types of RAM

## EDO RAM (extended data output RAM)

EDO (extended data output) RAM is a type of random access memory (RAM) chip that improves the time to read from memory on faster microprocessors such as the Intel Pentium. EDO RAM was initially optimized for the 66 MHz Pentium.

**Static random-access memory (SRAM)** is a type of semiconductor memory that uses bi-stable latching circuitry to store each bit. The term static differentiates it from dynamic RAM (DRAM) which must be periodically refreshed. SRAM exhibits data remainence, but it is still volatile in the conventional sense that data is eventually lost when the memory is not powered. FSB will be 166 MHz.

Double-Data-Rate Synchronous Dynamic Random Access Memory, better known as **DDR SDRAM** or **DDR RAM** for short, is a type of very fast computer memory. It's based on the same architecture as SDRAM, but uses the clock signal differently to transfer twice the data in the same amount of time.

DDR SDRAM at 400 MHz (DDR-400 or PC-3200)

DDR2 SDRAM at 800 MHz (DDR2-800 or PC2-6400)

DDR3 SDRAM at 1600 MHz (DDR3-1600 or PC3-12800)

Suppose a computer system has DDR memory, a Memory Divider of 1:1, a FSB operating at 200 MHz and a CPU multiplier of 10x. Then, the base memory clock will operate at (Memory Divider) × (FSB) = 1 × 200 = 200 MHz and the effective memory clock would be 400 MHz since it's a DDR system ("DDR" stands for Double Data Rate; the effective memory clock speed is double the actual clock speed). The CPU will operate at 10 × 200 MHz = 2.0 GHz. Using I/O bus frequency of 200 MHz various types of DRAM will operate.

### 2.3.2 Secondary Memory

The computer may need to store data, programs etc., (because the primary memory is volatile). Secondary storage is also called backup storage. Secondary storage can be used to transmit data to another computer either immediately or a later time. This provides a mechanism for storing a large amount of data for a long period of time. Some of the commonly used secondary storage devices are hard disks, magnetic tapes, floppy disks and CD-ROM. To understand the physical mechanism of secondary storage devices one must have basic knowledge of magnetism, electronics and electro mechanical systems. The average time required to reach a storage location and obtain its contents is called its access time. In electro mechanical devices with moving parts such as disks and tapes, the access time consists of a seek time required to position the read write head to a location and transfer time required to transfer the data to or from the device.

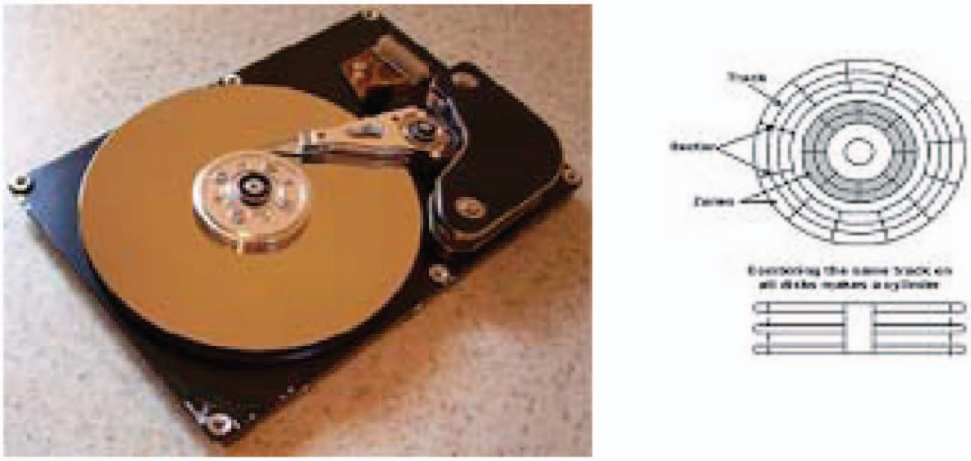


Figure2.21 Hard Disk Drive

### Hard Disk

Hard disk is a magnetic disk on which you can store computer data. The hard disk is direct-access storage medium. This means you can store and retrieve data randomly. Disk storage systems are essentially based on magnetic properties. The magnetic disk consists of high speed rotating surfaces coated with a magnetic recording medium. The rotating surface of the disk is a round flat plate. When writing data, a write head magnetizes the particles on the disk surface as either north or south poles. When reading data, a read head converts the magnetic polarizations on the disk surface to a sequence of pulses. The read and write heads are generally combined into a single head unit. There may be more than one read/write head. Data is arranged as a series of concentric rings. Each ring(called a track) is sub-divided into a number of sectors, each sector holding a specific number of data elements (bytes or characters).

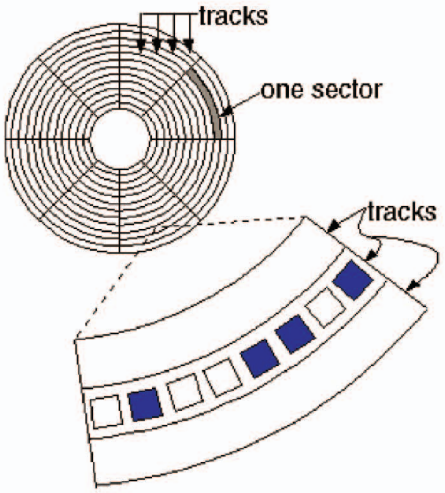



Figure 2.22 A track subdivided into sectors

The smallest unit that can be written to or read from the disk is a **sector**. Once a read or write request has been received by the disk unit, there is a delay involved until the required sector reaches the read/write head. This is known as rotational latency, and on average is one half of the period of revolution. The **storage capacity** of the disk is determined as **(number of tracks * number of sectors * bytes per sector * number of read/write heads).** Thus, the data is stored as magnetized spots arranged in concentric circles (tracks) on the disk. Each track is divided into sectors. The arrangement of tracks and sectors on a disk is known as its 'format'.

High data rates demand that the disk rotates at a high speed(about 80,000 rpm). As the disk rotates read/write heads move to the correct track and fetch the desired data. The storage capacity of a hard disk can be Gigabytes (GB). i.e. thousands of Mega bytes of information.

## Magnetic Tape

This recording medium contains a thin tape with a coating of a fine magnetic strip, used for recording digital data. The tape itself is a strip of plastic, coated with a magnetic recording medium. Bits are recorded as magnetic spots on the tape along several tracks. Usually, seven or nine bits are recorded simultaneously to form a character together with a parity bit. Read/write heads are mounted one in each track so that data can be recorded and read as a sequence of characters.

Figure2.23 Magnetic Tape Reader

Data is stored in frames across the width of the tape. The frames are grouped into blocks or records which are separated from other blocks by gaps. Magnetic tape is a serial access medium, similar to an audio cassette, and so data cannot be randomly located. This characteristic has prompted its use in the regular backing up of hard disks.

## Floppy Disk

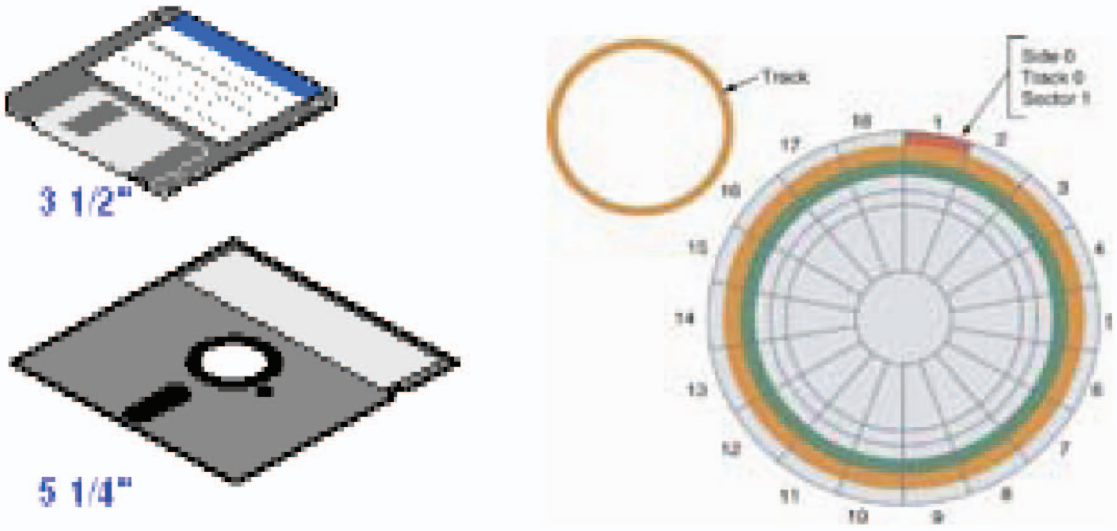



Figure2.24 Floppy Disk

The floppy drive uses a thin circular disk for data storage. It is a soft magnetic disk. It is a thin magnetic-coated disk contained in a flexible or semi-rigid protective jacket. The disk rotates at 360rpm (Rotations per minute). A read/write head makes physical contact with the disk surface. Data is recorded as a series of tracks sub-divided into sectors. The floppy disks are usually 3.5" in size. However, older floppy disks may be in use; these would be 5.25" in size or even 8" in size. A 3.5" floppy disk can hold 1.44 MB of data. Once data is stored on a floppy disk it can be 'write protected' by clicking a tab on the disk. This prevents any new data being stored or any old data being erased. Disk drives for floppy disks are called floppy drives. Floppy disks are slower to access than hard disks and have less storage capacity. It is less expensive and is portable. It can be accessed randomly.

