CHAPTER 1

PROGRAMMING TECHNIQUES

SHORT AND LONG QUESTIONS

Q1. Explain the criteria for measuring efficiency of an algorithm.

Ans: Measuring Efficiency of an Algorithm:

The efficiency of an algorithm Is the property which relate the algorithm to the amount of computational resources used in it. An Algorithm must be analyzed to determine its resources usage (e.g. time, memory and storage space)

For maximum efficiency we wish to minimize resources usage. However, the various resources cannot be compared directly, so which of two algorithms is considered to be more efficient often depends on which measure of efficiency is considered the most important e.g. the requirement for high speed, minimum memory usage is considered.

There may be several algorithms for solving a particular problem. How fast a problem can be solved, depends on efficient algorithm.

Therefore, analysis of algorithms is very important to compare algorithms and conclude that which one is better than the other.

Analyze the efficiency of algorithms means comparing efficient of different methods of solutions of a problem.

Q2. Problem: Find the Sum, Product and Average of Five given Numbers.

Ans Planning the Solution:

Input: Five given numbers

Required Output: Sum, product and average of five numbers

Processing: Addition, multiplication and division of numbers

Algorithm

```
Step 1: Start
    Let the five numbers be A=2, B=5, C-=8, D=4 and E=12
Step 2: Find the sum (SUM)
    SUM=A+B+C+D+E
Step 3: FIND the product (PROD)
    PROD=A*B*C*D*E
Step 4: FIND the average (AVG)
    AVG=SUM/5
Step 5: Output SUM, PROD, AVG
Step 6: Stop
```

Q3. Problem: Find the largest of Three Unequal Numbers.

Ans: Planning the Solution:

Input Three unequal numbers

Required Output: The largest of three numbers

Processing Comparison of each number with the other two one by one

Algorithm

```
Step 1: Start
    Let the three numbers be A=10, B=20 AND C=30
Step 2: Check if A is the largest number
    If A>Band A>C THEN LARGEST=A otherwise GOTO Step 4
```

```
Step 3: GOTO Step 7
Step 4: Check if B is the largest number
    IF B>A and B>C THEN LARGEST=B otherwise GOTO Step 6
Step 5: GOTO Step 7
Step 6: LARGEST=C
Step 7: Output LARGEST
Step 8: Stop
```

Q4. Problem: Find Acceleration of a Moving Object for Given Mass and the Force applied.

Ans: Planning the Solution:

Input Mass and the Force

Required Output Acceleration of moving object

Processing Divide the force by the mass

Algorithm:

```
Step1 Start
Let the mass (M) be 50 and the Force (F) be 12
Step 2: CALCULATE the acceleration (A)
        A=F/M
Step 3 Output A
Step 4: Stop
```

Q5. Problem: Find the Volume of a Cube.

Ans: Planning the Solution:

Input Length of side of cube

Required Output Volume of cube

Processing Side of cube raised to the power of three

Algorithm

```
Step 1 Start
    Let the length of one side of cube. L be 12
Step 2 CALCULATE the volume V
Step 3 Output V
Step 4 Stop
```

Q6. Problem: Find the Area of a Triangle when the Lengths of Height and Base are given.

Ans: Planning the Solution:

Input Height and base of triangle

Required Output Area of triangle

Processing Multiply height with base and divide by two

Algorithm:

```
Step 1 Start
    Let the Height H be 10 and base B be 15
Step 2 CALCULATE the area A
Step 3 Output A
Step 4 Stop
```

Q7. Problem: Read Marks (M) and Print Letter Grade According to the Following scheme:

Marks	**Letter Grade**
M≥80 and M≤100	A1
M≥70 and M<80	A
M≥60 and M<70	B
M≥50 and M<60	C
M≥40 and M<50	D
M≥33 and M<40	E
M≥0 and M<33	F

Ans: Planning the Solution:

Input Marks

Required Output Letter Grade

Processing Check in which range the marks fall and accordingly print the letter grade.

