Programming Concepts

Introduction to Programming Concepts

Language

- Human Language:
  - Commonly used to express feelings and understand other person expressions.
  - It can be oral or gestural kind of communication

- Computer Language:
  - Computer languages are the languages by which a user command a computer to work on the algorithm which a user has written to get an output.

Definition of Program

- A computer program is a series of organised instructions that directs a computer to perform tasks.

Definition of Programming Language

- A programming language is a set of words, symbols and codes that enables humans to communicate with computers.

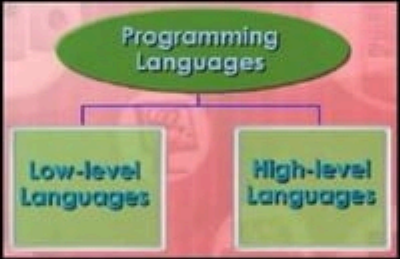
Definition of programming language

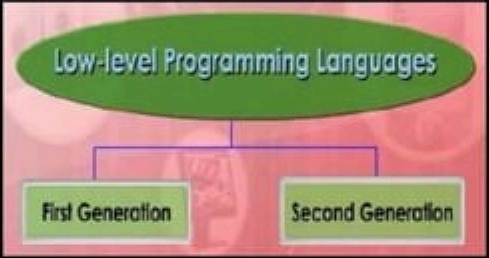
- Programming languages are use to write application programs which are used by end users.
- The programming languages are generally used only by professional programmers to write programs.
- The development of programming languages has improved considerably with the ease and ability of programmers to write powerful applications programs that can solve any task in the world today.
- Each computer programming language has its own distinctive grammars and syntax and its own manner of expressing ideas. In principle most computational task could be accomplish by any of the languages but the programs would look very different moreover, writing a program for a particular task could be easier with some languages than the others.

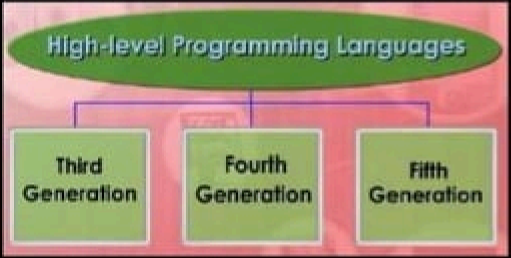
Example of Programming Languages

- Hundreds of programming languages exist today. Each language has its own standard or rules for writing the commands and/or instructions.
- Examples of programming languages are:
  - BASIC (Beginner's All Purpose Symbolic Instruction Code)
  - Pascal
  - C
  - Smalltalk

Levels of Programming Language







The Evolution of Programming Languages

To build programs, people use languages that are similar to human language. The results are translated into machine code, which computers understand.

Programming languages fall into three broad categories:

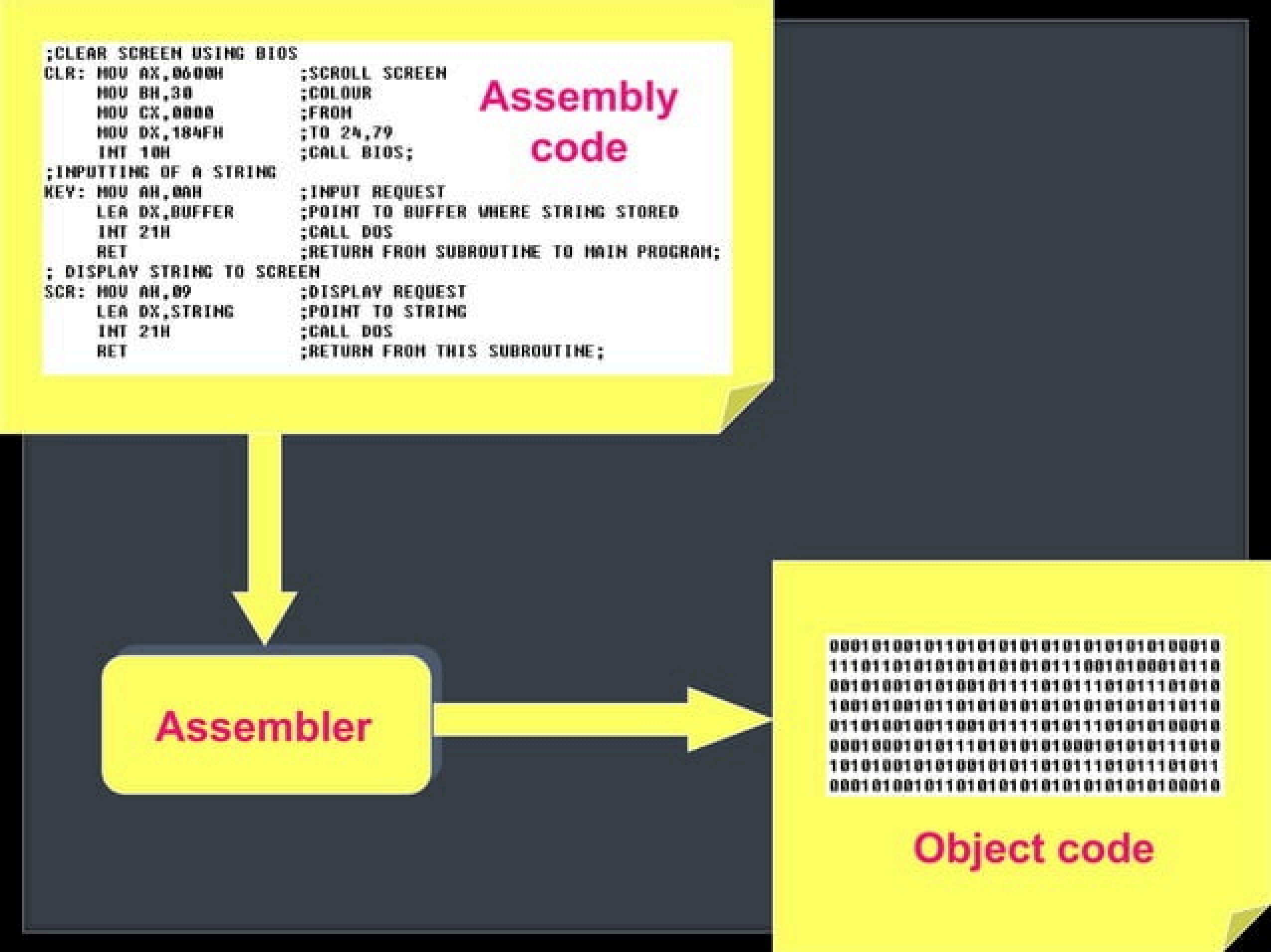
- Machine languages
- Assembly languages
- Higher-level languages

The Evolution of Programming Languages - Machine Languages

- Machine languages (first-generation languages) are the most basic type of computer languages, consisting of strings of numbers the computer's hardware can use.
- Different types of hardware use different machine code. For example, IBM computers use different machine language than Apple computers.

The Evolution of Programming Languages - Assembly Languages

- Assembly languages (second-generation languages) are only somewhat easier to work with than machine languages.
- To create programs in assembly language, developers use cryptic English-like phrases to represent strings of numbers.
- The code is then translated into object code, using a translator called an assembler.



```
;CLEAR SCREEN USING BIOS
CLR: MOV AX,0600H       ;SCROLL SCREEN
     MOV BH,30          ;COLOUR
     MOV CX,0000        ;FROM
     MOV DX,184FH       ;TO 24,79
     INT 10H            ;CALL BIOS;
;INPUTTING OF A STRING
KEY: MOV AH,0AH         ;INPUT REQUEST
     LEA DX,BUFFER      ;POINT TO BUFFER WHERE STRING STORED
     INT 21H            ;CALL DOS
     RET                ;RETURN FROM SUBROUTINE TO MAIN PROGRAM;
; DISPLAY STRING TO SCREEN
SCR: MOV AH,09          ;DISPLAY REQUEST
     LEA DX,STRING      ;POINT TO STRING
     INT 21H            ;CALL DOS
     RET                ;RETURN FROM THIS SUBROUTINE;
```

```
0001010010110101010101010101010100010
1110110101010101010101110010100010110
0010100101010010111101011101011101010
1001010010110101010101010101010110110
0110100100110010111101011101010100010
0001000101011101010101000101010111010
1010100101010010101101011101011101011
0001010010110101010101010101010100010
```

