UNIT 1 PROGRAMMING FUNDAMENTALS

Structure

1.0 INTRODUCTION

In our daily life, we routinely encounter and solve problems. We pose problems that we need or want to solve. For this, we make use of available resources, and solve them. Some categories of resources include: the time and efforts of yours and others; tools; information; and money. Some of the problems that you encounter and solve are quite simple.But some others may be very complex.

In this unit we introduce you to the concepts of problem-solving, especially as they pertain to computer programming**.**

The problem-solving is a skill and there are no universal approaches one can take to solving problems. Basically one must explore possible avenues to a solution one by one until s/he comes across a right path to a solution. In general, as one gains experience in solving problems, one develops one's own techniques and strategies, though they are often intangible. Problem-solving skills are recognized as an integral component of computer programming. It is a demand and intricate process which is equally important throughout the project life cycle especially – study, designing, development, testing and implementation stages. The computer problem solving process requires:

- Problem anticipation
- Careful planning
- Proper thought process
- Logical precision
- Problem analysis
- Persistence and attention.

At the same time it requires personal creativity, analytic ability and expression. The chances of success are amplified when the problem solving is approached in a systematic way and satisfaction is achieved once the problem is satisfactorily solved. The problems should be anticipated in advance as far as possible and properly defined to help the algorithm definition and development process.

Computer is a very powerful tool for solving problems. It is a symbol-manipulating machine that follows a set of stored instructions called a program. It performs these manipulations very quickly and has memory for storing input, lists of commands and output. A computer cannot think in the way we associate with humans. When using the computer to solve a problem, you must specify the needed initial data, the operations which need to be performed (in order of performance) and what results you want for output. If any of these instructions are missing, you will get either no results or invalid results. In either case, your problem has not yet been solved. Therefore, several steps need to be considered before writing a program. These steps may free you from hours of finding and removing errors in your program (a process called **debugging**). It should also make the act of problem solving with a computer a much simpler task.

All types of computer programs are collectively referred to as **software**. Programming languages are also part of it. Physical computer equipment such as electronic circuitry, input/output devices, storage media etc. comes under **hardware**. Software governs the functioning of hardware. Operations performed by software may be built into the hardware, while instructions executed by the hardware may be generated in software. The decision to incorporate certain functions in the hardware and others in the software is made by the manufacturer and designer of the software and hardware. Normal considerations for this are: cost, speed, memory required, adaptability and reliability of the system. Set of instructions of the high level language used to code a problem to find its solution is referred to as **Source Program**. A translator program called **a compiler or interpreter**, translates the source program into the object program. This is the compilation or interpretation phase. All the testing of the source program as regards the correct format of instructions is performed at this stage and the errors, if any, are printed. If there is no error, the source program is transformed into the machine language program called **Object Program**. The Object Program is executed to perform calculations. This stage is the execution phase. Data, if required by the program, are supplied now and the results are obtained on the output device. The complete process is shown in fig 1.1 below:

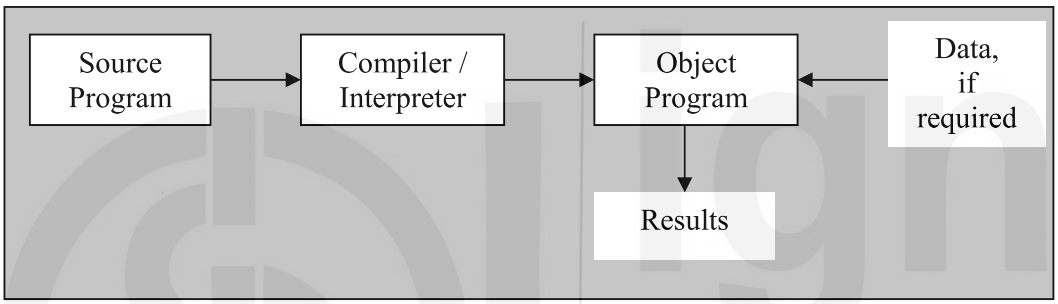


Fig 1.1: Conversion of Source Program to Object Program

1.1 OBJECTIVES

After going through this unit, you should be able to:

- apply problem solving techniques;
- define an algorithm and its features;
- design flowcharts;
- Define a program;
- Understand the history of C programming language;
- Compile a C program;
- Identify the syntax errors;
- Run a C program; and
- Understand what are run time and logical errors.

1.2 PROBLEM - SOLVING TECHNIQUES

Problem solving is a creative process which defines systematization and mechanization. There are a number of steps that can be taken to raise the level of one's performance in problem solving.

1.2.1 Steps for Problem - Solving

A problem-solving technique follows certain steps in finding the solution to a problem. Let us look into the steps one by one:

Problem definition phase

The success in solving any problem is possible only after the problem has been fully understood. That is, we cannot hope to solve a problem, which we do not understand. So, the problem understanding is the first step towards the solution of the problem. In *problem definition phase*, we must emphasize *what must be done* rather than *how is it to be done*. That is, we try to extract the precisely defined set of tasks from the problem statement. Inexperienced problem solvers too often gallop ahead with the task of problem - solving only to find that they are either solving the wrong problem or solving just one particular problem.

Getting started on a problem

There are many ways of solving a problem and there may be several solutions. So, it is difficult to recognize immediately which path could be more productive. Sometimes you do not have any idea where to begin solving a problem, even if the problem has been defined. Such block sometimes occurs because you are overly concerned with the details of the implementation even before you have completely understood or worked out a solution. The best advice is not to get concerned with the details. Those can come later when the intricacies of the problem has been understood.

The use of specific examples

To get started on a problem, we can make use of heuristics i.e., the rule of thumb. This approach will allow us to start on the problem by picking a specific problem we wish to solve and try to work out the mechanism that will allow solving this particular problem. It is usually much easier to work out the details of a solution to a specific problem because the relationship between the mechanism and the problem is more clearly defined. This approach of focusing on a particular problem can give us the foothold we need for making a start on the solution to the general problem.

Similarities among problems

One way to make a start is by considering a specific example. Another approach is to bring the experience to bear on the current problem. So, it is important to see if there are any similarities between the current problem and the past problems which we have solved. The more experience one has the more tools and techniques one can bring to bear in tackling the given problem. But sometimes, it blocks us from discovering a desirable or better solution to the problem. A skill that is important to try to develop in problem - solving is the ability to view a problem from a variety of angles. One must be able to metaphorically turn a problem upside down, inside out, sideways, backwards, forwards and so on. Once one has developed this skill it should be possible to get started on any problem.