Algorithm:

```
Step 1 Start
    Let the marks be M
Step 2 Compare the marks
    IF M≥80 then print Grade A1 otherwise GOTO Step 4
Step 3 GOTO Step 13
Step 4 Compare the marks
```

```
    IF M≥70 THEN print "Grade A" otherwise GOTO Step 6
Step 5 GOTO Step 13
Step 6 Compare the marks
    IF M≥60 THEN print "Grade B" otherwise GOTO Step 8
Step 7 GOTO Step 13
Step 8 Compare the marks
    IF M≥50 THEN print "Grade c" otherwise GOTO Step 10
Step 9 GOTO Step 13
Step 10 Compare the marks
    IF M≥40 THEN print "Grade D" otherwise GOTO Step 12
Step 11 GOTO Step 13
Step 12 Compare the marks
    IF M≥33 THEN print "Grade E" otherwise print Grade f
Step 13 Stop
```

Q8. Problem: Find Interest on a Given Amount:

Ans: Planning the Solution:

Input Loan Amount (P), Interest Rate (R) and Period of Loan in year (T)

Required Output: Interest

Processing Multiply Loan amount with Interest rate and Period of loan

Algorithm

```
Step 1 Start
```

```
    Let the Loan Amount (P) be 35000, Interest Rate (R) be 10% and Period of Loan (T) be 5 years
Sep 2 CALCULATE the Interest
    INTEREST=P*R*T
Step 3 Output INTEREST
Step 4 Stop
```

Q9. Problem: Find the Exponent of a Given Number

Exponent or power of a number means how many times to use the number in a multiplication. In other words, it is the products of a number that is multiplied as many times as its exponent.

Ans: Planning the Solution:

Input A number and its exponent

Required Output Exponent of given number

Processing: Multiply the number as many times as its exponent

Algorithm

```
Step 1 Start
Let the number, N be 8 and its exponent E be 5
Step 2 Initialize product (P) and K to 1
        P=1, K=1
Step 3: FIND the product (P)
        P=P*N
Step 4: Increment K by 1
```

```
        K=K+1
Step 5: Check if the value of K is less than or equal to E
If K≤E THENGOTO Step 3 otherwise GOTO Step 6
Step: Output P
Step 7: Stop
```

Q10. Problem: Print Odd numbers from 1 to 100:

1 3 5 7 9 11.....99

Ans: Planning the Solution:

Input this problem has no input

Required Output Printing odd numbers from 1 to 100

Processing: Initialize a variable and keep printing it with an increment of 2 till 99

Algorithm

```
Step 1 Start
Initialize variable K to 1
      K=1
Step 2 Output K
Step 3 Increment K by 2
      K=k+2
Step 4 Check if the value of K is less than 100
    IF K<100 THEN GOTO Step 2 otherwise GOTO Step 5
Step 5 Stop
```

Q11. Problem: Print the Following Sequence of Numbers in Descending Order:

27 24 21 28 15 12 9 3 0 -3 -6

Ans: Planning the Solution:

Input: This problem has no input

Required Output: Printing numbers from 27 to -6 in descending order with a step of -3

Processing: Initialize a variable to 27 and then keep printing it with a decrement of 3 till --6.

Algorithm

```
Step 1: Start
Initialize variable K to 27
      K=27
Step 2: Output K
Step 3: Decrement K by 3
Step 4: Check if the value of K is greater than or equal to -6
If k≥-6 THEN GOTO Step 2 otherwise GOTO Step 5
Step 5: Stop
```

Q12. Problem: Find the Sum of Even numbers up to 100:

SUM= 2 + 4 + 6 + 8 + 10 + 12 + 14 + ……. + 100

Ans: Planning the Solution

Input: This problem has no input

Required Output: Sum of even numbers up to 100

Processing: Add all the even numbers from 2 to 100

Algorithm:

```
Step 1: Start
Initialize SUM to 0 and K to 2
    SUM=0, K=2
Step 2 ADD K to SUM
    SUM= SUM + K
Step 3: Increment K by 2
    K=K+2
Step 4 Check if the value of K is less than or equal to 100
    IF K≤100 THEN GOTO Step 2 otherwise GOTO Step 5
Step 5 Output SUM
Step 6 Stop
```

Q13. Problem: Print a Multiplication Table of a Given Number:

Ans: Planning the Solution

Input: Number whose table is required

Required Output: Printing table of given number

Processing: Initialize a variable to 1 and print its product with the given number. Increment the variable by 1 and print the product continue the process till print the product of 12 and the given number.