## Optical Disk

Optical disks are the storage medium from which data is read and to which it is written **by lasers**. The optical disk is random access storage medium; information can be easily read from any point on the disk. CD-ROM stands for Compact Disk - Read Only Memory.


Figure 2.24 Compact Disk

It is now possible to have CD-ROMs where tracks of information can be written on to them by the user. These are called read/write CD-ROMs and these are becoming a popular and economical method of storage.

## Optical track

Optical track is a recording unit of data on the disc. The information stored on CD-ROM is arranged according to certain rules, and is shaped like an "Optical track", called "light rail" in spiral shapes. The data from the directory inside the CD-ROM (TOC, Table of Contents) is recorded in the starting address of the number of consecutive logical sectors of an Optical track. The audio CD in a song is corresponding to a light rail, therefore, there are many light rails. CD-ROM light rails are at most 99 in number. The minimum length of each light rail is indicated by Time: 4 seconds, or 300 sectors. This value is sometimes referred to as "threshold." Less than 4 seconds, light rail, if it cannot be used as light rail, it might be a "bad Optical track". The depression part on the Optical track is called information pit and the flat part is called land. Pit and land are used to record information.CD-R disc has been pressed with spiral groove, known as the "pre-groove", instead the pit of optical track. When burning, CD-R disc in a trench in an organic dye laser irradiation, the formation of bubbles, this is the "pit". Bubbles, once formed, will not be able to restore the status quo, therefore, CD-R can only be written once. These "pit" and "land" is the signal after "8-14 coded modulation" (EFM, Eight to Fourteen Modulation), plus three interval code could access code to form inside the burning to disc. This treatment can guarantee the accuracy of reading.

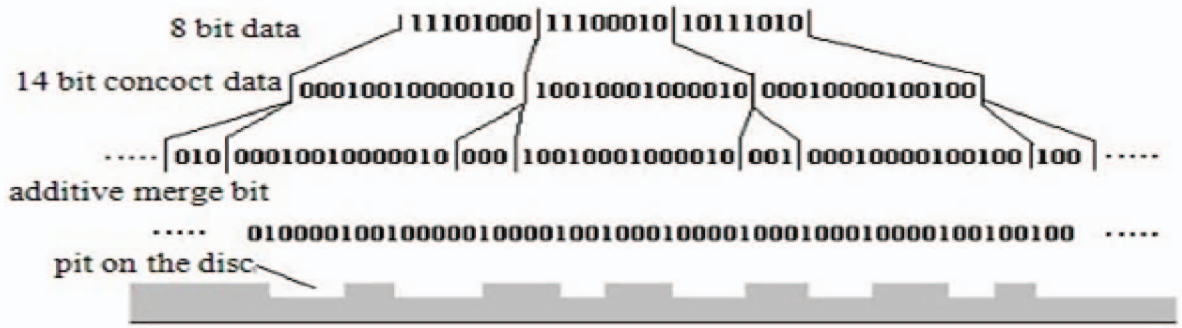



Figure2.25 Optical track

**DVD Digital Video Disc**, that is, "digital video disc." With the advances in optical disc technology, it can not only store video program, but also store music, data, along with increased use, it will be this type of CD-ROM referred to as "Digital Versatile Disc", and the English name is the **Digital Versatile Disc.**

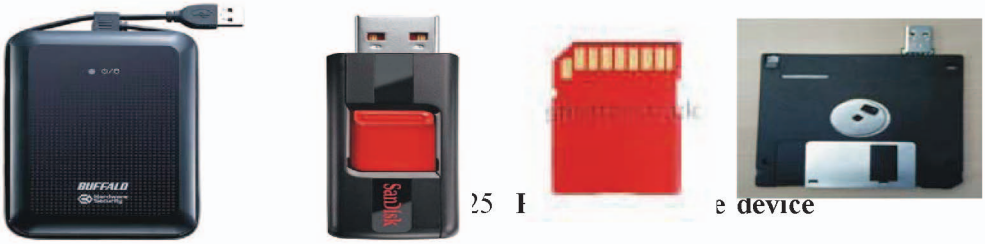
## BLUE ray disk

Blue-ray Disc, referred as BD. BD disc features are: It consists of a thickness of 1.1mm of the recording layer and a thickness of only 0.1mm composite made of a transparent protective layer. The work of the shorter wavelength light source, in the recording layer surface can be comparable with the operating wavelength of fingerprints, with storage capacity

| | |
|---|---|
| Recording capacity | 23.3GB/25GB/27GB |

## Portable storage device

A **portable storage device (PSD)** is a small hard drive designed to hold any kind of digital data. This is slightly different from a portable media player, which stores and plays music and movies. Some are fixed size hard drives of 256GB, 320GB,500Gb,1Tb,2Tb etc. Newer units are expandable using 2.5" laptop hard drives, allowing for an unlimited storage capacity, which is useful for video and images. When travelling, a portable storage device may be a useful alternative to backing up or purging memory cards if a computer is unavailable for downloading.




25 I e device

HDD Flash Drive Secure Disk USB Floppy

## 2.3.3 Cache Memory

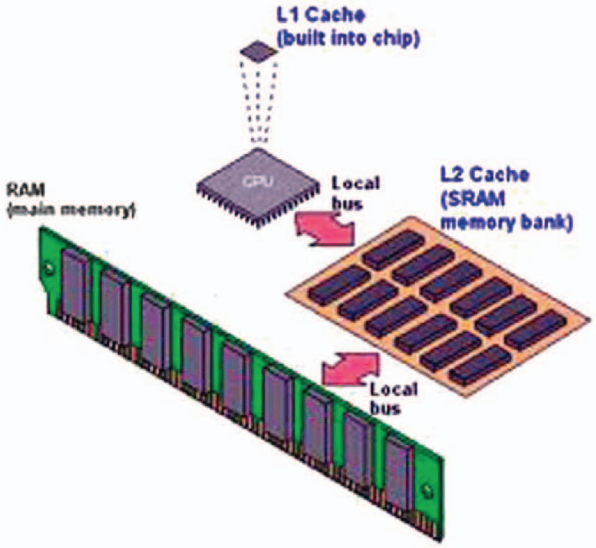



Figure 2.26 Cache memory

The *cache* is a small amount of high-speed memory, present between the primary memory and CPU (processor). There are two levels of cache memory L1 and L2, L1 cache memory will present inside the CPU, whereas the L2 cache will be present on the mother board, cache memory holds the most recent data/instructions. Usually with a memory cycle time comparable to the time required by the CPU to fetch one instruction. The cache is usually filled from main memory when instructions or data are fetched into the CPU. Often the main memory will supply a wider data word to the cache than the CPU requires, to fill the cache more rapidly. The amount of information which replaces at one time in the cache is called the *line size* for the cache. This is normally the width of the data bus between the cache memory and the main memory. A wide line size for the cache means that several instruction or data words are loaded into the cache at one time, providing a kind of perfecting for instructions or data.

# Review Question

**One mark questions:**

1. What is PC?
2. What is the use of input unit?
3. What happens to the data in the input unit?
4. What is the use of memory?
5. What is ROM and RAM?
6. Classify various units of memory.
7. What is cache memory?
8. What does MOUSE stand for ?
9. What is MICR?
10. Define the resolution of a monitor
11. What is use of speakers?

**Two marks questions:**

1. Compare input and output units.
2. What is difference between volatile and non-volatile memory.
3. Compare static and dynamic Ram
4. Give different types of ROM.
5. Explain the different types of keyboard.
6. Give the difference between hard copy and soft copy.
7. Explain different types of printers.
8. Explain the structure of CD-ROM.

**Three marks questions:**

1. Write the difference between ROM and RAM.
3. Give the applications of OCR, OMR, and MICR.
4. Explain impact and non-impact printers in detail.
5. Explain the storage medium in detail.

**Five marks questions:**

1. Explain input unit in detail.
2. Explain output in detail.
3. Explain storage medium in detail.
4. Illustrate the latest configuration of computers for today.

# CHAPTER 3

# DATA REPRESENTATION

## OBJECTIVES

- To understand representation of data and information
- Number systems
- Conversions
- Basic operations

## 3.1 Introduction

In digital computers, data and instructions are stored in the computer's memory using binary code (or machine code) represented by **B**inary dig**IT**'s 1 and 0 called **BIT**s. The data may contain digits, alphabets or special character, which are then converted to bits, understandable by the computer. All arithmetic operations are performed using binary bits. The study of different number systems is necessary to understand data representation.

The number system uses well defined symbols called digits. The values of digits depend on the position in which they appear in the number.

Number systems are basically classified into two types. They are,

1. Non-positional number system.
2. Positional number system.

## 3.2 Non-positional number system

In olden days people made use of this type of number system for simple calculations like additions and subtractions. The non-positional number system consists of different symbols that are used to represent numbers.

Roman number system is an example of the non-positional number system i.e. I=1, V=5, X=10, L=50. Each of these symbols represents a **value**, irrespective of the positions. This number system cannot be used effectively to perform arithmetic operations.

## 3.3 Positional number system

Decimal, Binary, Octal and Hexadecimal number systems are some of the examples of this type of number systems.

The base or radix of a number system is the total number of digits present in that system.

Every number is represented by a base (or radix) x, which represents x digits. To determine the quantity that the number represents, the number is multiplied by an integer power of x depending on the position it is located and then finds the sum of the weighted digits.

The base or radix of a number system is the total number of digits present in any number system.

### 3.3.1 Decimal number system

This is the most commonly used number system in our daily life. It has 10 numbers from 0 to 9; hence its radix is 10. The positional values are expressed in powers of 10.