Working backwards from the solution

In some cases we can assume that we already have the solution to the problem and then try to work backwards to the starting point. Even a guess at the solution to the problem may be enough to give us a foothold to start on the problem. We can systematize the investigations and avoid duplicate efforts by writing down the various steps taken and explorations made. Another practice that helps to develop the problem solving skills is, once we have solved a problem, to consciously reflect back on the way we went about discovering the solution.

1.2.2 Using Computer as a Problem - Solving Tool

The computer is a resource - a versatile tool - that can help you solve some of the problems that you encounter. A computer is a very powerful general-purpose tool. Computers can solve or help to solve many types of problems. There are also many ways in which a computer can enhance the effectiveness of the time and effort that you are willing to devote to solving a problem. Thus, it will prove to be well worth the time and effort you spend to learn how to make effective use of this tool.

In this section, we discuss the steps involved in developing a program. Program development is a multi-step process that requires you to understand the problem, develop a solution, write the program, and then test it. This critical process determines the overall quality and success of your program. If you carefully design each program using good structured development techniques, your programs will be efficient, error-free, and easy to maintain. The following are the steps in detail:

1. Develop an *Algorithm* and a *Flowchart*.
2. Write the program in a computer language (for example say C programming language).
3. Enter the program using some editor.
4. Test and debug the program.
5. Run the program, input data, and get the results.

1.3 BASICS OF ALGORITHMS

The first step in the program development is to devise and describe a precise plan of what you want the computer to do. This plan, expressed as a sequence of operations, is called an algorithm. An algorithm is just an outline or idea behind a program something resembling C or Pascal, but with some statements in English rather than within the programming language. It is expected that one could translate each pseudo-code statement to a small number of lines of actual code, easily and mechanically.

1.3.1 Definition

An **algorithm** is a finite set of steps defining the solution of a particular problem. An algorithm is expressed in pseudocode - something resembling C language or Pascal, but with some statements in English rather than within the programming language. Developing an efficient algorithm requires lot of practice and skill. It must be noted that an efficient algorithm is one which is capable of giving the solution to the problem by using minimum resources of the system such as memory and processor's time. Algorithm is a language independent, well structured and detailed. It will enable the programmer to translate into a computer program using any high-level language.

1.3.2 Features of Algorithm

Following features should be present in an algorithm:

Proper understanding of the problem

For designing an efficient algorithm, the expectations from the algorithm should be clearly defined so that the person developing the algorithm can understand the expectations from it. This is normally the outcome of the problem definition phase.

Use of procedures / functions to emphasize modularity

To assist the development, implementation and readability of the program, it is usually helpful to modularize (section) the program. Independent functions perform specific and well defined tasks. In applying modularization, it is important to watch that the process is not taken so far to a point at which the implementation becomes difficult to read because of fragmentation. The program then can be implemented as calls to the various procedures that will be needed in the final implementations.

Choice of variable names

Proper variable names and constant names can make the program more meaningful and easier to understand. This practice tends to make the program more self documenting. A clear definition of all variables and constants at the start of the procedure / algorithm can also be helpful. For example, it is better to use variable *day* for the day of the weeks, instead of the variable *a* or something else.

Documentation of the program

Brief information about the segment of the code can be included in the program to facilitate debugging and providing information. A related part of the documentation is the information that the programmer presents to the user during the execution of the program. Since, the program is often to be used by persons who are unfamiliar with the working and input requirements of the program, proper documentation must be provided. That is, the program must specify what responses are required from the user. Care should also be taken to avoid ambiguities in these specifications. Also the program should "catch" incorrect responses to its requests and inform the user in an appropriate manner.

1.3.3 Criteria to be followed by an Algorithm

The following is the criteria to be followed by an algorithm:

- **Input:** There should be zero or more values which are to be supplied.
- **Output:** At least one result is to be produced.
- **Definiteness:** Each step must be clear and unambiguous.
- **Finiteness:** If we trace the steps of an algorithm, then for all cases, the algorithm must terminate after a finite number of steps.
- **Effectiveness:** Each step must be sufficiently basic that a person using only paper and pencil can in principle carry it out. In addition, not only each step is definite, it must also be feasible.

Example 1.1

Let us try to develop an algorithm to compute and display the sum of two numbers

1. Start
2. Read two numbers *a* and *b*
3. Calculate the sum of *a* and *b* and store it in *sum*
4. Display the value of *sum*
5. Stop

Example 1.2

Let us try to develop an algorithm to compute and print the average of a set of data values.

1. Start
2. Set the sum of the data values and the count to zero.
3. As long as the data values exist, add the next data value to the sum and add 1 to the count.
4. To compute the average, divide the sum by the count.
5. Display the average.
6. Stop

Example 1.3

Write an algorithm to calculate the factorial of a given number.

1. Start
2. Read the number n
3. [Initialize]
   i← 1 , fact ← 1
4. Repeat steps 4 through 6 until i = n

5. fact ← fact * i
6. i ← i + 1
7. Print fact
8. Stop

Example 1.4

Write an algorithm to check that whether the given number is prime or not.

1. Start
2. Read the number num
3. [Initialize]
   i← 2 , flag ← 1
4. Repeat steps 4 through 6 until i < num or flag = 0
5. rem ← num mod i
6. if rem = 0 then
   flag← 0
      else
      i← i + 1
7. if flag = 0 then
         Print Number is not prime
      Else
         Print Number is prime
8. Stop

1.3.4 Top Down Design

Once we have defined the problem and have an idea of how to solve it, we can then use the powerful techniques for designing algorithms. Most of the problems are complex or large problems and to solve them we have to focus on to comprehend at one time, a very limited span of logic or instructions. A technique for algorithm design that tries to accommodate this human limitation is known as **top-down design or stepwise refinement.**

Top down design provides the way of handling the logical complexity and detail encountered in computer algorithm. It allows building solutions to problems in step by step. In this way, specific and complex details of the implementation are encountered only at the stage when sufficient groundwork on the overall structure and relationships among the various parts of the problem.Before the top down design can be applied to any problem, we must at least have the outlines of a solution. Sometimes this might demand a lengthy and creative investigation into the problem while at another time the problem description may in itself provide the necessary starting point for the top-down design. Top-down design suggests taking the general statements about the solution one at a time, and then breaking them down into a more precise subtask / sub-problem. These sub-problems should more accurately describe how the final goal can be reached. The process of repeatedly breaking a task down into a subtask and then each subtask into smaller subtasks must continue until the sub-problem can be implemented as the program statement. With each spitting, it is essential to define how sub-problems interact with each other. In this way, the overall structure of the solution to the problem can be maintained. Preservation of the overall structure is important for making the algorithm comprehensible and also for making it possible to prove the correctness of the solution.