Algorithm:

```
Step 1: Start
Let be the number N be 7
Step 2 Initialize K to 1
    K=1
Step 1 Find the product
    P=N*K
Step 4 Output N,K,P
Step 5 Increment K by 1
    K=K+1
Step 6 Check the value of K
IF K≤12 THEN GOTO Step 3 otherwise GOTO Step 7
Step 7 Stop
```

Q14. Problem: Convert Temperature from Fahrenheit to Celsius:

Ans: Planning the Solution

Input Temperature in Fahrenheit

Required Output Temperature in Celsius

Processing Compute the temperature in Celsius from Fahrenheit using conversion formula

Algorithm

```
Step 1 Start
Let the temperature in Fahrenheit. F be 100
Step 2 CALCULATE temperature in Celsius (C)
```

```
    C=5/9(F-32)
Step 3 Output C
Step 4: Stop
```

Q15. Problem: Find Factorial of a Given Number:

Ans: Planning the Solution

Input Given Number

Required Output: Factorial of given number

Processing: Find the product of all the numbers from 1 to the given number

Algorithm

```
Step 1 Start
 Let the number, N be 5
Step 2 Initialize loop variable K and factorial F to 1
    K=1, F=1
Step 3 CALCULATE the product
    F=F*K
Step 4 Increment K by 1
    K=K+1
Step 5 Check the value of K
    If K≤N THEN GOTO Step 3 otherwise GOTO Step 6
Step 6 Output F
Step 7 Stop
```

Q16. Determine the flowchart requirements of a given problem or algorithm by the flowchart, developer before drawing a flowchart

Ans: Steps for Drawing Flowchart:

The flowchart developer must determine the following requirements for the given problem or algorithm before drawing a flowchart

- Input to the flowchart
- Type of processing required
- Decisions to be taken
- The output to be produced after processing

Input:

The flowchart developer must know what exactly the input to the flowchart is. The input is determined from the problem statement. For example, the given problem is to convert temperature from Fahrenheit to Celsius. Here the input will be the temperature in Fahrenheit.

Processing:

The flowchart developer must decide what type of calculation is to be performed or which formula is to be applied to obtain the required result. For example, to find the area of triangle the following formula is to used

Area= (Base+Height)/2

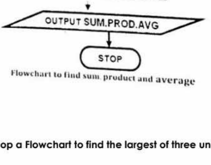
Decision:

The flowchart developer must decide which control structures (sequence repetition or selection) are to be applied for the solution of the problem. For example, selection structure must be applied to print letter grade of a student based on the marks obtained. The selection structure will check in which range the marks fall and accordingly print the grade.

Output: The flowchart must provide the required output.

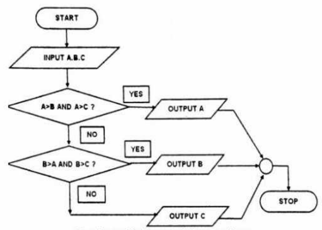
Q17. Draw/Develop a Flowchart to find sum, product and average of five numbers.

Ans:



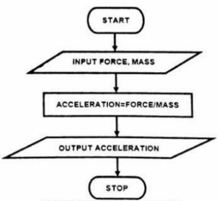
Flowchart to find sum. product and average

Q18. Draw/Develop a Flowchart to find the largest of three unequal numbers.



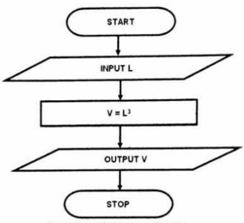
Flowchart to find largest of three numbers

Q19. Draw/Develop a Flowchart to find acceleration of a moving object given mass and the force applied.



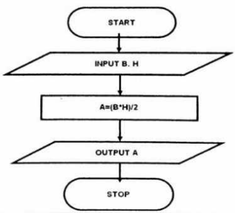
Flowchart to find acceleration

Q20. Draw/Develop a Flowchart to input the length of one side of cube and print its volume.



Flowchart to find volume of a cube

Q21. Draw/Develop a Flowchart to find the area of a triangle when the lengths of height and base are given.