Example 3.1 Consider a decimal number $542.76_{(10)}$ which can be represented in equivalent value as:

$$5x10^2 + 4x10^1 + 2x10^0 + 7x10^{-1} + 6x10^{-2}$$

Table 3.1 shows the weightage of the positional values of the decimal number:

| | Hundreds | Tens | Units | One-tenth | One-hundredth |
|---|---|---|---|---|---|
| Weights | $10^2$ | $10^1$ | $10^0$ | $10^{-1}$ | $10^{-2}$ |
| Digits | 5 | 4 | 2 | 7 | 6 |
| Values | 500 | 40 | 2 | 0.7 | 0.06 |

Table 3.1

### 3.3.2 Binary number system

The digital computers cannot process decimal numbers, hence it has to be converted to binary digits 0 (low voltage) and 1 (high voltage), which is suitable to represent the bi-stable of electronic components.

The representation of data in a computer is usually in binary digits 0 and 1. Hence the base is 2. The positional values are expressed in **powers of 2**. It is very essential to know how to count a binary number and also the conversion from binary to all other number systems.

Example 3.2 Consider a binary number $11011.101_{(2)}$ which can be represented in equivalent values:

$1x2^4 + 1x2^3 + 0x2^2 + 1x2^1 + 1x2^0 + 1x2^{-1} + 0x2^{-2} + 1x2^{-3}$

Table 3.2 shows the weightage of the positional values of the binary number:

| Weights | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | $2^{-1}$ | $2^{-2}$ | $2^{-3}$ |
|---|---|---|---|---|---|---|---|---|
| Bits | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| Values | 16 | 8 | 4 | 2 | 1 | 0.5 | 0.25 | 0.125 |

Table 3.2

In the binary number $11010_{(2)}$ the left most bit 1 is the highest order bit. It is called as the most significant bit (MSB). Rightmost bit 0 is the lower order bit. It is called least significant bit (LSB).

### 3.3.3 Octal number system

Binary number representation generates long sequence of 1's and 0's, while representing large decimal numbers. To overcome this problem, other number systems like octal and hexadecimal number system is used which can effectively compress long strings of binary numbers.

The octal number system has 8 digits 0, 1, 2, 3, 4, 5, 6 and 7. Its radix is 8. The positional values are expressed in powers of 8.

Example 3.3 Consider an octal number $234.56_{(8)}$ which can be represented in equivalent value as:

$$2x8^2 + 3x8^1 + 4x8^0 + 5x8^{-1} + 6x8^{-2}$$

The table 3.3 shows the weightage of the positional values of the octal number:

| Weights | $8^2$ | $8^1$ | $8^0$ | $8^{-1}$ | $8^{-2}$ |
|---|---|---|---|---|---|
| Digits | 2 | 3 | 4 | 5 | 6 |
| Values | 64 | 8 | 1 | 0.125 | 0.03125 |

Table 3.3

### 3.3.4 Hexadecimal number system

This number system has 16 digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E and F. The radix is 16. The positional values are expressed in powers of 16. The digits A, B, C, D, E and F have the decimal equivalents 10, 11, 12, 13, 14 and 15 respectively.

Example 3.4 Consider a hexadecimal number $5AF.D_{(16)}$ which can be represented in equivalent value as:

$$5x16^2 + Ax16^1 + Fx16^0 + Dx16^{-1}$$

The table 3.6 shows the weightage of the positional values of the hexadecimal number:

| Weights | $16^2$ | $16^1$ | $16^0$ | $16^{-1}$ |
|---|---|---|---|---|
| Digits | 5 | A | F | D |
| Values | 256 | 16 | 1 | 0.0625 |

Table 3.6

## 3.4 Number system conversions (All types)

In representing the data on computers we need to convert the data from one number system to other number system. In this section we study the inter conversions of number systems.

### 3.4.1 Decimal to binary conversion:

Step1: Divide the given decimal number by 2

Step2: Note the quotient and remainder.

Step2: Repeat the step1 and step2 until the quotient becomes zero.

Step3: The first remainder will be the LSB and the last remainder is the MSB. The equivalent binary number is then written from left to right i.e., from MSB to LSB.

Example 3.5 Consider the decimal number $53_{(10)}$ which can be represented in binary as:

| | | | | |
|---|---|---|---|---|
| 2 | 53 | | | |
| 2 | 26 | remainder | 1 | → LSB |
| 2 | 13 | remainder | 0 | |
| 2 | 6 | remainder | 1 | |
| 2 | 3 | remainder | 0 | |
| 2 | 1 | remainder | 1 | |
| 2 | 0 | remainder | 1 | → MSB |

Therefore, $53_{(10)} = 110101_{(2)}$

### 3.4.1.1 Decimal fraction to binary conversion:

Step 1: Multiply the decimal fraction by 2, note the carry and the product.

Step 2: Repeat Step1until the fractional product becomes zero.

Step 3: The first carry will be the MSB and the last carry is the LSB. The equivalent binary fraction is then written from MSB to LSB ( right to left).

Example 3.6 Consider the decimal fraction $0.3125_{(10)}$

| Multiply by 2 | Carry | Product |
|---|---|---|
| 0.3125 x 2 | 0 (MSB) | 0.625 |
| 0.625 x2 | 1 | 0.25 |
| 0.25 x 2 | 0 | 0.50 |
| 0.50 x2 | 1 (LSB) | 0.00 |
| 0.00 | | |

Therefore, $0.3125_{(10)} = 0.0101_{(2)}$

### 3.4.2 Binary to decimal conversion

Step1: Multiply each bit of the binary number by its positional weight.

Step2: Add all the products.

Example 3.7 Consider the binary number $11011.101_{(2)}$ which can be represented in decimal value as:

$$1x2^4+1x2^3+0x2^2+1x2^1+1x2^0+1x2^{-1}+0x2^{-2}+1x2^{-3}$$

The table 3.2 shows the weightage of the positional values of the binary number.

| Weights | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | $2^{-1}$ | $2^{-2}$ | $2^{-3}$ |
|---|---|---|---|---|---|---|---|---|
| Bits | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| Values | 16 | 8 | 4 | 2 | 1 | 0.5 | 0.25 | 0.125 |

Table 3.2

Therefore, $11011.101_{(2)} = 27.625_{(10)}$

### 3.4.3 Decimal to octal conversion

Step 1: Divide the given decimal number by 8

Step 2: Note the quotient and remainder.

Step 3: Repeat the step1 and step 2 until the quotient becomes zero.

Step 4: The first remainder will be the LSB and the last remainder is the MSB. The Equivalent octal number is then written from left to right i.e. from MSB to LSB.

Example 3.8 Consider the decimal number $459_{(10)}$

| | | | | |
|---|---|---|---|---|
| 8 | 459 | | | |
| 8 | 57 | remainder | 3 | → LSB |
| 8 | 7 | remainder | 1 | ↑ |
| 8 | 0 | remainder | 7 | → MSB |

Therefore, $459_{(10)} = 713_{(8)}$

### 3.3.4 Octal to decimal conversion

Step 1: Multiply each digit of an octal number by its weight.

Step 2: Add all the products.

Example 3.9 Consider an octal number $234.56_{(8)}$ which can be represented in decimal value as:

$2x8^2 + 3x8^1 + 4x8^0 + 5x8^{-1} + 6x8^{-2}$

Table 3.3 below shows the weightage of the positional values of the octal number:

| Weights | $8^2$ | $8^1$ | $8^0$ | $8^{-1}$ | $8^{-2}$ |
|---|---|---|---|---|---|
| Digits | 2 | 3 | 4 | 5 | 6 |
| Values | 64 | 8 | 1 | 0.125 | 0.03125 |

Table 3.3

Therefore, $234.56_{(8)} = 156.71875_{(10)}$

### 3.3.5 Decimal to hexadecimal conversion

Step 1: Divide the given decimal number by 16.

Step 2: Note the quotient and remainder.

Step 3: Repeat step1and step2 until the quotient is becomes zero.

Step 4: The first remainder is the LSB and the last remainder is the MSB. The hexadecimal number is written from left to right with MSB occurring first.

Example 3.10 Consider a decimal number $559_{(10)}$

| | | | | | |
|---|---|---|---|---|---|
| 16 | 559 | | | | |
| 16 | 34 | remainder | 15 → F | → | LSB |
| 16 | 2 | remainder | 2 | ↑ | |
| 16 | 0 | remainder | 2 | → | MSB |

Therefore, $559_{(10)} = 22F_{(16)}$

### 3.3.6 Hexadecimal to decimal conversion

Step1: Multiply each digit of the hexadecimal number by its positional weight.

Step2: Add all the products.

Example 3.11 Consider a hexadecimal number $5AF.D_{(16)}$ which can be represented in decimal value as:

$$5x16^2 + A \times 16^1 + F \times 16^0 + D \times 16^{-1}$$

Table 3.6 shows the weightage of the positional values of the hexadecimal number:

| Weights | $16^2$ | $16^1$ | $16^0$ | $16^{-1}$ |
|---|---|---|---|---|
| Digits | 5 | A | F | D |
| Values | 256 | 16 | 1 | 0.0625 |

Table 3.6

Therefore, $5AF.D_{(16)} = 1455.8125_{(10)}$

### 3.3.7 Binary to octal conversion

In the given binary number, the binary digits are grouped into groups of three bits starting from the binary point and convert each group into its equivalent octal number. For whole numbers, it may be necessary to add a zero as the MSB. Similarly, when representing fractions, it may be necessary to add a trailing zero in the LSB to complete grouping of three bits.