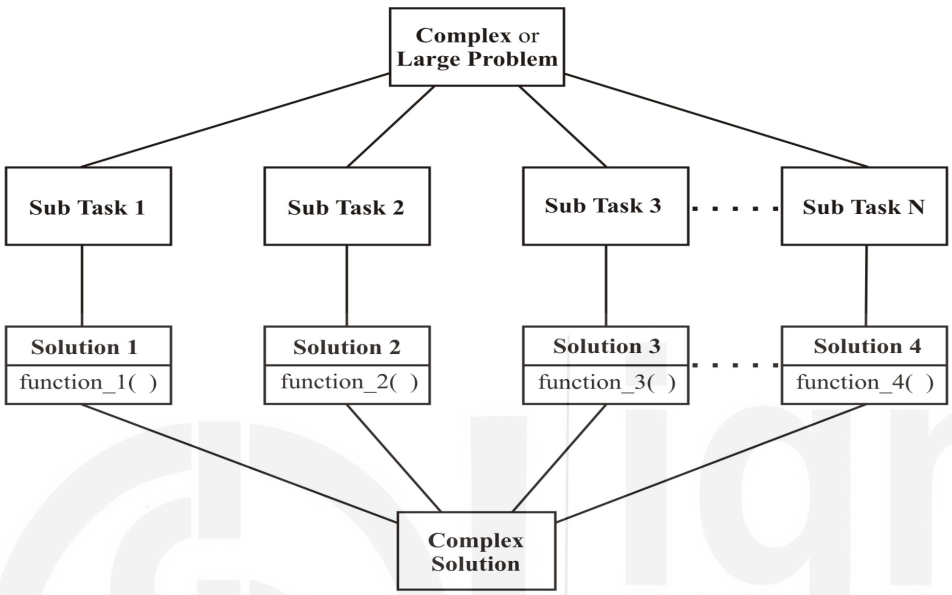


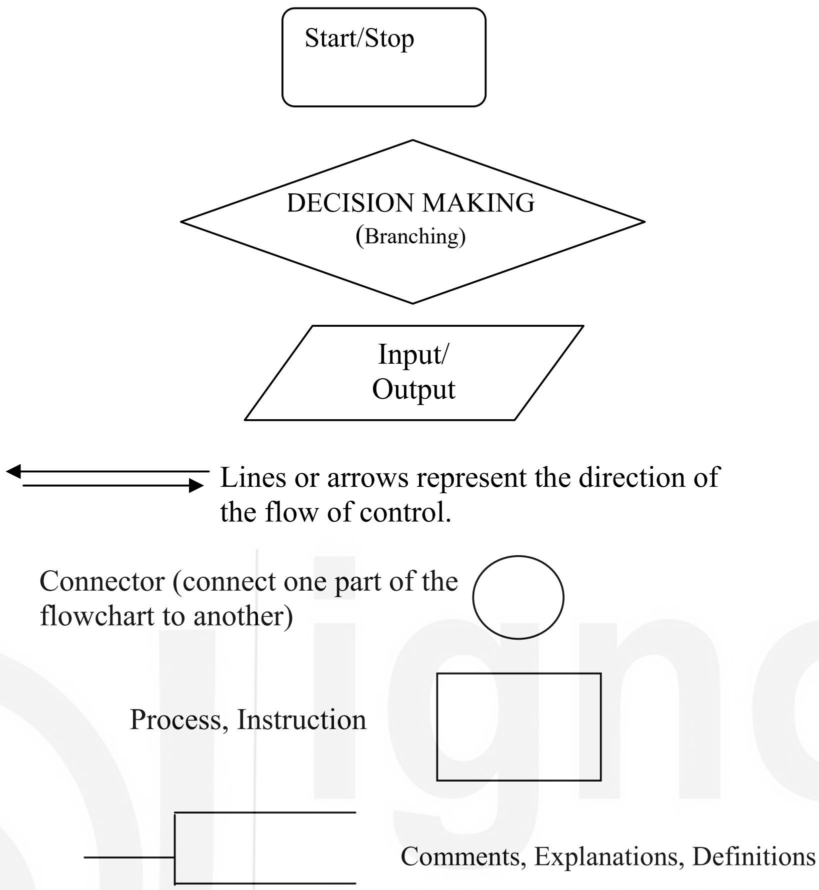
Figure 1.2: Schematic breakdown of a problem into subtasks as employed in top down design

Let us see how to represent the algorithm in a graphical form using a flowchart in the following section.

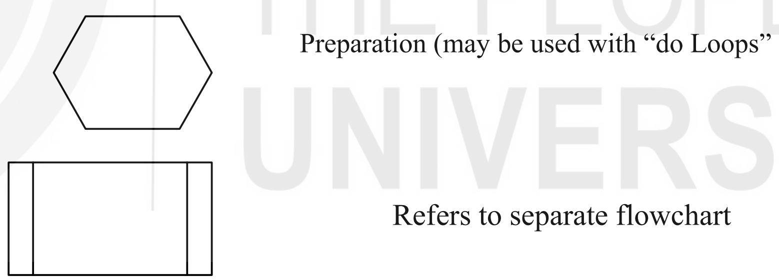
1.4 FLOWCHARTS

The next step after the algorithm development is the flowcharting. Flowcharts are used in programming to diagram the path in which information is processed through a computer to obtain the desired results. Flowchart is a graphical representation of an algorithm. It makes use of symbols which are connected among them to indicate the flow of information and processing. It will show the general outline of how to solve a problem or perform a task. It is prepared for better understanding of the algorithm.