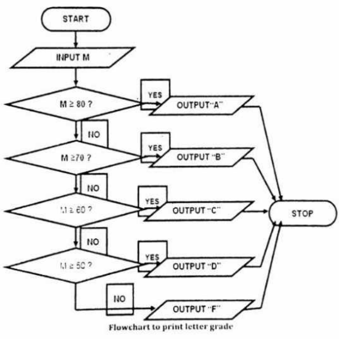


Flowchart to find area of a triangle

Q22. Draw/Develop a Flowchart to read Marks (M) and print letter grade according to the following scheme

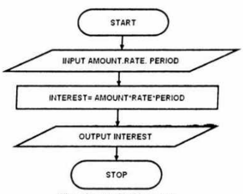
Marks	Letter Grade
-----------	------------------
M≥80 AND M≤100	A
M≥70 and M<80	B
M≥60 and M<70	C
M≥50 and M<70	D
M<50	F

Ans: Flowchart to print letter grade is shown in Fig



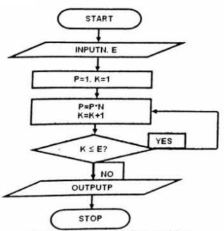
Flowchart to print letter grade

Q23. Draw/Develop a Flowchart to find interest on a given amount and period of loan in years.



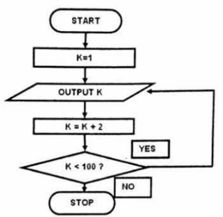
Flowchart to find interest

Q24. Draw/Develop a Flowchart to find the exponent (E) of a given number (N) in this flowchart, the value P represents N raised to the power E.



Flowchart to find exponent of a number

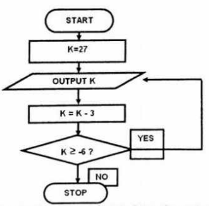
Q25. Draw/Develop a Flowchart to print odd numbers from 1 to 100



Flowchart to print odd numbers

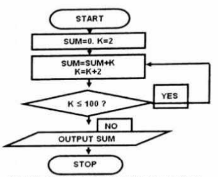
Q26. Draw/Develop a Flowchart to print the given sequence of numbers in descending order.

27 24 21 18 15 12 9 6 3 0 -3 -6



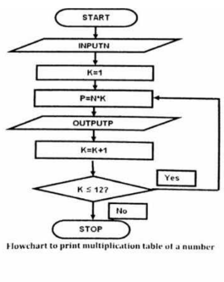
Flowchart to print numbers in descending order

Q27. Draw/Develop a Flowchart to find the sum of even numbers up to 100



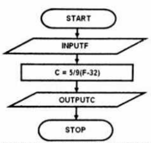
Flowchart to find the sum of even numbers

Q28. Draw/ Develop a Flowchart to print a multiplication table of a given number.



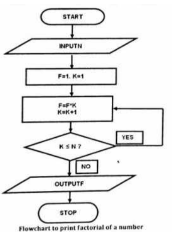
Flowchart to print multiplication table of a number

Q29. Draw/ Develop a Flowchart to convert temperature from Fahrenheit to Celsius.



Flowchart to convert temperature

Q30. Draw/ Develop a Flowchart to find factorial of a number.



Flowchart to print factorial of a number

KEY POINTS

- **Computer** is a general-purpose electronic machine invented to help people solve various problems.
- **Candid Solutions** of a problem are all the possible solutions for a problem.
- **Algorithm** is a step by step problem solving method that is easy to understand and follow. It is a set of steps that clearly defines a sequence of operations to solve a problem.
- **Flowchart** is a diagrammatic representation of algorithm.
- **Sequential Structure** refers to the execution of operations in the order in which they appear.
- **Repetition Structure** or **loop** provides a way to repeat one or more operations as many times as required to solve a problem.
- **Selection Structure** allows a choice among various options while solving a problem.

EXERCISE

Q1. Select the best answer for the following MCQs.

i. **Which of the following structure repeats one or more operation?**
   A. Sequence
   B. Selection
   C. Loop
   D. Decision

ii. **Which of the following structure allows a choice among various options?**
   A. Sequence
   B. Selection
   C. Loop
   D. Decision

iii. **Which of the following is a sequence of instructions written in a computer language to solve a problem?**
   A. Algorithm
   B. Flowchart
   C. Program
   D. Problem Analysis

iv. **What illustrates a sequence of operations to be performed to solve a problem in the form of a diagram?**
   A. Algorithm
   B. Flowchart

