Chapter-5

PROBLEM SOLVING METHODOLOGY

➢ Introduction

- The term problem solving is used in many disciplines, sometimes with different perspectives and often with different terminologies.
- The problem-solving process starts with the problem specification and end with a correct program.
- The steps to follow in the problem-solving process are:
    - ♦ Problem definition
    - ♦ Problem Analysis
    - ♦ Algorithm development
    - ♦ Coding
    - ♦ Testing & Debugging
    - ♦ Documentation & Maintenance
- The stages of analysis, design, programming, implementation and maintenance form the life cycle of the system.

➢ Problem definition:

- This step defines the problem thoroughly. Here requirements are specified. This step includes understanding the problem very well. The problem solver must understand problem very well to solve problem efficiently.

➢ Problem Analysis:

- Analyzing the problem or analysis involves identifying the following:
    - ♦ Inputs, i.e. the data you have to work with.
    - ♦ Outputs i.e. the desired results.
    - ♦ Any additional requirements on the solutions.

➢ ALGORITHM

- **An Algorithm is a step-by-step procedure to solve a given problem.**
- The word algorithm originates from the word ‘algorism’ which means process of doing arithmetic with Arabic numerals.

- In 9th-century Arab Mathematician, **Mohammed Al-Khowarizmi**, who developed methods for solving problems which is, used specific step-by-step instructions.

✓ **Characteristics of algorithm:**

- A well defined algorithm has the five basic characteristics; as follows
  1. **Input**: Algorithm starts with procedural steps to accept input data. The algorithm must accept one or more data to be processed.
  2. **Definite**: Each operational step or operation must be definite i.e. each and every instruction must clearly specify that what should be done.
  3. **Effective**: Each operational step can at least in principle is carried out by a person using a paper and pencil in a minimum number of times.
  4. **Terminate**: After some minimum number operation algorithm must come to an end.
  5. **Output**: An algorithm is written to solve the problem, therefore it must produce one or more computed result or answer called output.

Example: An algorithm to find the area of a rectangle can be expressed as follows:

- Given the length l and the breadth b, this algorithm finds the area of rectangle rec.

```
Step 1:     START
Step 2:     [Read the vales of l, b]
            INPUT l, b
Step 3:     [Calculate are of rectangle]
            rec = l * b
Step 4:     [Print the area of rectangle]
            OUTPUT rec
Step 5:     [End of Algorithm]
            STOP
```

In the above example, we used = that represents assignment.

1. Design an algorithm to find the average of four numbers

```
Step 1:     START
Step 2:     INPUT A, B, C, D
Step 3:     [Calculate]    AVG = (A+B+C+D)/4
Step 4:     OUTPUT AVG
Step 5:     STOP
```

2. **Design an algorithm to calculate the Simple Interest, given the Principal (P), and Rate (R) and Time (T)**

```
Step 1:     START
Step 2:     INPUT P, T, R
Step 3:     [Calculate]    SI = (P*T*R)/100
Step 4:     OUTPUT SI
Step 5:     STOP
```

3. **Design an algorithm to find the greatest of three number (A, B, C)**

```
Step 1:     START
Step 2:     INPUT A, B, C
Step 3:     [Assign A to large]
            Large = A
Step 4:     [Compare large and B]
            If( B > large )
                Large = B
            Endif
Step 5:     [Compare large and C]
            If( C > large )
                Large = C
            Endif
Step 6:     [Print the largest number]
            OUTPUT large
Step 7:     STOP
```

4. **Design an algorithm to find factorial of a number (N)**

```
Step 1:     START
Step 2:     INPUT N
Step 3:     [Initialize factorial to 1]
            Fact = 1
Step 4:     [compute the factorial by successive multiplication]
            Repeat for I = 1 to N
                Fact = Fact * I
            [End of Step 4 for loop]
Step 5:     [Print factorial of given number]
            OUTPUT Fact
Step 6:     STOP
```

5. Design an algorithm to find Fibonacci series (N)

```
Step 1:     START
Step 2:     INPUT N
Step 3:     [Initialize the variables]
            First = 0
            Second = 1
            Term = 2
Step 4:     [Print the values of first and second]
            PRINT First, Second
Step 5:     Third = First + Second
Step 6:     Repeat while ( term <= N )
                PRINT Third
                First = Second
                Second = Third
                Third = First + Second
                Term = Term + 1
            [End of While loop]
Step 7:     STOP
```

6. Design an algorithm to find the GCD of two numbers (A, B)

```
Step 1:     START
Step 2:     INPUT A, B
Step 3:     Repeat while ( B != 0 )
                Rem = A % B
                A = B
                B = Rem
             [End of While loop]
Step 4:     [Print the last divisor]
            PRINT A
Ste 5:      STOP
```

✓ Advantage of Algorithm

1. It is a step-by-step representation of a solution to a given problem, which is very easy to understand.
2. It has got a definite procedure, which can be executed within a set period of time.
3. It is independent of programming language.
4. It is easy to debug as every step has got its own logical sequence.