1.4.1 Basic Symbols used in flowchart design

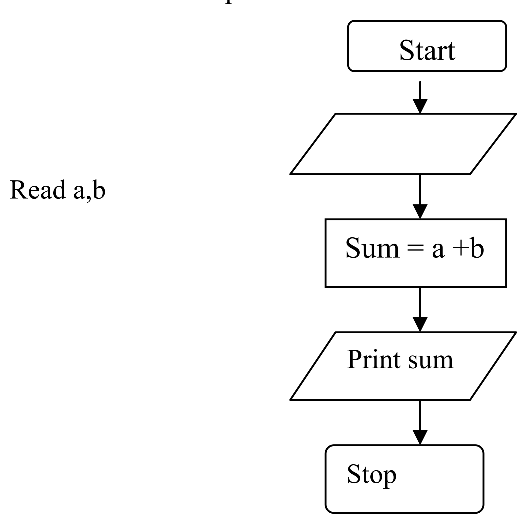


Additional Symbols Related to more advanced programming



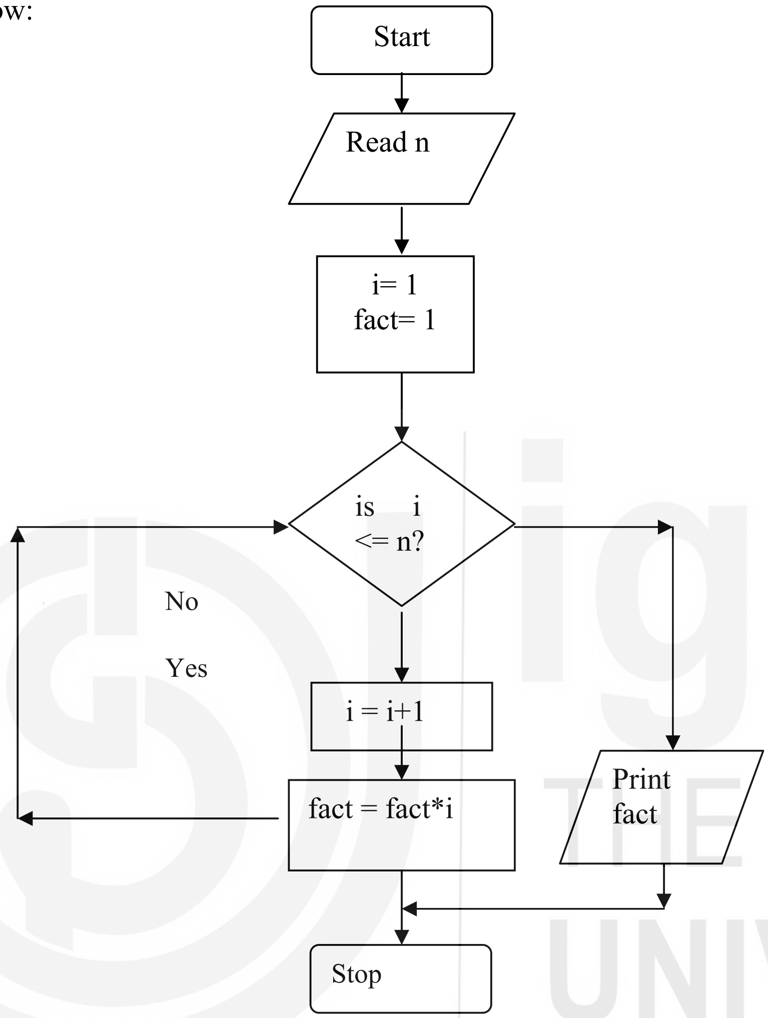
Example 1.5

The flowchart for the Example 1.1 is shown below:



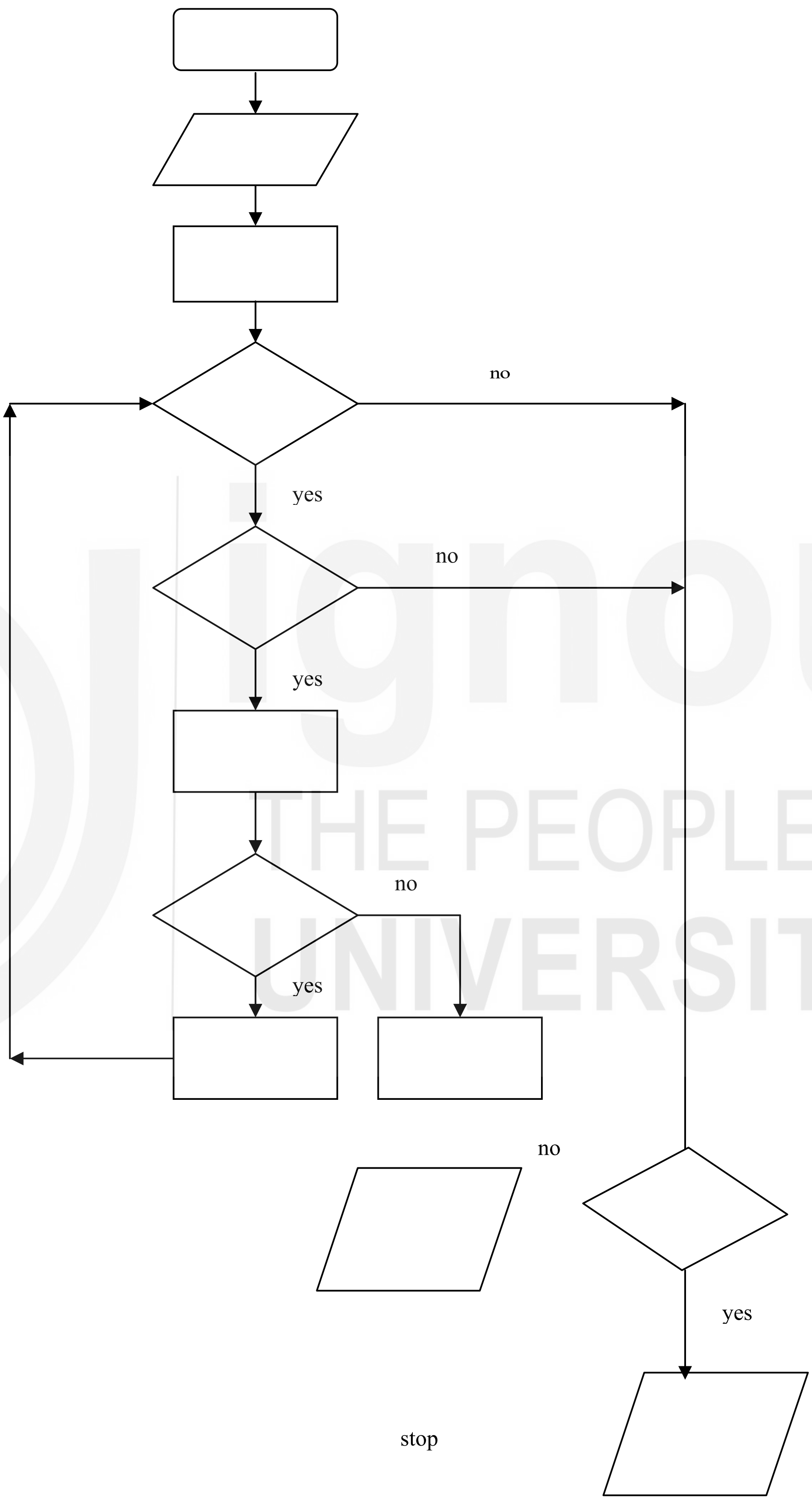
Example 1.6

The flowchart for the Example 1.3 (to find factorial of a given number) is shown low:



Example 1.7:

The flowchart for Example 1.4 is shown below:


no
yes
no
yes
no
yes
no
yes
stop

Check Your Progress 1

1. Differentiate between flowchart and algorithm.

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2. Compute and print the sum of a set of data values.

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3. Write the following steps are suggested to facilitate the problem solving process using computer.

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4. Draw an algorithm and flowchart to calculate the roots of quadratic equation

   Ax^2 + Bx + C = 0.

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1.5 PROGRAM AND PROGRAMMING LANGUAGE

A language is a mode of communication between two people. It is necessary for those two people to understand the language in order to communicate. But even if the two people do not understand the same language, a translator can help to convert one language to the other, understood by the second person. Similar to a translator is the mode of communication between a user and a computer is a computer language. One form of the computer language is understood by the user, while in the other form it is understood by the computer. A translator (or compiler) is needed to convert from user's form to computer's form. Like other languages, a computer language also follows a particular grammar known as the syntax.

In this unit we will introduce you the basics of programming language C.

We have seen in the earlier section's that a computer has to be fed with a detailed set of instructions and data for solving a problem. Such a procedure which we call an *algorithm* is a series of steps arranged in a logical sequence. Also we have seen that a *flowchart* is a pictorial representation of a sequence of instructions given to the computer. It also serves as a document explaining the procedure used to solve a problem. In practice it is necessary to express an algorithm using a *programming language*. A procedure expressed in a programming language is known as a *computer program*.

Computer programming languages are developed with the primary objective of facilitating a large number of people to use computers without the need for them to know in detail the internal structure of the computer. Languages are designed to be *machine-independent*. Most of the programming languages ideally designed, to execute a program on any computer regardless of who manufactured it or what model it is.

Programming languages can be divided into two categories:

i) **Low Level Languages or Machine Oriented Languages:** The language whose design is governed by the circuitry and the structure of the machine is known as the **Machine language**. This language is difficult to learn and use. It is specific to a given computer and is different for different computers i.e. these languages are **machine-dependent**. These languages have been designed to give a better machine efficiency, i.e. faster program execution. Such languages are also known as Low Level Languages. Another type of Low-Level Language is the Assembly Language. We will code the assembly language program in the form of mnemonics. Every machine provides a different set of mnemonics to be used for that machine only depending upon the processor that the machine is using.

ii) **High Level Languages or Problem Oriented Languages:** These languages are particularly oriented towards describing the procedures for solving the problem in a concise, precise and unambiguous manner. Every high level language follows a precise set of rules. They are developed to allow application programs to be run on a variety of computers. These languages are *machine-independent*. Languages falling in this category are FORTRAN, BASIC, PASCAL etc. They are easy to learn and programs may be written in these languages with much less effort. However, the computer cannot understand them and they need to be translated into machine language with the help of other programs known as Compilers or Translators.

1.6 C PROGRAMMINGLANGUAGE

Prior to writing C programs, it would be interesting to find out what really is C language, how it came into existence and where does it stand with respect to other computer languages. We will briefly outline these issues in the following section.

1.6.1 History of C Programming Language

C is a programming language developed at AT&T's Bell Laboratory of USA in 1972. It was designed and written by Dennis Ritchie. As compared to other programming languages such as Pascal, C allows a precise control of input and output.

Now let us see its historical development. The late 1960s were a turbulent era for computer systems research at Bell Telephone Laboratories. By 1960, many programming languages came into existence, almost each for a specific purpose. For example COBOL was being used for Commercial or Business Applications, FORTRAN for Scientific Applications and so on. So, people started thinking why could not there be a one general purpose language. Therefore, an International Committee was set up to develop such a language, which came out with the invention of ALGOL60. But this language never became popular because it was too abstract and too general. To improve this, a new language called Combined Programming Language (CPL) was developed at CambridgeUniversity. But this language was very complex in the sense that it had too many features and it was very difficult to learn. Martin Richards at CambridgeUniversity reduced the features of CPL and developed a new language called Basic Combined Programming Language (BCPL). But unfortunately it turned out to be much less powerful and too specific. Ken Thompson at AT & T's Bell Labs, developed a language called B at the same time as a further simplification of CPL. But like BCPL this was also too specific. Ritchie inherited the features of B and BCPL and added some features on his own and developed a language called C. C proved to be quite compact and coherent. Ritchie first implemented C on a DEC PDP-11 that used the UNIX Operating System.

For many years the *de facto* standard for C was the version supplied with the UNIX version 5 operating system. The growing popularity of microcomputers led to the creation of large number of C implementations. At the source code level most of these implementations were highly compatible. However, since no standard existed there were discrepancies. To overcome this situation, ANSI established a committee in 1983 that defined an ANSI standard for the C language.

1.6.2 Salient features of C

C is a general purpose, structured programming language. Among the two types of programming languages discussed earlier, C lies in between these two categories. That's why it is often called a ***middle level language.*** It means that it combines the elements of high level languages with the functionality of assembly language. It provides relatively good programming efficiency (as compared to machine oriented language) and relatively good machine efficiency as compared to high level languages). As a middle level language, C allows the manipulation of bits, bytes and addresses – the basic elements with which the computer executes the inbuilt and memory management functions. C code is very portable, that it allows the same C program to be run on machines with different hardware configurations. The flexibility of C allows it to be used for systems programming as well as for application programming.