   C. Program
   D. Problem Analysis

v. **What is represented by parallelogram in a flowchart?**
   A. Input/Output
   B. Processing
   C. Start/Stop
   D. Decision

vi. **What is represented by a small circle in a flowchart?**
   A. Start/Stop
   B. Decision
   C. Processing
   D. Connector

vii. **Which symbol is used for decision in a flowchart?**
   A. Rectangle
   B. Parallelogram
   C. Diamond
   D. Oval

viii. **Which symbol is used for processing in a flowchart?**
   A. Rectangle
   B. Parallelogram
   C. Diamond
   D. Oval

Answers

i. **C**	ii. **B**	iii. **C**	iv. **B**
v. **A**	vi. **D**	vii. **C**	viii. **A**

SHORT QUESTIONS

Q2. Give short answers to the following questions.

i. **Define computer**

Ans: Computer:

A computer is a general-purpose electronic machine invented to help people solve various problems. Computer must be programmed by human beings to perform various tasks. Various programming techniques are used for solving problems on computer.

OR

Computer:

A computer is an electronic data processing device. It reads data processing and produces results accurately at a very high speed.

OR

Computer is a general-purpose programmable machine that has the ability to store, retrieve and process data that is represented in the form of 0s and 1s.

ii. **What is algorithm and what is the role of algorithm in problem solving?**

Ans: Algorithm

Algorithm means method, procedure, technique or plan. Algorithm is a step-by-step problem-solving method that is easy to understand and follow. It is a set of steps that clearly defines a sequence of operations to solve a problem.

Role of Algorithm in Problem Solving:

Algorithm plays an important role in computer programming. Computer programming is the process of taking an algorithm and coding it in a programming language. Formulating an algorithm is the first step for developing a computer program.

iii. **What is a flowchart?**

Ans: Flowchart:

Flowchart is a diagrammatic representation of algorithm. It describes what operations are required to solve a given problem.

iv. **What are the advantages of using flowcharts?**

Ans: Importance of Flowchart in Solving a Problem:

Flowchart illustrates the sequence of operations to be performed to solve a problem in the form of a diagram.

Computer programmers draw flowcharts before writing computer programs. Flowchart provides an easy way to analyze and find solutions of problems.

Once, the flowchart is drawn, it becomes very easy to write the program in any high-level language.

Flowchart is very helpful in communicating the problem-solving method to other people. It also helps in finding and removing errors in computer programs.

v. **Draw any four graphical symbols used in flowchart and explain them.**

Ans: Flowchart Symbols:

Flowcharts are drawn using standard symbols. These symbols have specific meaning and are connected by arrows indicating the flow from one step to another.

Table 1-1 Flowchart symbols

Symbol Description	Symbol Shape	Symbol Description	Symbol Shape
Flow Line	→	**Process**	▭
Start/Stop	▢	**Decision**	◇
Input/Output	▱	**Connector**	○ **On-Page** ⬠ **Off-Page**

Flow line: →

It is a line with arrow head used to connect various flowchart symbols and indicates the flow of control in the flowchart.

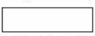
Start/Stop Symbol: ▢

It is a rounded rectangular shaped symbol. It is used to indicate the start or end of a flowchart. We can only write the words Start or Stop inside this symbol. A flowchart can only have on start but it may have many ends.

Input/Output Symbol: ▱

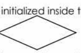
Parallelogram represents input or output operations in a flowchart. It contains the word READ or INPUT along with the variables for input operation or PRINT or OUTPUT along with the output data for output operation.

Process Symbol:



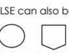
A rectangular block is used for any data processing operation. All the calculations appear inside the processing symbol such as "SUM=A+B" Variables are also initialized inside the process symbol such as K=1

Decision Symbol



A diamond shaped symbol represents decision in a flowchart and it contains a condition. If the condition is true, the path marked YES is to be followed. If the condition is false, the path marked NO is to be followed. The words TRUE or FALSE can also be used instead YES or NO.

Connector Symbol



These symbols are used to connect one part of a flowchart to the other on the same page (On-page connector) or the new page (Off-page connector).

EXTENSIVE QUESTIONS

Q3. Describe the steps involved in problem solving.

Ans: The following Five steps are involved in problem solving on the computer.

i. **Defining the Problem:**

Defining the problem is initial stage of problem solving. It is very important to understand the problem before the programmer starts working on its solution.

The following are the steps to properly define and understand the problem:

- Carefully read the problem to understand what it tells
- Find out what the problems asks to do
- What information can be obtained from the problem?
- What is required to be calculated as the solution of the problem?