Adding a leading 0 as the MSB into the whole number and adding a 0 trailing 0 as the LSB into the fractional binary number does not change the value of the number.

Example 3.12 Consider the binary number $1010111_{(2)}$

$$\underbrace{1}_{1}\quad\underbrace{010}_{2}\quad\underbrace{111}_{7}$$

Therefore, $1010111_{(2)} = 127_{(8)}$

Example 3.13 Consider the binary number $0.110111_{(2)}$

$$\underbrace{110}_{6}\quad\underbrace{111}_{7}$$

Therefore, $0.110111_{(2)} = 0.67_{(8)}$

### 3.3.8 Octal to binary conversion

The application of octal numbers is to represent binary numbers, as it is easier to read large numbers in octal form than in binary form. Each octal digit is represented by a three-bit binary number as in table 3.4. Hence it is very easy to convert from octal to binary.

| Octal digit | Binary digit |
|---|---|
| 0 | 000 |
| 1 | 001 |
| 2 | 010 |
| 3 | 011 |
| 4 | 100 |
| 5 | 101 |
| 6 | 110 |
| 7 | 111 |

Table 3.4

Example 3.14 Consider the octal number $456_{(8)}$

4 ⟶ 100

5 ⟶ 101

6 ⟶ 110

Therefore, $456_{(8)} = 100101110_{(2)}$

Example 3.15 Consider the octal number $73.16_{(8)}$

7 → 111

3 → 011

1 → 001

6 → 110

Therefore, $73.16_{(8)} = 111011.001110_{(2)}$

### 3.3.9 Binary to Hexadecimal conversion

The binary bits are grouped into four bits starting from the binary point and replace each group by a hexadecimal digit. For whole numbers, it may be required to add a zero as the MSB to complete a group of four bits. Similarly, when representing fractions, it may be required to add a trailing zero as the LSB to complete a group of four bits. **This addition of zeros will not change the value of the binary number.**

Table 3.5 shows each hexadecimal number may be represented as a 4-digit number.

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

Table 3.5

Example 3.16 Consider a binary number $1011001_{(2)}$

$$\underbrace{0101}_{5}\quad\underbrace{1001}_{9}$$

Therefore, $1011001_{(2)} = 59_{(16)}$

Example 3.17 Consider a binary number $0.11010111_{(2)}$

$$\underbrace{1101}_{D}\quad\underbrace{0111}_{7}$$

Therefore, $0.11010111_{(2)} = 0.D7_{(16)}$

### 3.3.10 Hexadecimal to binary conversion

Each digit of a hexadecimal number is replaced by a 4-bit binary number (Refer table 3.5).

Example 3.18 Consider a hexadecimal number $CEBA_{(16)}$

C → 12 → 1100
E → 14 → 1110
B → 11 → 1011
A → 10 → 1010

Therefore, $CEBA_{(16)} = 1100\ 1110\ 1011\ 1010_{(2)}$

### 3.3.11 Octal to Hexadecimal conversion

Using binary system, we can easily convert octal numbers to hexadecimal numbers and vice-versa.

Step 1: Write the binary equivalent of each octal digit.

Step 2: Regroup them into 4 bits from the right side with zeroes added, if necessary.

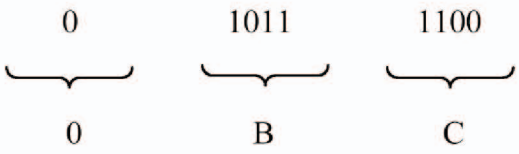
Step 3: Convert each group into its equivalent hexadecimal digit.

Example 3.19 Consider an octal number $274_{(8)}$

2 → 010
7 → 111
4 → 100

Therefore, $274_{(8)} = 010\ 111\ 100_{(2)}$

Group the bits into groups of 4-bits as 0 1011 1100




Therefore, $274_{(8)} = BC_{(16)}$

### 3.3.12 Hexadecimal to octal conversion

Step 1: Write the binary equivalent of each hexadecimal digit.

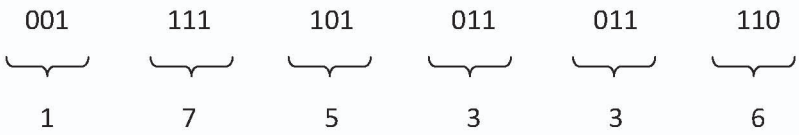
Step 2: Regroup them into 3-bits from the right side with zeros added, if necessary.

Step 3: Convert each group into octal equivalent.

Example 3.20 Consider a hexadecimal number $FADE_{(16)}$

F → 15 → 1111
A → 10 → 1010
D → 13 → 1101
E → 14 → 1110

Therefore, $FADE_{(16)} = 1111\ 1010\ 1101\ 1110_{(2)}$




Therefore, $FADE_{(16)} = 175336_{(8)}$

## 3.5 Representation of signed integers

The digital computers handle both positive and negative integers. So some means is required for representing the sign of the number (+ or -). This is done by adding the leftmost bit to the number called the sign bit. A positive number has a sign bit 0, while the negative has a sign bit 1. Hence it is also called as **fixed point representation.**

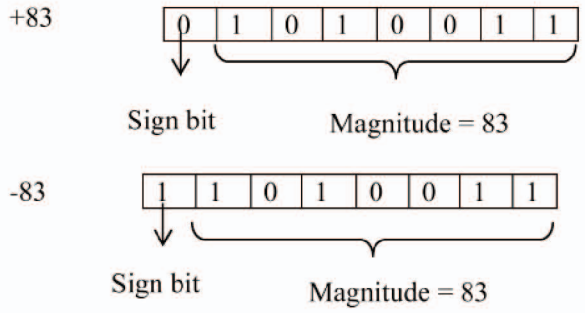
A negative signed integer can be represented in one of the following ways

- Sign and magnitude representation
- One's complement representation
- Two's complement representation

### 3.5.1 Sign and magnitude representation

An integer containing a sign bit followed by magnitude bits are called sign-magnitude integer. The MSB is always the sign bit and the remaining bits always stand for magnitude.

Example 3.21 If in a Computer of word size of 1 byte (8 bits), then an integer +83 and -83 is represented in 8-bit sign-magnitude representation as




$2^7 = 128$ numbers can be represented using 7 bits, numbers from 0 to +127 and 0 to -128.

### 3.5.2 1's complement representation

This is the simple method of representing negative binary numbers. The negative binary number is formed by subtracting the value of each bit in the word from 1. This changes the value of each bit from 0 to 1 and 1 to 0.

Example 3.22 Consider the binary number 101000.

1's complement of this number is obtained as follows:

$$\begin{array}{r} 111111 \\ -\ 101000 \\ \hline 010111 \end{array}$$

Thus, one's complement of 101000 is 010111.

We observe that one's complement of a binary number is easily obtained by changing all 1's into 0's and all 0's into 1's of the binary number.

### 3.5.3 2's complement representation

The 2's complement of a binary number is obtained by adding 1 to the 1's complement of the binary number.

Two's complement of a binary number = One's complement + 1

Example 3.23 Consider the binary number 101000. 2's complement of this number is obtained as follows:

One's complement of 101000 = One's complement of 101000 + 1

$$= 010111 + 1$$
$$= 011000$$

Thus, 011000 is the 2's complement of 101000.

Example 3.24

Consider a signed integer -14 to be stored in an 8-bit register.

It can be represented in three ways as follows,

a. Sign-magnitude representation: 1 0001110


b. Signed 1's complement: 0 1110001
Complements all bits of +14 including the sign bit

c. Signed 2's complement: 1 1110010
Take the 2's complement of the +ve no including its sign bit

All modern computers operate based on 2's complement representation because of its hardware being simpler which makes the computer work faster.

## 3.6 Binary arithmetic

It involves addition, subtraction, multiplication and division operations which are fundamental to all digital computers. Binary addition is the most important operation because it can be used to perform other arithmetic operations.

### 3.6.1 Binary addition

The basic rules of binary addition are given in table 3.7:

| Addend1 | Addend2 | Sum | Carry |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |

Table 3.7

The above table adds only two bits and gives sum and carry. If a carry is generated, it should be carried over to the addition of next two bits. Thus the addition is a 3-bit addition.

Table 3.8 gives the rules to add two addend bits and a carry generated from the addition of previous bits.

| Addend1 | Addend2 | Previous carry | Sum | Carry |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 |
| 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 |

Table 3.8

Example 3.25 Add 75 and 18 in binary

75 = 64 + 8 + 2 + 1 = 1001011

18 = 16 + 2 = 10010

Carry ⟶ 1

Addend 1 ⟶ 1001011

Addend 2 ⟶ 10010

Sum ⟶ 1011101

### 3.6.2 Binary Subtraction

It is performed as the addition of negative binary numbers.
For example, 8-5 may be performed as 8+ (-5).

The basic rules for binary subtraction are given in table 3.8.

| Minuend | Subtrahend | Difference | Borrow |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |

Table 3.8

When we subtract a 1 from a 0, it is necessary to borrow 1 from the next left column i.e. from the next higher order position.

**Simple subtraction**

Example 3.27 Add 75 and -25.

75 = 64 + 8 + 2 +1 = 1001011
25 = 16 + 8 + 1 = 11001

| | | |
|---|---|---|
| Borrow | → | |
| Minuend | → | 1001011 |
| Subtrahend | → | 11001 |
| Difference | → | 110010 |

### 3.6.2.1 Subtraction using 1's complement

Though subtraction using borrow is straight, the computer does not use this method due to circuit complications. It does subtraction using complement methods.