C is commonly called a structured language because of structural similarities to ALGOL and Pascal. The distinguishing feature of a structured language is compartmentalization of code and data. Structured language is one that divides the entire program into modules using top-down approach where each module executes one job or task. It is easy for debugging, testing, and maintenance if a language is a structured one. C supports several control structures such as **while, do-while and for** and various data structures such as **strucs, files, arrays** etc. as would be seen in the later units. The basic unit of a C program is a **function -** C's standalone subroutine**.** The structural component of C makes the programming and maintenance easier.

Check Your Progress 2

1. "A Program written in Low Level Language is faster." Why?

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2. What is the difference between high level language and low level language?

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3. Why is C referred to as middle level language?

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1.7 STRUCTURE OF A C PROGRAM

As we have already seen, to solve a problem there are three main things to be considered. Firstly, what should be the output? Secondly, what should be the inputs that will be required to produce this output and thirdly, the steps of instructions which use these inputs to produce the required output. As stated earlier, every programming language follows a set of rules; therefore, a program written in C also follows predefined rules known as syntax. C is a case sensitivelanguage**.** All C programs consist of one or more functions. One function that must be present in every C program is **main()**. This is the first function called up when the program execution begins. Basically, **main()** outlines what a program does. Although **main** is not given in the keyword list,it cannot be used for naming a variable. The structure of a C program is illustrated in Figure.1.3 where functions *func1()* through *funcn()* represent user defined functions.

```
Preprocessor directives
                Global data declarations
                 main ( )     /* main function*/
                 {
                         Declaration part;
                         Program statements;
                  }

                 /*User defined functions*/
                 func1( )
                 {
                         …………
                 }

                 func2 ( )
                 {
                         …………
                  }
                  .
                  funcn ( )
                   {
                         …………
                  }
```

Figure. 1.3: Structure of a C Program.

A Simple C Program

From the above sections, you have become familiar with, a programming language and structure of a C program. It's now time to write a simple C program. This program will illustrate how to print out the message "This is a C program".

Example 1.8: Write a program to print a message on the screen.

```
/*Program to print a message*/

#include<stdio.h>                /* header file*/
```

```
main()                                  /* main function*/
{
 printf("This is a C program\n");  /* output statement*/
}
```

Though the program is very simple, a few points must be noted.

Every C program contains a function called **main()**. This is the starting point of the program. This is the point from where the execution begins. It will usually call other functions to help perform its job, some that we write and others from the standard libraries provided.

#include <stdio.h> is a reference to a special file called stdio.h which contains information that must be included in the program when it is compiled. The inclusion of this required information will be handled automatically by the compiler. You will find it at the beginning of almost every C program. Basically, all the statements starting with # in a C program are called preprocessor directives. These will be considered in the later units. Just remember, that this statement allows you to use some predefined functions such as, *printf(),* in this case.

main() declares the start of the function, while the two curly brackets { } shows the start and finish of the function. Curly brackets in C are used to group statements together as a function, or in the body of a loop. Such a grouping is known as a compound statement or a block. Every statement within a function ends with a terminator semicolon (;).

printf("This is a C program\n"); prints the words on the screen. The text to be printed is enclosed in double quotes. The **\n** at the end of the text tells the program to print a newline as part of the output. That means now if we give a second printf statement, it will be printed in the next line.

Comments may appear anywhere within a program, as long as they are placed within the delimiters **/*** and ***/.** Such comments are helpful in identifying the program's principal features or in explaining the underlying logic of various program features.

While useful for teaching, such a simple program has few practical uses. Let us consider something rather more practical. Let us look into the example given below, the complete program development life cycle.

Example 1.9

Develop an algorithm, flowchart and program to add two numbers.

Algorithm

1. Start
2. Input the two numbers ***a*** and ***b***
3. Calculate the sum as ***a+b***
4. Store the result in ***sum***
5. Display the result
6. Stop.

Flowchart

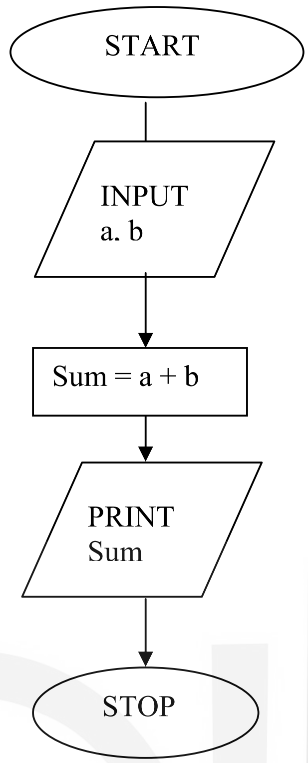

Figure 1.4: Flow chart to add two numbers

Program

```
#include<stdio.h>

main()
{
int a,b,sum;                    /* variables declaration*/

   printf("\n Enter the values for a and b: \n");
   scanf("%d, %d", &a, &b);

   sum=a+b;

   printf("\nThe sum is %d",sum);     /*output statement*/
}
```

OUTPUT

Enter the values of a and b:
2 3
The sum is 5

In the above program considers two variables *a* and *b*. These variables are declared as integers **(int)**, it is the data type to indicate integer values. Next statement is the printf statement meant for prompting the user to input the values of ***a***and ***b***. scanf is the function to intake the values into the program provided by the user. Next comes the processing / computing part which computes the **sum**. Again the **printf** statement is a bit different from the first program; it includes a format specifier (%d). The format specifier indicates the kind of value to be printed. We will study about other data types and format specifiers in detail in the following units. In the printf statement above, sum is not printed in double quotes because we want its value to be printed. The number of format specifiers and the variable should match in the printf statement.

At this stage, don't go much in detail. However, in the following units you will be learning all these details.

1.8 WRITING A C PROGRAM

A C program can be executed on platforms such as DOS, UNIX etc. DOS stores C program with a file extension ***.c***. Program text can be entered using any text editor such as EDIT or any other. To edit a file called ***testprog.c*** using edit editor, gives:

C:> edittestprog.c

If you are using **Turbo C**, then Turbo C provides its own editor which can be used for writing the program. Just give the full pathname of the executable file of Turbo C and you will get the editor in front of you. For example:

C:> turboc\bin\tc

Here, tc.exe is stored in bin subdirectory of turboc directory. After you get the menu just type the program and store it in a file using the menu provided. The file automatically gets the extension of .c.