For example

Problem 1: A person is Unhappy with a Product or Service He/She has Purchased from A Company:

After reading the above statement, we understand that a customer has purchased any product or service from a Company and now the customer is not satisfied with it. This statement defines the problem clearly and requires the solution. It is a general type of problem.

Problem 2: Finding Average Marks of a Student:

It is clear from the problem statement that average marks of a student have to be found: This in numeric problem.

ii. **Analyzing the Problem:**

At this stage of problem solving, the programmer investigates the problem and gathers as much information as possible to find a solution. The following questions are to be asked to analyze the problem.

- Is it possible to solve the problem on a computer?
- What is to be done to find the solution of the problem?
- What is the proper sequence of steps to solve the problem?
- What are the inputs and what output is required?
- How many solutions are possible?
- Which solution is the best and why?
- How solution will be implemented?

To analyze the **Problem 1** (given above), the following points are to be kept in mind and some information is to be gathered.

Know the Outcome you Want:

- Think about what is important to you and what you want to achieve. For example, do you want a refund, a replacement?
- Would you like them provide the service again, this time meeting agreed standards?
- The more specific you are the more likely it is that you will get the outcome you want

Prepare for the Discussion:

- Find out about your legal rights
- Write down exactly what your complaint is, including details such as dates and times
- Gather any relevant paperwork, e.g. advertisement that misled you, or a quote that the trader gave you

Find out what the Organization's Complaint Process is and Follow this:

- Have a look on their website or on any documentation, they had given you

  To analyze Problem 2, the following information is required.
- What are the subject marks of the student in each subject?
- How many subjects are there?
- What is the formula to find the average marks?

iii. **Planning the Solution of the Problem:**

Planning the solution of the problem is a creative stage of problem solving. It refers to dividing the solution into steps and arranging them into proper order that will solve the problem.

To plan the solution of the Problem 1 (given above), after analyzing the problem, the following planning is required.

How to discuss a Problem:

- Talk to the right person. The person you speak must have the ability to resolve the issue e.g. a store manager, business owner or supervisor.
- Focus on talking about the problem with the product or service, rather than taking issue with a person.
- Stay calm and reasonable. Explain the problem in detail and provide any evidence you may have.
- Tell them what outcome you want. It is the store or service provider's responsibility to resolve the problem, but it can be helpful to ask them for a specific solution.
- Expect questions. A store or service provider may ask you for more details.
- Ask to speak with someone else if you are not happy with the way the conversation is going. It is okay to walk away and come back later, or to follow up in writing.
- Listen to their response. Ask for time to consider it if you need to.

Consider Their Response:

- Does the response resolve your issue or Is it a reasonable comprise?
- Do you want to take the time and effort to carry on if the response is unsatisfactory?
- Based on what you know of your rights, do you think you have a solid basis to take the matter further?

  To solve the Problem 2 the following planning is required
- All subject marks are to be added together to find the sum of all the marks
- The sum is to be divided by the total number of subjects to find the average marks

iv. **Candid Solutions of a Problem:**

All the possible solutions of a problem that produce correct result are known as candid solutions. To find candid solutions of a problem,

programmer has to look for different methods to solve the problem and come up with several solutions.

For example, many solutions can be considered to resolve the **Problem 1.**

Solution 1: The customer can lodge the complaint personally visiting the company.

Solution 2: The customer can also use the courier services to send the product back.

Solution 3: The customer can use company's website to file the complaint.

v. **Select the Best Solution:**

After finding the candid solutions, only one solution can be selected. The selection of final solution of a problem should be based on the following criteria.

Speed:

The selected solution of the problem should be efficient. In other words, it means when the solution is implemented in a programming language, the program should run fast.

Cost:

The selected solution of the problem should provide a cost-effective way of implementation.

Complexity:

The selected solution of the problem should not be complicated. It should contain minimum number of instructions/simple steps.

Q4. Write an algorithm to calculate the area of a rectangle for given breadth and length.

Ans:
```
Step 1:  Input the Width (W) and Length (L) of a rectangle
    Step2: Calculate the area (A) by multiplying L with W
    Step 3: Print A
```

Q5. Write an algorithm that inputs length in inches and calculate and prints it in centimeters.