✓ **Disadvantage of Algorithm**

- It is time-consuming
- An algorithm is developed first which is converted into a flowchart and then into a computer program.

✓ **Analysis of Algorithm**

- There may be more than one approach to solve a problem. The choice of a particular algorithm depends on the following performance analysis and measurements.
    - **Space complexity**: The amount of memory needed by the algorithm to complete its run.
    - **Time Complexity**: The amount of time, the algorithm needed to complete its run.
- When we analyze an algorithm depends on input data, there are three cases
    - Best Case
    - Average Case
    - Worst Case

➢ FLOWCHART

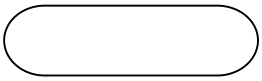
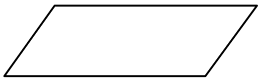
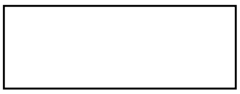
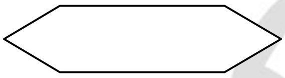
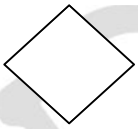
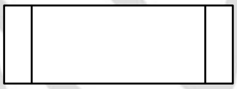
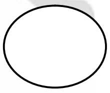
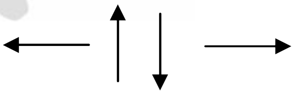
- **A Flowchart is a pictorial or graphical representation of an algorithm.**
- Flowchart plays an important role in the programming of a problem and helpful in understanding the logic of program.
- Once the flow chart is drawn, it becomes easy to write program in any high level language.
- Flowcharts are classified into two categories:
    1. Program Flowcharts
    2. System Flowcharts
- **Program flowcharts** present a diagrammatic representation of a sequence of instructions for solving a program.
- **System flowcharts** indicate the flow of data throughout a data processing system, as well as the flow into and out of the system. Such flowcharts are widely used by designers, to explain a data processing system.

✓ **Importance of Flowchart**

1. **Communication**: Flowcharts are better way of communication of the logic of a program.
2. **Effective Analysis**: With the help of flowchart, problem can be analyzed in more effective way.
3. **Proper documentation**: Program flowcharts serve as a good program documentation, which is needed for various programs.

4. **Efficient coding**: The flowchart acts as guide or blueprint during the system analysis and program development phase.
5. **Proper Debugging**: The flow chart helps in debugging process.
6. **Efficient program maintenance**: The maintenance of a program become easy with the help of flowcharts.

✓ **Symbols Used In Flowcharts**

SYMBOLS	**PURPOSE**
	**TERMINAL (START or STOP)** The beginning, end, or point of interruption in a program
	**INPUT OR OUTPUT** Input or Output data or information
	**PROCESSING** An instruction or group of instructions which changes the program
	**PREPARATION**[Looping] An instruction or group of instructions which changes the program
	**DECISION or BRANCHING** Represents a comparison, a question or a decision that determinates alternative paths to be followed
	**PREDEFINED PROCESS** A group of operation not detailed in the particular set of flowcharts
	**CONNECTOR** An entry form, or an exit to the another part of the program flowchart
	**FLOW DIRECTION** The direction of processing or data flow.

Example: Design a flow chart and an algorithm to find the area of a square.

Step 1: START

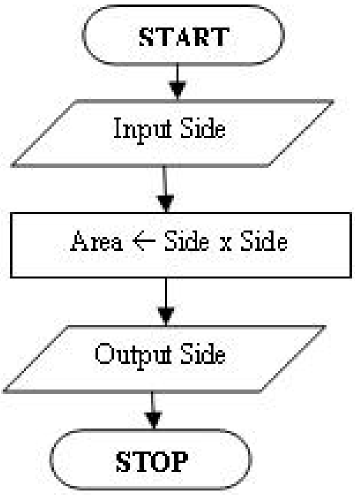
Step 2: INPUT Side

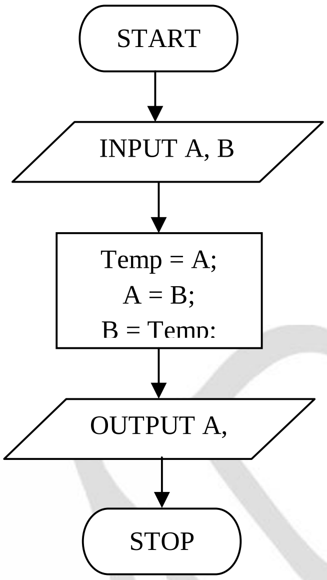
Step 3: [Calculate Area]