**Case1: Subtracting a smaller number from a larger number (minuend is greater than subtrahend)**

Step 1: Find the 1's complement of the subtrahend.

Step 2: Add this to the minuend.

Step 3: Carry is generated. This carry is called as the end around carry.

Step 4: Add the end around carry back to the LSB to get the final difference.

Example 3.28 Subtract 15 from 23 using 1's compliment

| | | |
|---|---|---|
| Minuend | 23 | 10111 |
| Subtrahend | -15 | -01111 |
| | ? | ? |

| | |
|---|---|
| Minuend | 10111 |
| 1's compliment of Subtrahend | +10000 |
| End around carry | **1**00111 |
| Add end carry to LSB | + **1** |
| Difference | 1000 |

**Case 2: Subtracting a larger number from a smaller number (minuend is less than subtrahend).**

Step 1: Find the 1's complement of the subtrahend.

Step 2: Add this to the minuend.

Step 3: There will be no carry. Re-complement the answer to get the difference.

Step 4: Add the end around carry back to the LSB to get the final difference.

Example 3.29 Subtract 52 from 25 using 1's compliment.

| | | |
|---|---|---|
| Minuend | 25 | 011001 |
| Subtrahend | -52 | - 110100 |
| | ? | ? |

| | |
|---|---|
| Minuend | 011001 |
| 1's compliment of Subtrahend | + 001011 |
| | 100100 |

There is no carry. Therefore re-complement and insert a negative sign, we get - 011011

### 3.6.2.2 Subtraction using 2's complements

**Case 1**: Subtracting a smaller number from a larger number (minuend is greater than subtrahend).

Step 1: Find the 2's complement of the subtrahend.

Step 2: Add it to the minuend.

Step 3: Carry is generated. Discard the carry and the remaining bits give the difference.

Example 3.30 Subtract 9 from 17 using 2's complement.

| | | |
|---|---|---|
| Minuend | 17 | 10001 |
| Subtrahend | - 9 | -01001 |
| | ? | ? |

2's complement of 01001 = 1's complement of 01001 + 1

= 10110 + 1

= 10111

| | |
|---|---|
| Minuend | 10001 |
| 2's complement of Subtrahend | +10111 |
| | **1**01000 |

Carry is generated. Discarding the carry, we get 1000 = 8.

**Case 2: Subtracting a larger number from a smaller number (minuend is less than subtrahend).**

Step 1: Find the 2's complement subtrahend.

Step 2: Add it to the minuend.

Step 3: There is no carry. Hence take the 2's complement of the answer and place a negative sign in front.

Example 3.31 Subtract 47 from 26 using 2's complement

| | | |
|---|---|---|
| Minuend | 26 | 011010 |
| Subtrahend | - 47 | - 101111 |
| | ? | ? |

2's complement of 101111 = 1's complement of 101111 + 1
= 010000 + 1
= 010001

| | |
|---|---|
| Minuend | 011010 |
| 2's complement of Subtrahend | + 010001 |
| | 101011 |

2's complement of the answer = -10101 = -21

## 3.7 Computer codes

Computer codes are used for internal representation of data in computers. As computers use binary numbers for internal data representation, computer codes use binary coding schemes. In binary coding, every symbol that appears in the data is represented by a group of bits. Thus computer codes represent various characters, numbers and control keys that the computer user selects on the keyboard. Some of the commonly used computer codes are:

- Binary coded decimal (BCD)
- Extended binary coded decimal interchange code (EBCDIC)
- American standard code for information interchange (ASCII)
- Excess-3 code

### 3.7.1 Introduction to BCD, EBCDIC, ASCII, Excess-3 Codes

One way of encoding decimal numbers digit by digit using group of 4 bits is called BCD code. Two popular 4-bit BCD codes are

#### i. BCD code (or Weighted BCD code or 8421 code)

BCD stands for **B**inary **C**oded **D**ecimal. It is one of the early computer codes. In this coding system, the bits are given from left to right, the weights 8, 4, 2, 1 respectively. Since these weights are just the place values in the binary system, a decimal digit is encoded as its binary representation.

Example 3.32 The decimal number 537 is represented in 4-bit 8421 BCD code as

| 5 | 3 | 7 |
|---|---|---|
| 0101 | 0011 | 0111 |

In 4-bit BCD code only $2^4=16$ configurations are possible which is insufficient to represent the various characters used by computers. Hence 6-bit BCD code was developed by adding two zone positions with which it is possible to represent $2^6=64$ characters.

| Character | BCD code | | | | |
|---|---|---|---|---|---|
| | Zone | Digit | | | |
| A | 01 | 0 | 0 | 0 | 1 |
| B | 01 | 0 | 0 | 1 | 0 |
| C | 01 | 0 | 0 | 1 | 1 |
| D | 01 | 0 | 1 | 0 | 0 |
| E | 01 | 0 | 1 | 0 | 1 |
| F | 01 | 0 | 1 | 1 | 0 |
| G | 01 | 0 | 1 | 1 | 1 |
| H | 01 | 1 | 0 | 0 | 0 |
| I | 01 | 1 | 0 | 0 | 1 |

| Character | BCD code | | | | |
|---|---|---|---|---|---|
| | Zone | Digit | | | |
| J | 10 | 0 | 0 | 0 | 1 |
| K | 10 | 0 | 0 | 1 | 0 |
| L | 10 | 0 | 0 | 1 | 1 |
| M | 10 | 0 | 1 | 0 | 0 |
| N | 10 | 0 | 1 | 0 | 1 |
| O | 10 | 0 | 1 | 1 | 0 |
| P | 10 | 0 | 1 | 1 | 1 |
| Q | 10 | 1 | 0 | 0 | 0 |
| R | 10 | 1 | 0 | 0 | 1 |

| Character | BCD code | | | | |
|---|---|---|---|---|---|
| | Zone | Digit | | | |
| S | 11 | 0 | 0 | 0 | 1 |
| T | 11 | 0 | 0 | 1 | 0 |
| U | 11 | 0 | 0 | 1 | 1 |
| V | 11 | 0 | 1 | 0 | 0 |
| W | 11 | 0 | 1 | 0 | 1 |
| X | 11 | 0 | 1 | 1 | 0 |
| Y | 11 | 0 | 1 | 1 | 1 |
| Z | 11 | 1 | 0 | 0 | 0 |

| Character | BCD code | | | | |
|---|---|---|---|---|---|
| | Zone | Digit | | | |
| 1 | 00 | 0 | 0 | 0 | 1 |
| 2 | 00 | 0 | 0 | 1 | 0 |
| 3 | 00 | 0 | 0 | 1 | 1 |
| 4 | 00 | 0 | 1 | 0 | 0 |
| 5 | 00 | 0 | 1 | 0 | 1 |
| 6 | 00 | 0 | 1 | 1 | 0 |
| 7 | 00 | 0 | 1 | 1 | 1 |
| 8 | 00 | 1 | 0 | 0 | 0 |
| 9 | 00 | 1 | 0 | 0 | 1 |
| 0 | 00 | 1 | 0 | 1 | 0 |

### i. Excess-3 BCD Code or XS-3 Code

The excess–3 BCD code is a non-weighted code and is obtained from 8421 BCD code by adding 3 (0011).

Example 3.33: The decimal number 537 would be represented in the XS-3 code as

| | | | | |
|---|---|---|---|---|
| 5 | 3 | 7 | → | Decimal digit |
| 0101 | 0011 | 0111 | → | 8421 BCD Code |
| 0011 | 0011 | 0011 | → | Add 3 (0011) |
| 1000 | 1010 | 0110 | → | XS-3 Code |

There are 8 bit BCD systems. They are EBCDIC and ASCII.

### iii. EBCDIC code - EBCDIC stands for Extended Binary Coded Decimal Interchange Code

This coding was developed by IBM. It is an 8 bit code and so it has $2^8 = 256$ possible code groups

This coding scheme is used with large computers as mainframes.

| Character | EBCDIC code | | | | |
|---|---|---|---|---|---|
| | Zone | Digit | | | |
| A | 1100 | 0 | 0 | 0 | 1 |
| B | 1100 | 0 | 0 | 1 | 0 |
| C | 1100 | 0 | 0 | 1 | 1 |
| D | 1100 | 0 | 1 | 0 | 0 |
| E | 1100 | 0 | 1 | 0 | 1 |
| F | 1100 | 0 | 1 | 1 | 0 |
| G | 1100 | 0 | 1 | 1 | 1 |
| H | 1100 | 1 | 0 | 0 | 0 |
| I | 1100 | 1 | 0 | 0 | 1 |

| Character | EBCDIC code | | | | |
|---|---|---|---|---|---|
| | Zone | Digit | | | |
| J | 1101 | 0 | 0 | 0 | 1 |
| K | 1101 | 0 | 0 | 1 | 0 |
| L | 1101 | 0 | 0 | 1 | 1 |
| M | 1101 | 0 | 1 | 0 | 0 |
| N | 1101 | 0 | 1 | 0 | 1 |
| O | 1101 | 0 | 1 | 1 | 0 |
| P | 1101 | 0 | 1 | 1 | 1 |
| Q | 1101 | 1 | 0 | 0 | 0 |
| R | 1101 | 1 | 0 | 0 | 1 |

| Character | EBCDIC code | | | | |
|---|---|---|---|---|---|
| | Zone | Digit | | | |
| S | 1110 | 0 | 0 | 0 | 1 |
| T | 1110 | 0 | 0 | 1 | 0 |
| U | 1110 | 0 | 0 | 1 | 1 |
| V | 1110 | 0 | 1 | 0 | 0 |
| W | 1110 | 0 | 1 | 0 | 1 |
| X | 1110 | 0 | 1 | 1 | 0 |
| Y | 1110 | 0 | 1 | 1 | 1 |
| Z | 1110 | 1 | 0 | 0 | 0 |

| Character | EBCDIC code | | | | |
|---|---|---|---|---|---|
| | Zone | Digit | | | |
| 01 | 1111 | 0 | 0 | 0 | 1 |
| 02 | 1111 | 0 | 0 | 1 | 0 |
| 03 | 1111 | 0 | 0 | 1 | 1 |
| 04 | 1111 | 0 | 1 | 0 | 0 |
| 05 | 1111 | 0 | 1 | 0 | 1 |
| 06 | 1111 | 0 | 1 | 1 | 0 |
| 07 | 1111 | 0 | 1 | 1 | 1 |
| 08 | 1111 | 1 | 0 | 0 | 0 |
| 09 | 1111 | 1 | 0 | 0 | 1 |

### i. ASCII code - ASCII stands for American Standard Code for Information Interchange

It is a 7 bit code, which is possible to represent $2^7 = 128$ characters. The first 3 bits are used as zone bits and the last 4 bits indicate the digit. This coding is used to represent alphanumeric and some special characters. It is used in micro computers for data communications. Since microcomputers use 8-bits the ASCII was extended to an 8 bit code.