UNIX also stores C program in a file with extension is ***.c***. This identifies it as a C program. The easiest way to enter your text is using a text editor like *vi*, *emacs* or *xedit*. To edit a file called testprog.c using ***vi***,

$ vi testprog.c

The editor is also used to make subsequent changes to the program

1.9 COMPILING A C PROGRAM

After you have written the program the next step is to save the program in a file with extension . c . This program is in high-level language. But this language is not understood by the computer. So, the next step is to convert the high-level language program (source code) to machine language (object code). This task is performed by a software or program known as a compiler. Every language has its own compiler that converts the source code to object code. The compiler will compile the program successfully if the program is syntactically correct; else the object code will not be produced. This is explained pictorially in Figure 1.5.

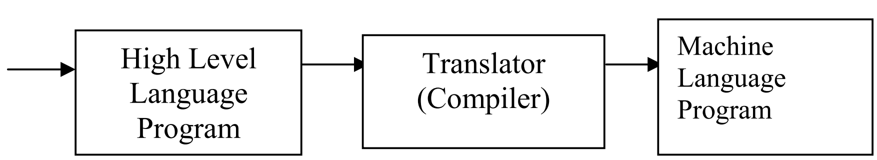

Figure 1.5: Process of Translation

1.9.1 The C Compiler

If you are working on UNIX platform, then if the name of the program file is testprog.c, to compile it, the simplest method is to type

cc testprog.c

This will compile testprog.c, and, if successful, will produce a executable file called ***a.out***. If you want to give the executable file any other, you can type

cc testprog.c -o testprog

This will compile ***testprog.c***, creating an executable file testprog.

If you are working with TurboC on DOS platform then the option for compilation is provided on the menu. If the program is syntactically correct then this will produce a file named as **testprog.obj**. If not, then the syntax errors will be displayed on the screen and the object file will not be produced. The errors need to be removed before compiling the program again. This process of removing the errors from the program is called as the **debugging**.

1.9.2 Syntax and Semantic Errors

Every language has an associated grammar, and the program written in that language has to follow the rules of that grammar. For example in English a sentence such a "Shyam, is playing, with a ball". This sentence is syntactically incorrect because commas should not come the way they are in the sentence.

Likewise, C also follows certain syntax rules. When a C program is compiled, the compiler will check that the program is syntactically correct. If there are any syntax errors in the program, those will be displayed on the screen with the corresponding line numbers.Let us consider the following program.

Example 1.10: Write a program to print a message on the screen.

```
/* Program to print a message on the screen*/
#include <stdio.h
main( )
{
  printf("Hello, how are you\n")
```

Let the name of the program be **test.c** .If we compile the above program as it is we will get the following errors:

Error test.c 1:No file name ending

Error test.c 5: Statement missing ;

Error test.c 6: Compound statement missing }

Edit the program again, correct the errors mentioned and the corrected version appears as follows:

```
#include <stdio.h>
main( )
{
```

```
  printf ("Hello, how are you\n");
}
```

Apart from syntax errors, another type of errors that are shown while compilation are semantic errors. These errors are displayed as warnings. These errors are shown if a particular statement has no meaning. The program does compile with these errors, but it is always advised to correct them also, since they may create problems while execution. The example of such an error is that say you have declared a variable but have not used it, and then you get a warning "code has no effect". These variables are unnecessarily occupying the memory.

Check Your Progress 3

1. What is the basic unit of a C program?

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   ……………………………………………………………………………………...
   ……………………………………………………………………………………...
   ……………………………………………………………………………………...
   ……………………………………………………………………………………...

2. "The program is syntactically correct". What does it mean?

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   ……………………………………………………………………………………...
   ……………………………………………………………………………………...
   ……………………………………………………………………………………...
   ……………………………………………………………………………………...

3. Indicate the syntax errors in the following program code:

```
include <stdio.h>
main( )
[
  printf("hello\n");
]
```

   ……………………………………………………………………………………...
   ……………………………………………………………………………………...
   ……………………………………………………………………………………...
   ……………………………………………………………………………………...
   ……………………………………………………………………………………...

1.10 LINK AND RUN THE C PROGRAM

After compilation, the next step is linking the program. Compilation produces a file with an extension **.obj**. Now this **.obj** file cannot be executed since it contains calls to functions defined in the standard library (header files) of C language. These functions have to be linked with the code you wrote. C comes with a standard library that provides functions that perform most commonly needed tasks. When you call a function that is not the part of the program you wrote, C remembers its name. Later the linker combines the code you wrote with the object code already found in the standard library. This process is called *linking.* In other words, Linker is a program that links separately compiled functions together into one program. It combines the functions in the standard C library with the code that you wrote. The output of the linker in an executable program i.e., a file with an extension ***.exe***.

1.10.1 Run the C Program Through the Menu

When we are working with TurboC in DOS environment, the menu in the GUI that pops up when we execute the executable file of TurboC contains several options for executing the program:

i) Link , after compiling

ii) Make, compiles as well as links

iii) Run

All these options create an executable file and when these options are used we also get the output on user screen. To see the output we have to shift to user screen window.

1.10.2 Run From an Executable File

An ***.exe*** file produced by can be directly executed.

UNIX also includes a very useful program called **make**. **Make** allows very complicated programs to be compiled quickly, by reference to a configuration file (usually called makefile). If your C program is a single file, you can usually use make by simply typing –

make testprog

This will compile **testprog.c** as well as link your program with the standard library so that you can use the standard library functions such as printf and put the executable code in **testprog.**

In case of DOS environment , the options provided above produce an executable file and this file can be directly executed from the DOS prompt just by typing its name without the extension. That is if the name of the program is test.c, after compiling and linking the new file produced is test.exe only if compilation and linking is successful.

This can be executed as:

c>test

1.10.3 Linker Errors

If a program contains syntax errors then the program does not compile, but it may happen that the program compiles successfully but we are unable to get the executable file, this happens when there are certain linker errors in the program. For example, the object code of certain standard library function is not present in the standard C library; the definition for this function is present in the header file that is why we do not get a compiler error. Such kinds of errors are called linker errors. The executable file would be created successfully only if these linker errors are corrected.

1.10.4 Logical and Runtime Errors

After the program is compiled and linked successfully we execute the program. Now there are three possibilities:

1) The program executes and we get correct results,
2) The program executes and we get wrong results, and
3) The program does not execute completely and aborts in between.