Area = Side * Side

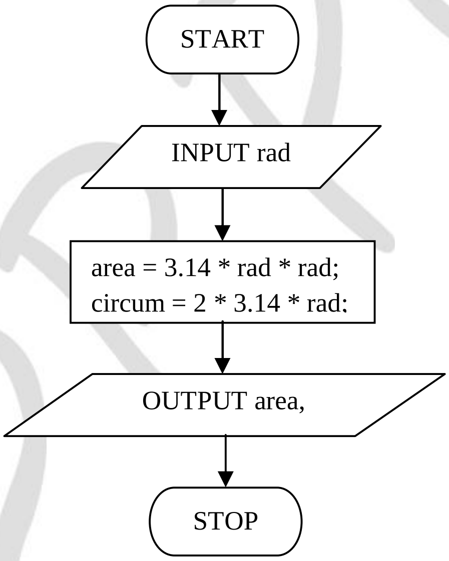
Step 4: OUTPUT Area

Step 5: STOP

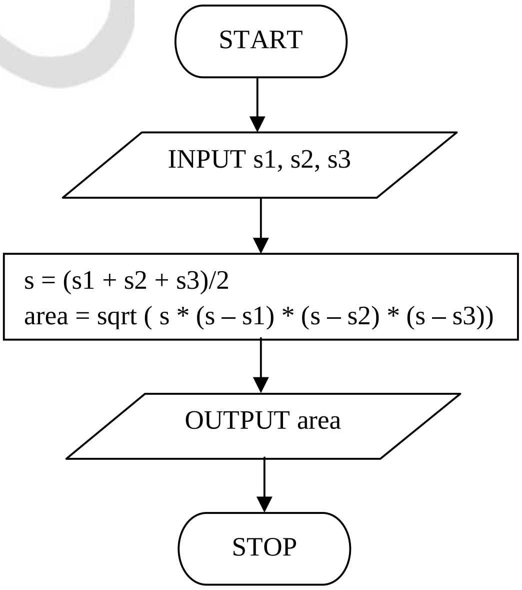




Swap 2 Number



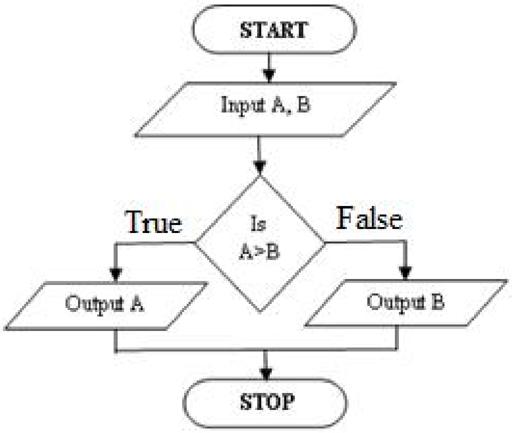
area of Circle & Circumference



Area of triangle

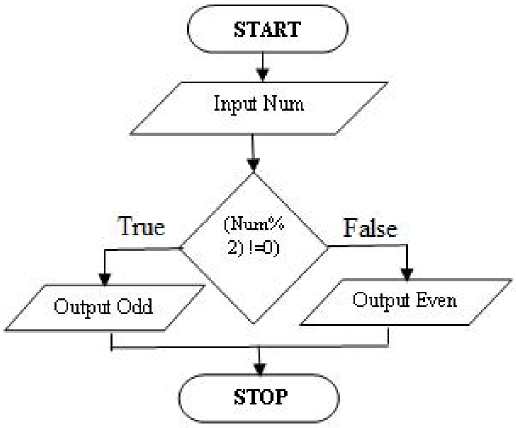
1. Write a program, design a flow chart and an algorithm to find the larger of two numbers.

```
Step 1:     Start
Step 2:     Input A and B
Step 3:     If(A>B) then
                Output A
            Else
                Output B
            [End if]
Step 4:     Stop
```



2. **Write a program, design a flow chart and an algorithm to find given number is odd or even.**

```
Step 1:     Start
Step 2:     Input Num
Step 3:     If((Num%2)!=0) then
                  Output Odd
            Else
                  Output Even
            [End if]
Step 4:     Stop
```



♦ **Advantage of Flowcharts**

1. Flowcharts provide an excellent means of communication, which is very easy to understand.
2. It has got a definite procedure, which shows all the major parts of a program, It is easy to convert it into a program.
3. It is independent of programming language.
4. It is easy to debug as every step has got its own logical sequence.

♦ **Disadvantages of Flowcharts**

1. It is time-consuming and it requires the uses of a number of symbols which are to be properly represented.
2. The represented of complex logic is difficult in a flowchart.
3. Alterations and modifications can be only made by redrawing the flowcharts.

➢ Pseudo code:

- This is an abstract representation of program in English statement.
- In pseudo code English words & phrases are used to represent operations.
- **Advantages:** Easy to read, understand & modify.