## ASCII Table and Description

Computers can only understand numbers, so an ASCII code is the numerical representation of a character such as 'a' or '@' or an action of some sort. ASCII was developed a long time ago and now the non-printing characters are rarely used for their original purpose. Below is the ASCII character table and this includes descriptions of the first 32 non-printing characters. ASCII was actually designed for use with

teletypes and so the descriptions are somewhat obscure. If someone says they want your CV however in ASCII format, all this means is they want 'plain' text with no formatting such as tabs, bold or underscoring the raw format that any computer can understand. This is usually so they can easily import the file into their own applications without issues. Notepad.exe creates ASCII text, or in MS Word you can save a file as 'text only'.

| ASCII | Hex | Symbol |
|---|---|---|
| 0 | 0 | NUL |
| 1 | 1 | SOH |
| 2 | 2 | STX |
| 3 | 3 | ETX |
| 4 | 4 | EOT |
| 5 | 5 | ENQ |
| 6 | 6 | ACK |
| 7 | 7 | BEL |
| 8 | 8 | BS |
| 9 | 9 | TAB |
| 10 | A | LF |
| 11 | B | VT |
| 12 | C | FF |
| 13 | D | CR |
| 14 | E | SO |
| 15 | F | SI |

| ASCII | Hex | Symbol |
|---|---|---|
| 16 | 10 | DLE |
| 17 | 11 | DC1 |
| 18 | 12 | DC2 |
| 19 | 13 | DC3 |
| 20 | 14 | DC4 |
| 21 | 15 | NAK |
| 22 | 16 | SYN |
| 23 | 17 | ETB |
| 24 | 18 | CAN |
| 25 | 19 | EM |
| 26 | 1A | SUB |
| 27 | 1B | ESC |
| 28 | 1C | FS |
| 29 | 1D | GS |
| 30 | 1E | RS |
| 31 | 1F | US |

| ASCII | Hex | Symbol |
|---|---|---|
| 32 | 20 | (space) |
| 33 | 21 | ! |
| 34 | 22 | " |
| 35 | 23 | # |
| 36 | 24 | $ |
| 37 | 25 | % |
| 38 | 26 | & |
| 39 | 27 | ' |
| 40 | 28 | ( |
| 41 | 29 | ) |
| 42 | 2A | * |
| 43 | 2B | + |
| 44 | 2C | , |
| 45 | 2D | - |
| 46 | 2E | . |
| 47 | 2F | / |

| ASCII | Hex | Symbol |
|---|---|---|
| 48 | 30 | 0 |
| 49 | 31 | 1 |
| 50 | 32 | 2 |
| 51 | 33 | 3 |
| 52 | 34 | 4 |
| 53 | 35 | 5 |
| 54 | 36 | 6 |
| 55 | 37 | 7 |
| 56 | 38 | 8 |
| 57 | 39 | 9 |
| 58 | 3A | : |
| 59 | 3B | ; |
| 60 | 3C | < |
| 61 | 3D | = |
| 62 | 3E | > |
| 63 | 3F | ? |

| ASCII | Hex | Symbol |
|---|---|---|
| 64 | 40 | @ |
| 65 | 41 | A |
| 66 | 42 | B |
| 67 | 43 | C |
| 68 | 44 | D |
| 69 | 45 | E |
| 70 | 46 | F |
| 71 | 47 | G |
| 72 | 48 | H |
| 73 | 49 | I |
| 74 | 4A | J |
| 75 | 4B | K |
| 76 | 4C | L |
| 77 | 4D | M |
| 78 | 4E | N |
| 79 | 4F | O |

| ASCII | Hex | Symbol |
|---|---|---|
| 80 | 50 | P |
| 81 | 51 | Q |
| 82 | 52 | R |
| 83 | 53 | S |
| 84 | 54 | T |
| 85 | 55 | U |
| 86 | 56 | V |
| 87 | 57 | W |
| 88 | 58 | X |
| 89 | 59 | Y |
| 90 | 5A | Z |
| 91 | 5B | [ |
| 92 | 5C | \ |
| 93 | 5D | ] |
| 94 | 5E | ^ |
| 95 | 5F | _ |

| ASCII | Hex | Symbol |
|---|---|---|
| 96 | 60 | ` |
| 97 | 61 | a |
| 98 | 62 | b |
| 99 | 63 | c |
| 100 | 64 | d |
| 101 | 65 | e |
| 102 | 66 | f |
| 103 | 67 | g |
| 104 | 68 | h |
| 105 | 69 | i |
| 106 | 6A | j |
| 107 | 6B | k |
| 108 | 6C | l |
| 109 | 6D | m |
| 110 | 6E | n |
| 111 | 6F | o |

| ASCII | Hex | Symbol |
|---|---|---|
| 112 | 70 | p |
| 113 | 71 | q |
| 114 | 72 | r |
| 115 | 73 | s |
| 116 | 74 | t |
| 117 | 75 | u |
| 118 | 76 | v |
| 119 | 77 | w |
| 120 | 78 | x |
| 121 | 79 | y |
| 122 | 7A | z |
| 123 | 7B | { |
| 124 | 7C | \| |
| 125 | 7D | } |
| 126 | 7E | ~ |
| 127 | 7F | □ |

## Review Questions

**One mark questions:**

1. Define the **base** of the number system.
2. What is the expansion of **BIT**?
3. Define MSB
4. Define LSB.
5. What is the weight of the LSB of an 8-bit number?
6. What is the weight of the MSB of a 16-bit number?
7. What does BCD stand for?
8. What is the expansion of ASCII?
9. What is the expansion of EBCDIC?
10. What is binary system?
11. What is octal system?
12. What is hexadecimal system?
13. How are negative numbers represented?
14. Write 1's complement of $11010111_{(2)}$
15. Write 2's complement of $11011011_{(2)}$

**Two marks questions:**

1. Specify the general rule for representing number using positional notation in any number system.
2. Mention different types of positional number system.
3. Explain the need of binary number system in computers.
4. What is the importance of hexadecimal system?
5. What is 1's complement? Give an example.
6. What is 2's complement? Give an example.
7. What are computer codes? Give example.
8. Mention the different types of number systems.
9. What is the use of binary number system over decimal number system?
10. Convert $97.188_{(10)}$ to binary.
11. Convert $728.45_{(10)}$ to binary.
12. Convert $1101111.101_{(2)}$ to decimal
13. Convert $2835_{(16)}$ to decimal
14. Convert $789.625_{(10)}$ to octal
15. Convert 4563 in octal to binary.
16. Convert $BED_{(16)}$ to binary
17. Convert 1101.01101in binary to octal.
18. Convert A492.B in hexadecimal to decimal.

19. Convert $512.45_{(10)}$ to hexadecimal.
20. Convert $11011110_{(2)}$ to hexadecimal.
21. Convert $6A9.ABC_{(16)}$ to binary.
22. Add 1010101 and 1010111
23. Explain ASCII code.

**Three marks questions:**

1. Give the Radix of:
   (a) Decimal system (b) Binary system
   (c) Octal system (d) Hexadecimal system
2. Explain 1's and 2's complement with examples.
3. Subtract 36 from 83 using 2's complement.
4. Using 1's complement method, solve $54_{(10)} - 87_{(10)}$
5. Using 2's complement method, solve $73_{(10)} - 25_{(10)}$
6. Add: $64_{(10)} + 35_{(10)}$ using binary addition.

**Five marks questions:**

1. Find $(11001001.1011)_2 = (?)_8 = (?)_{16}$
2. Find $(FADE)_{16} = (?)_8 = (?)_{10}$
3. Explain different types of computer codes.
4. Evaluate: $BEAD_{(16)} = ()_{10} = ()_2 = ()_8$
5. Subtract: $25_{(10)} - 14_{(10)}$ using 1's and 2's complement.
6. Write a brief note on computer codes.
7. Write a note on ASCII code.