The first case simply means that the program is correct. In the second case, we get wrong results; it means that there is some logical mistake in our program. This kind of error is known as **logical error**. This error is the most difficult to correct. This error is corrected by debugging. Debugging is the process of removing the errors from the program. This means manually checking the program step by step and verifying the results at each step. Debugging can be made easier by a tracer provided in Turbo C environment. Suppose we have to find the average of three numbers and we write the following code:

Example 1.11:Write a C program to compute the average of three numbers

```
/* Program to compute average of three numbers *?
#include<stdio.h>
main( )
 {
   int a,b,c,sum,avg;
   a=10;
   b=5;
   c=20;
   sum = a+b+c;
   avg = sum / 3;
   printf("The average is %d\n", avg);
}
```

OUTPUT
The average is 8.

The exact value of average is 8.33 and the output we got is 8. So we are not getting the actual result, but a rounded off result. This is due to the logical error. We have declared variable **avg**as an integer but the average calculated is a real number, therefore only the integer part is stored in **avg.** Such kinds of errors which are not detected by the compiler or the linker are known as **logical errors**.

The third kind of error is only detected during execution. Such errors are known as **run time errors**. These errors do not produce the result at all, the program execution stops in between and the run time error message is flashed on the screen. Let us look at the following example:

Example 1.12: **Write a program to divide a sum of two numbers by their difference**

```
/* Program to divide a sum of two numbers by their difference*/

#include <stdio.h>

 main( )
 {

   int a,b;
   float c;

   a=10;
   b=10;

   c = (a+b) / (a-b);
   printf("The value of the result is %f\n",c);
}
```

The above program will compile and link successfully, it will execute till the first *printf* statement and we will get the message in this statement, as soon as the next statement is executed we get a runtime error of "Divide by zero" and the program halts. Such kinds of errors are **runtime errors**.

1.11 DIAGRAMMATIC REPRESENTATION OF C PROGRAM EXECUTION PROCESS

The following figure 1.6 shows the diagrammatic representation of the program execution process.

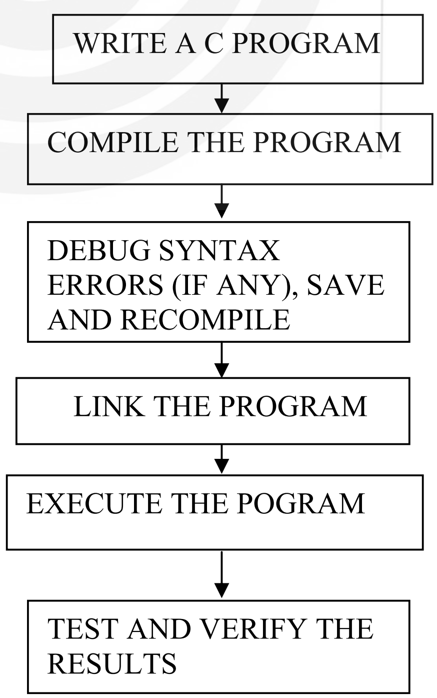

Figure 1.6: Program Execution Process

Check Your Progress 4

1. What is the extension of an executable file?

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2. What is the need for linking a compiled file?

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3. How do you correct the logical errors in the program?

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1.12 SUMMARY

To solve a problem different problem - solving tools are available that help in finding the solution to problem in an efficient and systematic way. Steps should be followed to solve the problem that includes writing the algorithm and drawing the flowchart for the solution to the stated problem**.** Top down design provides the way of handling the logical complexity and detail encountered in computer algorithm. It allows building solutions to problems in a stepwise fashion. In this way, specific and complex details of the implementation are encountered only at the stage when sufficient groundwork on the overall structure and relationships among the carious parts of the problem. We present C language - a standardized, industrial-strength programming language known for its power and portability as an implementation vehicle for these problem solving techniques using computer.

In this unit, you have learnt about a program and a programming language. You can now differentiate between high level and low level languages. You can now define what is C, features of C. You have studied the emergence of C. You have seen how C is different, being a middle level Language, than other High Level languages. The advantage of high level language over low level language is discussed.

You have seen how you can convert an algorithm and flowchart into a C program. We have discussed the process of writing and storing a C program in a file in case of UNIX as well as DOS environment.

You have learnt about compiling and running a C program in UNIX as well as on DOS environment. We have also discussed about the different types of errors that are encountered during the whole process, i.e. syntax errors, semantic errors, logical errors, linker errors and runtime errors. You have also learnt how to remove these errors. You can now write simple C programs involving simple arithmetic operators and the *printf( )* statement. With these basics, now we are ready to learn the C language in detail in the following units.

1.13 SOLUTIONS / ANSWERS

Check Your Progress 1

1. The process to devise and describe a precise plan (in the form of sequence of operations) of what you want the computer to do, is called an **algorithm**. An algorithm may be symbolized in a flowchart or pseudocode.

2. 1. Start
   2. Set the sum of the data values and the count of the data values to zero.
   3. As long as the data values exist, add the next data value to the sum and add 1 to the count.
   4. Display the average.
   5. Stop

3. The following steps are suggested to facilitate the problem solving process:
   a) Define the problem
   b) Formulate a mathematical model
   c) Develop an algorithm
   d) Design the flowchart
   e) Code the same using some computer language
   f) Test the program

Check Your Progress 2

1. A program written in Low Level Language is faster to execute since it needs no conversion while a high level language program need to be converted into low level language.

2. Low level languages express algorithms on the form of numeric or mnemonic codes while High Level Languages express algorithms in the using concise, precise and unambiguous notation. Low level languages are machine dependent while High level languages are machine independent. Low level languages are difficult to program and to learn, while High

level languages are easy to program and learn. Examples of High level languages are FORTRAN, Pascal and examples of Low level languages are machine language and assembly language.

3. C is referred to as middle level language as with C we are able to manipulate bits, bytes and addresses i.e. interact with the hardware directly. We are also able to carry out memory management functions.

Check Your Progress 3

1. The basic unit of a C program is a C function.
2. It means that program contains no grammatical or syntax errors.
3. Syntax errors:
   a) # not present with include
   b) {brackets should be present instead of [brackets.

Check Your Progress 4

1. The extension of an executable file is .exe.
2. The C program contains many C pre-defined functions present in the C library. These functions need to be linked with the C program for execution; else the C program may give a linker error indicating that the function is not present.
3. Logical errors can be corrected through debugging or self checking.

1.14 FURTHER READINGS

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