➢ Coding or Programming

- **The process of writing program instructions for an analyzed problem in a programming language.**
- It is the process of translating the algorithm or flowchart into the syntax of given purpose language.
- You must convert each step of the algorithm into one or more statements in a programming language such as C, C++, and Java etc.

➢ Testing and Debugging

- **Testing is the process of checking whether the program works according to the requirement of the user.**
- **Debugging is the process of identifying and correcting or removing the Bugs (errors).**
- There are four types of errors. They are
  - ♦ Syntax errors
  - ♦ Run-time errors
  - ♦ Semantic errors
  - ♦ Logic errors (bugs)

✓ Syntax Error

- **Syntax is the set of rules which should followed while creating the statements of the program.**
- The grammatical mistakes in the statements of the program are called syntax errors.
- Example:

```
void main( )
{
        int a, b;
        cout << ‘Enter the numbers” ;
        cin >> a >> b;
        cout << a + b
}
```

- In the example program, the fourth statement produces an syntax error as the missing semicolon.

✓ Run-time Error

- **During execution of the program, some errors may occur. Such errors are called run-time errors.**
- Example: Divide by zero.

✓ Semantic Error

- **An error, which occurs due to improper use of statements in programming language.**
- Consider an expression C = A + B, indicating the values of the variable A and B are added and assigned to variable C.
- If we written A + B = C, through the values of A and B are added, it cannot be assigned to variable C written to the right of = Sign.
- This is semantic error.

✓ **Logical Error**

- **Logical errors occur when there are mistakes in the logic of the program.**
- Unlike other errors logical errors are not displayed while compiling because the compiler does not understand the logic of the program.
- Example: To find the area of the circle, the formula to be used is area = 3.14 * r * r. But if we written area = 3.14 * 2 * r, then the required output is not obtained even though the program is successfully executed.

➢ Documentation and Maintenance

- **Documentation is a reference material which explains the use and maintenance of the program application for which it has been written.**
- There are two types of documentation.
  - Internal Documentation
  - External Documentation.

✓ **Internal Documentation:**

- This is also known as technical documentation.
- It is meant for the programmer who may update the program code at later stages.
- It is done by:
  - Defining meaningful variable names.
  - Including comments in program code.
  - Presenting the program code clearly.

✓ **External Documentation:**

- The program or application is supported with additional textual information about the application.
- It is useful for the user, administrator or developer.

➢ Maintenance:

- **Program maintenance means periodic review of the programs and modifications based on user's requirements.**
- Maintenance is a continuous task
- Documentation plays an important role in program maintenance. It helps speedy and efficient maintenance.

➢ Programming Constructs

- **A programming constructs is a statement in a program.**
- There are 3 basic programming constructs.
  - Sequential Constructs
  - Selection Constructs
  - Iteration Constructs

✓ Sequential Constructs:

- The program statements are executed one after another, in a sequence.
- Sequential constructs are:
  - Input Statement
  - Assignment Statement
  - Output Statement

❖ Input Statement

- This statement is used to input values into the variables from the input device.
- Example: INPUT A, B, C

❖ Assignment Statement

- This statement is used to store a value in a variable.
- In many languages '=' is used as the assignment operator.
- Example:

```
A = 10;
B = 5;
C = A + B;
```

❖ Output Statement

- This statement is used to display the values of variables on the standard output device.
- Example: OUTPUT C;

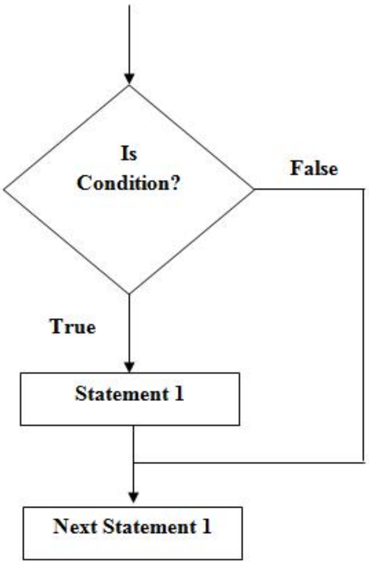
✓ Selection construct

- It is also known as conditional construct.
- This structure helps the programmer to take appropriate decision.
- There are five kinds of selection constructs, viz.
  - Simple – if
  - if – else
  - if – else – if
  - Nested – if
  - Multiple Selection

❖ Simple - if :

- This structure helps to decide the execution of a particular statement based on a condition.
- This statement is also called as **one-way branch**.
- The general form of simple – if statement is:

```
if (Test Condition)        // This Condition is true
        Statement 1;
Statement 2;
```



- Here, the test condition is tested which results in either a TRUE or FALSE value. If the result of the test condition is TRUE then the Statement 1 is executed. Otherwise, Statement 2 is executed.