# CHAPTER 4

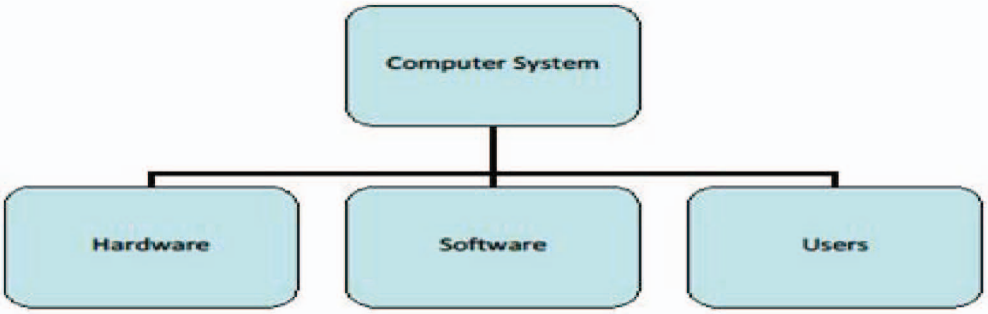
# SOFTWARE CONCEPTS

## OBJECTIVES

- To identify types of software
- Basic of different operating systems

## 4.1 Introduction

A computer system has three components viz. **Hardware**, **Software** and **Users**. Hardware consists of the physical devices and their interconnections for the purpose of storing and executing a program. Pictorially, we have the following overall view about a computer system as in figure 4.1.




**Computer software** or just **Software** is a collection of computer programs and related data that provides the instructions for instructing a computer what to do and how to do it. Software refers to one or more computer programs and data held in the storage of the computer.

We have an interesting example i.e. the processing of information in human brain. Human brain consists of **Neurons**, and Neurons are interconnected with each other. We can say our brain is a **"massively parallel processor".** The process of recalling a face, which a person may not be seen since last thirty years, is a very complex task requiring lots of comparison among similar faces/images stored in his mind. Interestingly, our brain can store approximately $2^{44}$ bits of data.

**Software is the set of programs, procedures, algorithms, and documents concerned with the operation of a data processing system".**

## 4.2 Types of software

Software is broadly grouped into two categories namely,

- **System software**
- **Application software**

### 4.2.1 System software

The objective of system software is to efficiently perform the functions commonly required by most of the users. In order to achieve this objective, these programs are generally written at the machine level using instructions for addressing various registers of the central processing unit. Thus system software

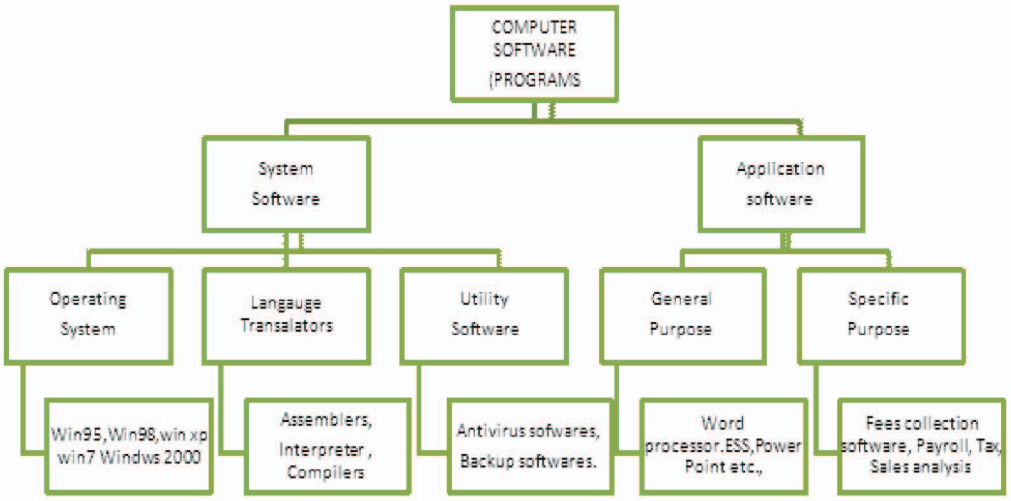



Figure 4.2

is hardware dependent and not portable. Input/output operations are generally performed by systems software. System software provides a convenient environment for program development and execution. Programming languages like assembly language/C/ C++ /Visual C++ /Pascal are used to develop system software.

**System software is a collection of systems programs to perform common tasks.**

### 4.2.2 Application software

Application software consists of user application packages such as Payroll, Inventory, Financial Accounting packages. Application software is generally written in high level languages. These are custom-made although many application packages for word processing, Data base management and spreadsheet are used by millions of users all over the world. Being hardware independent these are portable.

Examples of application software are Microsoft Office, Open Office, Oracle, Sybase, Informix, Ingress, DB2, Tally etc.

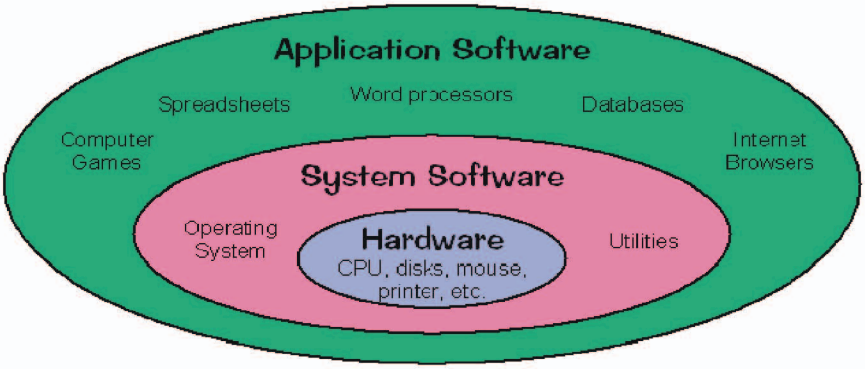
System software is of three types:

- Operating system
- Language translators (Assemblers, compilers, interpreters, Linkers and loaders)
- Utilities

## 4.3 Introduction to Operating system

An operating system is a set of program modules which provides a friendly interface between the user and the computer resources such as processors, memory, input/ output devices and information (files).

Operating systems manages these resources, resolves conflicts and tries to optimize the performance of the system. Generally part of the operating system resides in memory and supervises execution of all other programs executed on the computer. The user communicates with the computer through operating system commands and program instructions. It plays an important role in loading programs from disk into memory, displaying messages, translating programs and in outputting results. Basically, it executes the user programs without letting the user bother about the detailed steps involved in executing them.




Some examples of operating systems are: Unix operating system, OS/2, Linux Operating system, Sun Solaris, MS-DOS(Microsoft disk operating system), Microsoft Windows operating systems such as Windows 95, Windows 98, Windows 2000, Windows NT, Windows XP, Windows Vista, Windows 7, Windows 8, Windows 2000 server, 2003 server, 2008 server, .NET server, Android, Mac OS.

**An operating system is a set of programs which acts as an interface between the user and the computer**

Let us now discuss in short all the terminologies which is dealt with Operating system.

## Computer languages

Language is a medium of communication. If we have to communicate with the computer, we require a suitable language understandable by the computer. Such a language is called programming language or computer language. Using a programming language a user instructs the computer what it should do.

**Programming language is a set of rules called syntax which the user has to follow, to instruct the computer what operations are to be performed.**

Computer languages are classified into two categories:

**Low level languages**

**a) Machine level language**

**b) Assembly language**

**High level languages**

**1. General purpose high level language**. Ex: BASIC, Pascal, C languages

2. **Specific purpose high level language**

Ex: COBOL (specific for business applications)

Ex. FORTRAN (specific for scientific applications)

Ex. C++ (specific for object oriented programming)

## ■ Machine level language

Machine language is the only language of the system, and these are sequence of machine instructions. These instructions are externally represented by a sequence of 0's and 1's, and stored internally as a sequence of voltage levels (high/low) in primary memory (RAM). As general programmers come across many difficulties such as remembering of such a large sequence of 0's and 1's which is very difficult to program, debug, it requires lot of experience and knowledge about the internal architecture of the system. In spite of all these odds it is the fastest because no translation is required, and we can program each bits and bytes.

**Example 4.1** Sample machine language program to add two numbers

0001 00110010: Load the data

0100 10100101: Add the contents

1000 00101001: Store the results

0000 00000000: Stop

In our example 4.1 the first (most significant) 4-bits represent opcodes denoting the operation, or action such as load, move etc. and the last 8-bits (least significant) represents the operand denoting the address. **Advantages** of machine language are machine language instructions can be directly typed and executed and no compilation or translation is required. **Disadvantages** of machine language are machine language instructions are machine dependent and it is difficult to program, modify and debug errors.

## ■ Assembly Language

The disadvantages of a machine language lead to the development of a new programming language which uses symbolic instructions called as assembly language. The burden of remembering a lengthy machine code was reduced, and instead replaced them with symbolic codes. These symbolic instruction codes of machine language are referred to as the **mnemonics.** Some of the mnemonics are given in example 4.2 below.

**Example 4.2**

ADD for addition
SUB for subtraction
MUL for Multiplication
STA for storing value in accumulator
HALT for Halt

Since, the above instructions are English-like; the computer does not understand instructions. Therefore, the instructions have to be translated to

the equivalent machine codes. This process is carried out by a program called **assembler.**

**Advantages** :Assembly language are assembly language which has mnemonic code is easy to remember, easy to understand and write the assembly program and easy to modify and debug the assembly program.
**Disadvantages** : Assembly language are the mnemonics are machine dependent and assembly language programming takes longer to code.
**Assembly language is a symbolic language in which mnemonics are used to code operations and characters are used for address.**

### High level languages

The high level languages were developed to overcome the difficulties of low level languages. The high level languages are English-like languages and are machine independent. The programming language that is more concerned with the problem specification and not oriented towards the details of a computer is called High level languages (HLLs). Some of the High Level Languages are BASIC, COBOL, FORTRAN, PASCAL, C, C++ and JAVA.