Ans:
```
Step 1: Input the length in inches (LI)
    Step 2: Calculate the length in cm (LCM) by multiplying LI with 2.54
    Step 3: Print LCM
```

Q6. Write an algorithm that inputs marks and prints the message "PASS" or "FAIL". Passing marks are 33.

Ans:
```
Step 1: Input Marks (M)
Step 2: Check if (M<33) then Print "FAIL" GOTO Step 4
Step 3: ELSE Print "PASS"
Step 4: Stop
```

Q7. Write an algorithm to find the sum of given sequence.

SUM= 20+25+30+40+45+50+55+60

Ans:
```
Step 1:  Start
```

```
  Initialize SUM to 0 and K=5
        SUM=0,K=5
Step 2:  Add K to  SUM
      SUM=SUM+K
Step 3: Increment K by 5
      K=K+5
Step 4:  Check if the value of K is less than or equal to 60
    IF K≤100 THEN GOTO Step 2 otherwise GOTO Step 5
Step 5 Print SUM
Step 6 Stop
```

Q8. Write an Algorithm to find the product of given numbers.

PRODUCT= 1×3×5×7×9×11×13×15

Ans:
```
Step 1: Start
    Initialize variable K to 1 and prod=1
        K=1   Prod=1
Step 2: Increment K by 2
      K= K+2
Step 3: Find the Product
      Prod= Prod ×k
Step  4: Check If the value of K is less than 16
    If K<16 THEN GOTO Step 2 otherwise GOTO Step 5
```

```
Step 5: Print product
      Print Prod
Step 6: Stop
```

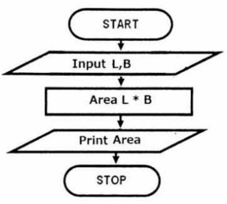
Q9. Write an algorithm to print multiplication table of a number in reserve order.

Ans:
```
Step 1: Enter the number N whose table is to be generated
Step 2: Initialize the value of 1 with 10
        I=10
Step 3: Find the product of N and I
        Prod=N ×I
Step 4: Print N, I and Prod
      Print N   I and Prod
Step 5 Decrease the value of I by 1
      I=I – 1
Step 6: If the value of I is > 0 then goto step 3 otherwise goto step 5
Step 7 stop
```

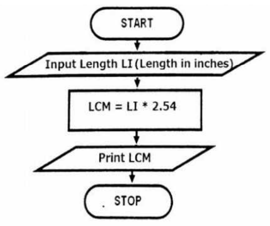
Q10. Convert the algorithms of questions Q4 to Q9 to flowcharts.

i. **Write an algorithm to calculate the area of a rectangle for given breadth and length.**

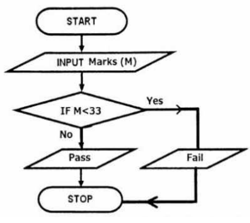
Ans: Flowchart for the area of a rectangle for given breadth and length:



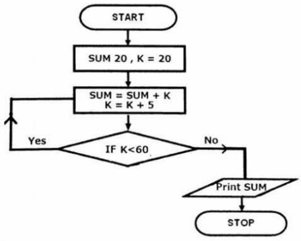
ii. **Write an algorithm that inputs length in inches and calculate and prints it in centimeters.**



iii. **Write an algorithm that inputs marks and prints the message "PASS" or "FAIL". Passing marks are 33.**

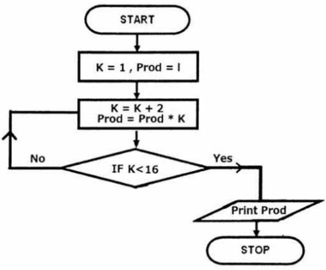


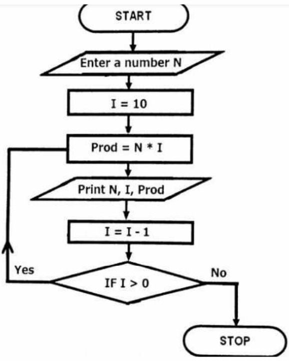
iv. **Write an algorithm to find the sum of given sequence.**
SUM= 20+25+30+35+40+45+50+55+60



v. **Write an algorithm to find the product of given numbers**

PRODUCT=1*3*5*9*11*13*15



vi. **Write an algorithm to print multiplication table of a number in reverse order**