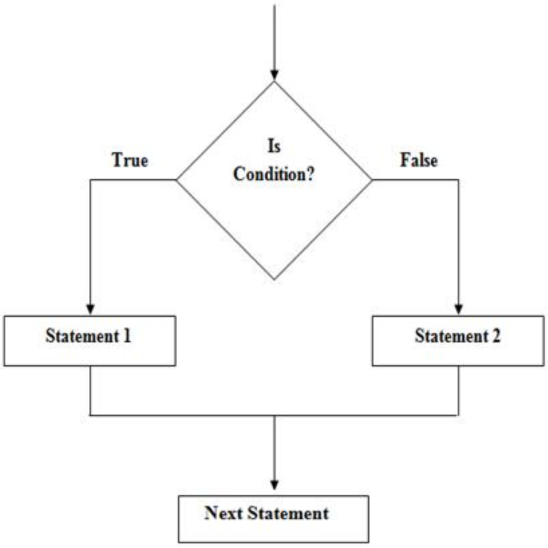
Ex:

```
if( amount > = 5000 )
        discount = amount * (10/100);
net-amount = amount – discount;
```

❖ if – else statement :

- This structure helps to decide whether a set of statements should be executed or another set of statements should be executed.
- This statement is also called as **two-way branch.**
- The general form of if – else statement is:

```
if (Test Condition)
        Statement 1;
else
        Statement 2;
```



- Here, the test condition is tested. If the test-condition is TRUE, statement-1 is executed. Otherwise Statement 2 is executed.

Ex:

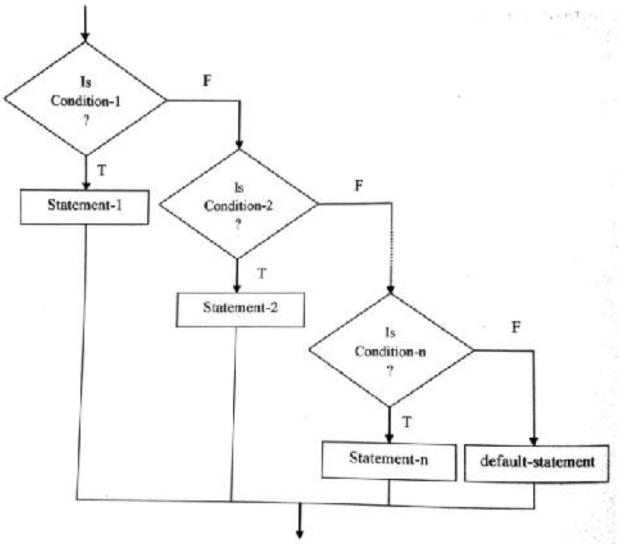
```
if( amount > = 5000 )
        discount = amount * (10/100);
else
        discount = amount * (5/100);
```

❖ if – else - if statement :

- This structure helps the programmer to decide the execution of a statement from multiple statements based on a condition.
- There will be more than one condition to test.

- This statement is also called as **multiple-way branch.**
- The general form of if – else – if statement is:

```
if (Test Condition 1)
        Statement 1;
else
        if (Test Condition 2)
                Statement 2;
        else
                ………..
                else
                        if( test Condition N)
                                Statement N;
                        else
                                Default Statement
```



- Here, Condition 1 is tested. If it is TRUE, Statement 1 is executed control transferred out of the structure. Otherwise, Condition 2 is tested. If it is TRUE, Statement 2 is executed control is transferred out of the structure and so on.
- If none of the condition is satisfied, a statement called default statement is executed.
- **Example:**

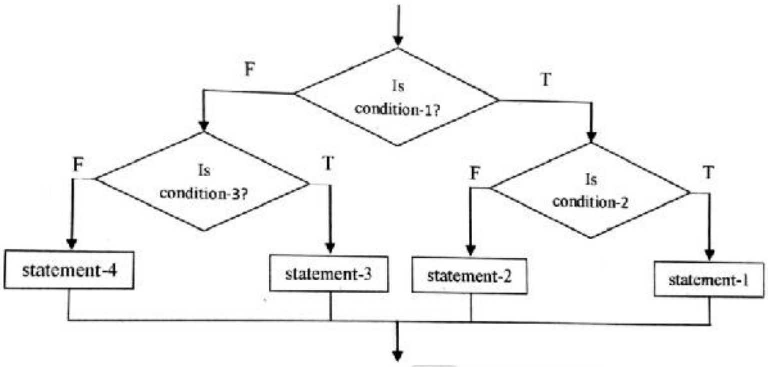
```
if( marks > = 85 )
        PRINT "Distinction"
else
        if( marks > = 60 )
                PRINT "First Class"
        else
                if( marks > = 50 )
                        PRINT "Second Class"
                else
                        if( marks > = 35 )
                                PRINT "Pass"
                        else
                                PRINT "Fail"
```