**Advantages** : High level language are HLLs are machine independent, easy to learn and understand, easy to write the program using HLL as it does not require the knowledge of the internal structure of the computer and easy to debug and modify the program.
**Disadvantages :** High level language are HLL lacks flexibility because the features of HLL always occur and are not under the control of the programmer. HLL is slower in execution due to the generality of the statements and that they are portable between different machines but with suitable compiler. HLL requires a translator or a compiler to convert source code to object code. HLL programs take more time to execute and require more memory. Hence becomes less efficient.

### Language Translators

Language translators perform the translation of high level language program or assembly language program into machine language. These language translators even check for some types of errors that may be present in the program being translated.


There are three types of translator programs:

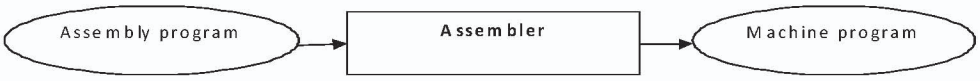
- Assembler
- Compiler and
- Interpreter

**Assembler** is the translator for assembly language. Assembly language requires translation of English like statements to machine language. The system

software Assembler will check for the syntax and semantics of code and translate it into its equivalent machine code also known as object code.

The following are some of the generally used assemblers **TASM** (Turbo assembler), **MASM** (Microsoft Macro assembler), **as** (Unix. assembler), **FASM** (Flat Assembler), **NASM** (Net wide assembler) and many others.

**Assembler is system software which translates programs written in assembly language into machine language.**




**Compiler** is the language translator for translating high level language **source code** into machine code known as **object code**. A compiler will check the entire source code for syntax and semantic errors line by line and produces an executable file only if it is free from all errors.

Compiler is system software that translates source code written in high level language into object code which is in machine language.

. **Interpreter**

As discussed above the process of compilation consumes lot of memory and so systems with less amount of RAM always prefer interpreters where the source code is analyzed line by line and executed immediately, and it reduces the need of larger RAM capacity. Source level debugging also becomes easier when compared to compiled one, but overall execution time is more compared to a compiled program, because during execution we require both source code and Interpreter, and translation is required afresh. This invites security problems also.

All system specific software will use compiled program, because it does not require a recompilation of source code. The earlier versions of COBOL, FORTRAN used interpreters for translation now they have compilers for translation. Web application languages are mainly dependent on Interpreters, for example java is an interpreted language. It requires JVM (java virtual machine) for running web applications. C/ C++/Visual C++ are compiler dependent languages due to their inherent application nature.

**Interpreter is a language processor that translates an instruction of a high-level language program and immediately executes it before translating the next instruction of the source program.**

Ø **Utilities**

Utilities are those helpful programs that assist the computer by performing useful functions (housekeeping functions) like backing up disk or scanning/cleaning viruses or arranging information etc. Utility software is generally called as **Application oriented ready-made system programs**. Some of the important utilities are: Text Editor, Backup Utility, Compression Utility, Disk defragmenter, Antivirus Software.

**Linkers and loaders**

A source program written in high-level language may contain a number of modules or segments. For the program to be executed properly the modules are to be linked properly and the various library segments included so that execution of the program is sequential. This operation is performed by software called as the **linker**.

**A linker is system software which links the modules or program segments together so that they can be executed properly with proper reference.**

The output of the linker is a single program, which includes all the modules and the entire library required for execution. The linker is thus responsible for generating the executable code of a program.

Once an executable program is generated someone will have to load the program into the main memory of the computer so that it can be executed. This operation is performed by system software called as the **loader**. It actually places the object code from secondary memory storage into main memory and starts execution

**A loader is system software which accepts the object program produced by the compiler or assembler and prepares these programs for execution.**

## 4.4 Functions of operating systems

Operating system is a large and complex software consisting of several components. Each component of the operating system has its own set of defined inputs and outputs. Different components of OS perform specific tasks to provide the overall functionality of the operating system. Main functions of the operating system are as follows:

**4.4.1 Memory Management**— The activities of memory management handled by OS are—

i Allocate memory,
ii Free memory,
iii Re-allocate memory to a program when a used block is freed, and
iv Keep track of memory usage.

**4.4.2 Process Management**— The process management activities handled by the OS are—

(1) Control access to shared resources like file, memory, I/O and CPU.
(2) Control execution of applications.
(3) Create, execute and delete a process (system process or user process).
(4) Cancel or resume a process.
(5) Schedule a process.
(6) Synchronization, communication and deadlock handling for processes.

**Process is defined as a program in execution.**

**4.4.3 Device management**— The device management tasks handled by OS are—

(1) Open, close and write device drivers, and
(2) Communicate, control and monitor the device driver.

**4.4.4 File Management**— The file management tasks include—
(1) Create and delete both files and directories,
(2) Provide access to files,
(3) Allocate space for files,
(4) Keep back-up of files, and
(5) Secure files.

**4.4.5 Protection and Security**— OS protects the resources of system. User authentication, file attributes like read, write, encryption, and back-up of data are used by OS to provide basic protection.

**4.4.6 User Interface or Command Interpreter**— Operating system provides an interface between the computer user and the computer hardware. The user interface is a set of commands or a graphical user interface via which the user interacts with the applications and the hardware.

## 4.5 Types of operating systems

Based upon the time constraints and service requirements or criticality every operating system will come under one of the following groups namely, batch operating system, online operating system, and Real time operating system.

The different types of operating systems are

1. Single user operating system
2. Batch operating system
3. Multiprogramming operating system
    a. Multitasking Operating system
    b. Multiuser operating system
    c. Time sharing systems (online / multiuser)
    d. Real time system
4. Distributed operating system
5. Network operating system
6. Multithreading operating system

### 4.5.1 Single user operating system

This OS allows only one user to share the system resources including the CPU. These are mainly the operating systems configured for the use of desktop personal computers and Laptops. DOS and windows-95, windows-98, Apple Macintosh etc. are examples for such systems. However, all others except DOS has ability called context switching allowing it to operate on multiple program windows/applications.

### 4.5.2 Batch operating systems

Batch operating systems usually allow little or no interaction between users and executing programs. It requires programs, data and necessary commands (Job Control Language-JCL) to be submitted in the form of a job. It has a better potential for resource utilization compared to simple serial systems serving multiple users. This is well suited for applications with large computation time and no user interaction. Payroll, forecasting, statistical analysis and large scientific number crunching programs are examples for its usage.

Users need not wait during its execution. Batch operating systems will function in FIFO (first in first out) order. The main disadvantages of batch operating systems are Non-interactive mode of execution and Offline debugging.

IBM System/360 operating system (OS/360) for IBM system/360, is an example for batch processing operating systems. In DOS we can emulate the batch processing using .BAT files.

### 4.5.3 Multiprogramming operating systems

Multiprogramming is the capability of CPU to execute two or more programs concurrently. This capability is accomplished through the operating system. Essentially, two or more programs are stored concurrently in primary storage, and the CPU moves from one program to another, partially executing each in turn. Early computer system and many personal computers execute program in the order in which it is read into the system, and only one program is executed at a time.

### 4.5.4 Multitasking operating systems

A multitasking operating system is distinguished by its ability to support concurrent execution of two or more processes. A process or task is an instance of a program in execution. Multitasking is usually implemented by code and data of several programs in memory simultaneously and multiplexing

processor and I/O devices among them. Multitasking is also called context switching. Multitasking usually refers to a single user. Example: Windows 98 and some real time systems.

### 4.5.5 Multi-user operating system

Multitasking with sophisticated memory protection and enforcement of concurrency control among processes which try to access shared resources such as I/O devices and files are called multiprogramming operating systems. Since it supports multiple users, it is also known as Multi-user operating system. It creates and maintains individual user environments, individual authentication and security levels/privileges, provides per user resource usage accounting. Due to these reasons we can say Multiprogramming /Multitasking implies multitasking but the converse need not be true. We have systems with more than one processors, each processor can be multitasked. So in purely multiuser/multiprogramming system processor is also a resource.

### 4.5.6 Time-Sharing systems

Time-sharing is a popular representative of multiprogramming and multi-user systems. Large CAD and text processing systems belongs to this category. Good terminal response is one of the main objectives of such systems providing an illusion of total dedication. Time-sharing systems provide equitable sharing of common resources. Most of the time-sharing operating systems adopted time-slicing/round robin scheduling algorithm. Each user/process will receive a portion of the time slot.

UNIX and its flavors, Windows Server are the best examples for multiprogramming, multi-user and time sharing systems.

### 4.5.7 Real-time systems

Real time systems are used in environments where a large number of events, mostly external to the computer system, must be accepted and processed in a very short time or within certain deadlines. Such applications include industrial control, telephone and switching equipment, flight control, real-time simulations and military applications. The primary objective of real-time systems is to provide quick event-response times and thus meeting the scheduling deadlines. User convenience and resource utilization are of secondary concern to real time systems design.

Lynx OS, Windows CE are examples for real-time operating systems.

### 4.5.8 Distributed operating systems

A distributed operating system is a collection of autonomous computer systems capable of communication and cooperation via their software and hardware interconnections.

For example, if we have 'n' systems in a distributed environment then the distributed operating system helps us in balancing the load by sharing processors, I/O devices, and memory etc. without the knowledge of the user. The end user will get his output on his terminal. This has a very reliable mode of operation.

The ATM (Automatic Teller Machine) centers of a bank are a classic example of application of distributed operating systems.