❖ Nested if statement :

- The statement within the if statement is another if statement is called Nested – if statement.
- The general form of Nested – if statement is:

```
if (Test Condition 1)
        if (Test Condition 2)
```

```
                Statement 1;
        else
                Statement 2;
else
        if (Test Condition 3)
                Statement 3;
        else
                Statement 4;
```



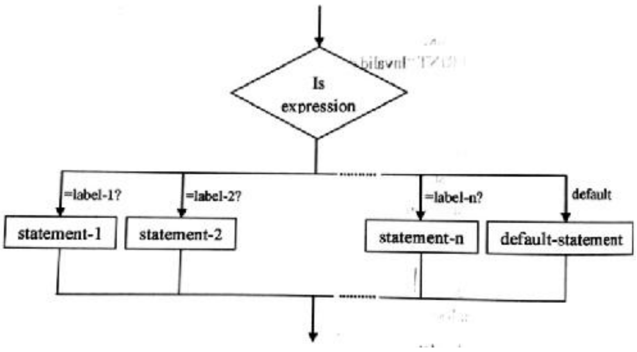
Ex: To find the greatest of three numbers a, b and c.

```
        if ( a>b )
                if ( a > c )
                        OUTPUT a
                else
                        OUTPUT c
        else
                if ( b > c )
                        OUTPUT b
                else
                        OUTPUT c
```

❖ Multiple Selection constructs or Switch statement :

- If there are more than two alternatives to be selected, multiple selection construct is used.
- The general form of Switch statement is:

```
Switch ( Expression )
{
        Case Label-1:           Statement 1;
                                Break;
        Case Label-2:           Statement 1;
                                Break;
                                …………..
        Case Label-N:           Statement N;
                                Break;
        Default         :       Default- Statement;
}
```



- **Ex**: To find the name of the day given the day number

```
Switch ( dayno )
{
        Case 1:         PRINT "Sunday";
                        Break;
        Case 2:         PRINT "Monday";
                        Break;
        Case 3:     PRINT "Tuesday";
                    Break;
        Case 4:     PRINT "Wednesday";
                    Break;
        Case 5:     PRINT "Thursday";
                    Break;
        Case 6:     PRINT "Friday";
                    Break;
        Case 7:     PRINT "Saturday";
                    Break;
        default:    PRINT "Invalid Day Number";
    }
```

✓ **Iterative Constructs or Looping**

- **The process of repeated execution of a sequence of statements until some condition is satisfied is called as iteration or repetition or loop.**
- Iterative statements are also called as repetitive statement or looping statements.
- There are two iterative constructs, viz.
  - Conditional Looping
  - Unconditional Looping

❖ **Conditional Looping :**

- This statement executes a group of instructions repeatedly until some logical condition is satisfied.
- The number of repetitions will not be known in advance.
- The two conditional looping constructs are:
  - **While**
  - **do while**

❖ **Unconditional Looping :**

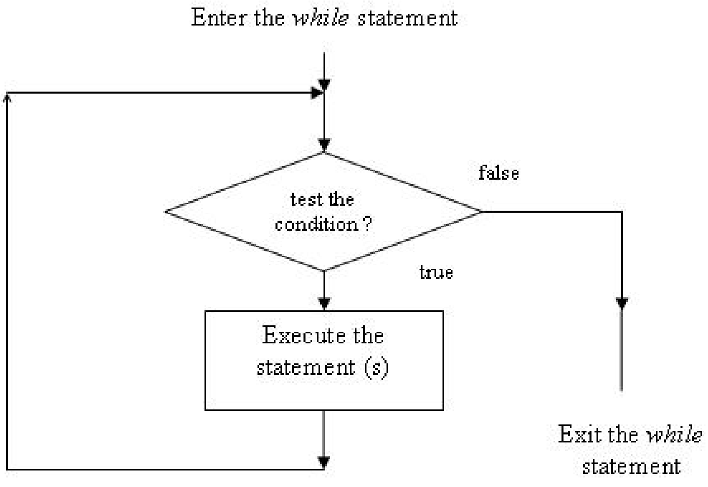
- This statement executes a group of instructions is repeated for specified number of times.
- The unconditional looping constructs is **for** statement.

✓ **While Constructs:**

- This is a **pre-tested loop** structure.
- This structure checks the condition at the beginning of the structure.
- The set of statements are executed again and again until the condition is true.
- When the condition becomes false, control is transferred out of the structure.
- The general form of while structure is

```
While ( Test Condition)
```

```
        Statement 1
        Statement 2
        ……..
        Statement N
    End of While
```


Enter the *while* statement
test the condition ?
false
true
Execute the statement (s)
Exit the *while* statement

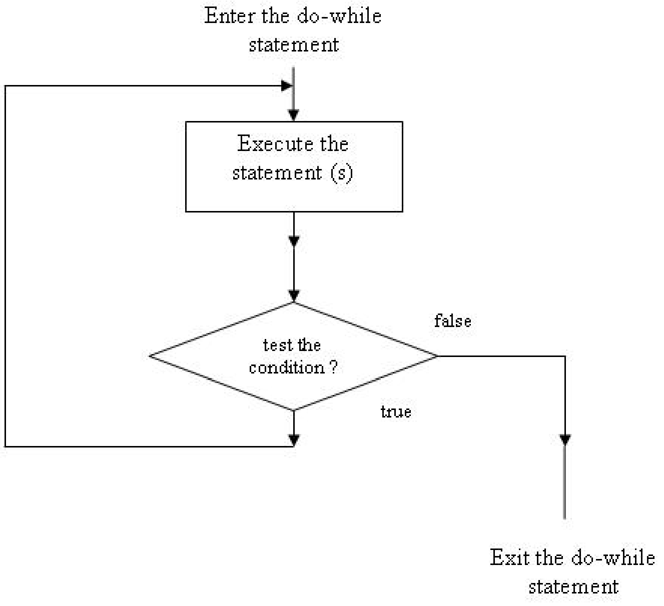
- Example:

```
        i = 1;
        While ( i < = 5)
                PRINT i;
                i = i + 1;
        end of while
        Output: 1 2 3 4 5
```

✓ **do while Constructs:**

- This is a **post-tested loop** structure.
- This structure checks the condition at the end of the structure.
- The set of statements are executed again and again until the condition is true.
- When the condition becomes false, control is transferred out of the structure.
- The general form of while structure is

```
    do
        Statement 1
        Statement 2
        ……..
        Statement N
    while ( Test Condition)
    End of While
```


Enter the do-while statement
Execute the statement (s)
test the condition ?
false
true
Exit the do-while statement

- Example:

```
        sum = l;
        i = 1;
        do
                sum = sum + i;
                i = i + 1;
        while ( i < = 100);
```

✓ **Difference between while and do while loop:**

while	do while
This is pre- tested loop	This is post tested loop
Minimum execution of loop is zero	Minimum execution of loop is once**.**

Syntax:
while (Test condition)
{
statement 1;
statement 2;
…………….;
statement n;
}
	Syntax:
	do
	{
	statement 1;
	statement 2;
	statement n;
	}
	while (Test condition);

Semi colon is not used.	Semi colon is used.

✓ **for Constructs:**

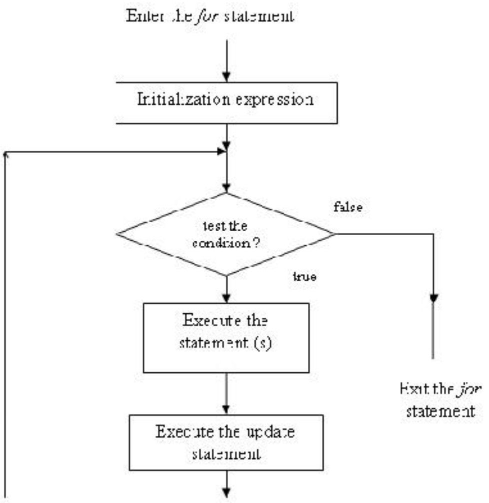
- This structure is the **fixed execution structure**.
- This structure is usually used when we know in advance exactly how many times asset of statements is to be repeatedly executed again and again.
- This structure can be used as increment looping or decrement looping structure.
- The general form of for structure is as follows:

```
for ( Expression 1;     Expression 2;  Expression 3)
{
        Statement 1;
        Statement 2;
        Statement N;
}
```

Where, Expression 1 represents Initialization

Expression 2 represents Condition

Expression 3 represents Increment/Decrement


Enter the for statement
Initialization expression
test the condition?
false
true
Execute the statement (s)
Exit the for statement
Execute the update statement

- Example:

```
sum = 0;
for ( i=1; i<=10; i++)
        sum = sum + i;
```

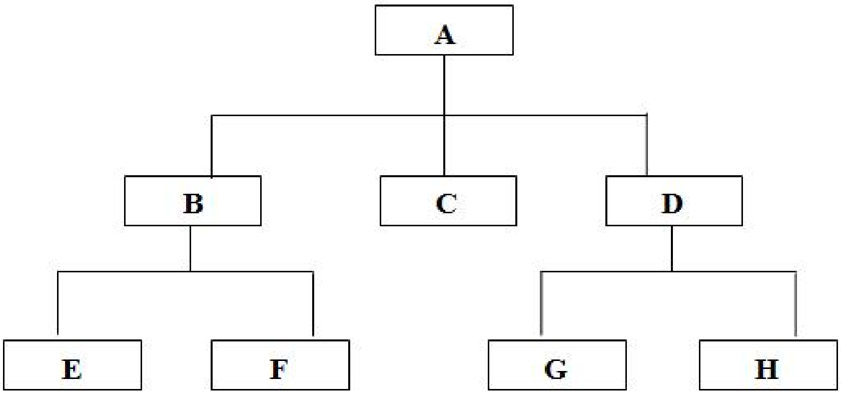
➢ Characteristics of a good program:

- The best program to solve a given problem is one that requires less space in memory, takes less execution time, easy to modify and portable.
- **Modification:** A good program is the one which allows any modifications easily whenever needed.
- **Portability:** A good program is the one which can be run on different type of machine with a minimum or no change.

➢ Approaches to problem solving:

1. Top-down design:

- Top-down design involves dividing a problem into sub-problems and further dividing the sub-problems into smaller sub-problems until it leads to sub-problems that can be implemented as program statements.



- Where A is the main problem and remaining are the sub-problems.
- The top-down approach is taken for program design; the programs can be developed easily, quickly, committing a minimum of errors.

2. Stepwise refinement:

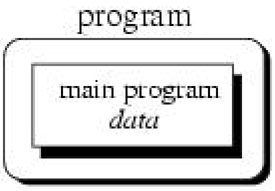
- The process of breaking down the problem at each stage to obtain a computer solution is called ***stepwise refinement.***

3. Bottom-up design:

- **A design method, in which system details are developed first, followed by major process.**
- This approach is the reverse of top-down design.
- The process starts with identification of set of modules which are either available or to be constructed.
- An attempt is made to combine the lower level modules to form modules of high level.
- Examples include object oriented programming using C++.

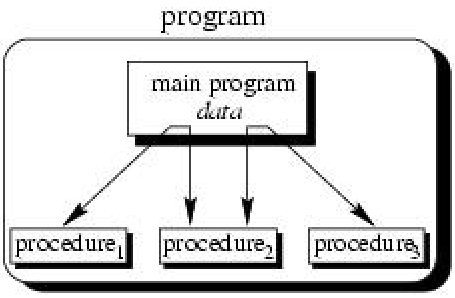
4. Programming techniques:

i. **Unstructured programming:**



- During learning stage by writing small and simple programs without planning leads to unstructured programming.

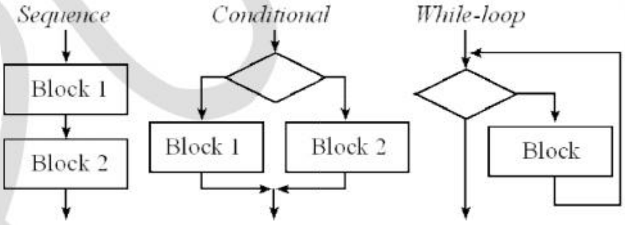
ii. **Procedural programming:**



- This method allows us to combine the returning sequences of statements into one single place.
- A procedure call is used to invoke the procedure. After the sequence is processed, flow of control proceeds right after the position where the call was made.
- Procedures (sub procedures) programs can now be written as more structured and error free.

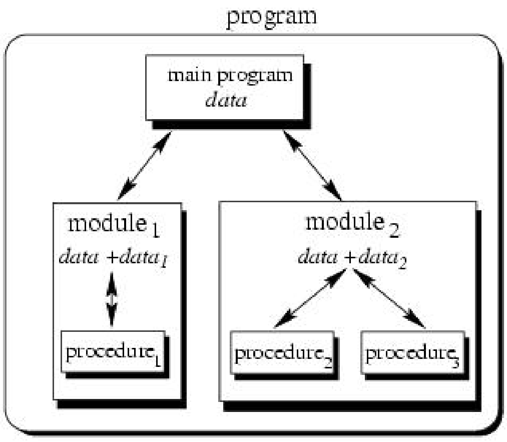
iii. **Structured programming:**

- Structured programming is method of programming by using the following type of code structures to write program:
  - Sequence (input, output, assignment)
  - Selection (if, if-else etc.)
  - Iteration (while, do-while, for)
  - Subroutines (functions)



iv. **Modular programming:**

- The process of splitting the lengthier and complex programs into number of smaller units (modules) is called modularization and programming with such an approach is called ***modular programming***.
- This technique provides grouping of procedures which are common functionality into separate modules.
- Advantages of modular programming:
  - Reusability
  - Debugging is easier
  - Building library
  - Portability



CHAPTER 5– PROBLEM SOLVING METHODOLOGY BLUE PRINT				
VSA (1 marks)	SA (2 marks)	LA (3 Marks)	Essay (5 Marks)	Total
01 Question	01 Question	01 Question	01 Question	11 Marks

****