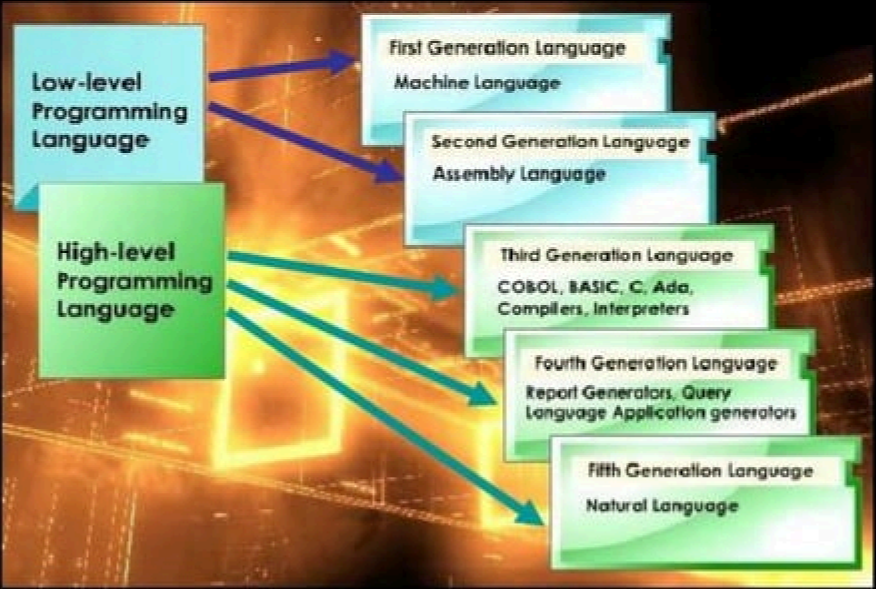
The Evolution of Programming Languages - Higher-Level Languages

Higher-level languages are more powerful than assembly language and allow the programmer to work in a more English-like environment.

Higher-level programming languages are divided into three "generations," each more powerful than the last:

- Third-generation languages
- Fourth-generation languages
- Fifth-generation languages

Generations of programming languages


Low-level Programming Language
High-level Programming Language
First Generation Language
Machine Language
Second Generation Language
Assembly Language
Third Generation Language
COBOL, BASIC, C, Ada, Compilers, Interpreters
Fourth Generation Language
Report Generators, Query Language Application generators
Fifth Generation Language
Natural Language

1st generation languages

- Programming language history really began with the work of Charles Babbage in the early nineteenth century who developed automated calculation for mathematical functions.
- Further developments in early 1950 brought us machine language without interpreters and compilers to translate languages.
- The first generation computer language was machine language, all the machine used machine code which consisted of 0s and 1s.
- Machine language is highly efficient and allows direct control of each operation; however programmers had to write computer programs using 0 and 1.
- Machine languages were created differently for different CPUs. Machine dependency was a problem because this programming language would only work for the system that it was written for.
- Some of the drawbacks of the first generations languages were:
  - Programs were difficult to write and debug
  - Programming process was tedious
  - Programming was time confusing
  - Programs were error prone: This generation of programming languages were written in binary, a series of zeros and ones. Binary is difficult to read and errors occurred frequently.

2nd generation languages

- These were developed in the mid 1950's with the ability to use acronyms or symbolic codes to speed programming and coding of programs. They were called assembly languages.
- Symbolic addresses allowed programmers to represent memory locations, variables and instructions with names.
- They had the capability to performs operation such like add, sum.
- Like machine languages, assembly languages were designed for specific machine and microprocessor, this implies that the program cannot be move from one computer architecture without writing the code which means learning another language where you are to transfer the programs.

3rd generation languages

- These were introduced between 1956 and 1963 which saw a major breakthrough in computing history with the development of high level computer languages popularly known as 3rd(3GLS).
- Languages like ALGOL 58, 60 and 68, COBOL, FORTRAN IV, ADA and C are examples of this and were considered as high level languages.
- Most of these languages had compilers and the advantage of this was speed.
- Independence was another factor as these languages were machine independent and could run on different machines.
- The advantages of high level languages include the support for ideas of abstraction so that programmers can concentrate on finding the solution to the problem rapidly, rather than on low-level details of data representation.
- The comparative ease of use and learning, improved portability and simplified debugging, modifications and maintenance led to reliability and lower software costs.
- Example of the 3rd generation languages includes the following:

1. FORTRAN – Formula Translation
   - FORTRAN was developed in 1956 to provide easier way for scientific and engineering application and these were especially useful for processing Numeric data.
2. COBOL – Common Business Oriented Languages
   - COBOL came into use in the early 1960. It was designed with business administration in mind for processing large data types with alphanumeric characters which were mixture of alphabet and data and does repetitive tasks like payroll. The other language was BASIC. These were the early computer programming languages in the early history of computers.

4th generation languages

- A fourth-generation programming language(1970s-1990) (abbreviated 4GL) is a programming language or programming environment designed with a specific purpose in mind, such as the development of commercial business software.
- programmers who use the computers and programs to solve problems from other applications are the main users of the fourth generation languages.
- fourth generation languages must be user friendly, portable and independent of operating systems, usable by non-programmers, having intelligent default options about what the user wants and allowing the user to obtain results fasts using minimum requirement code generated with bug-free code from high-level expressions (employing a data-base and dictionary management which makes applications easy and quick to change), which was not possible using COBOL or PL/I.
- Examples of this generation of languages are IBM's ADRS2, APL, CSP and AS, Power Builder, Access.

5th generation languages

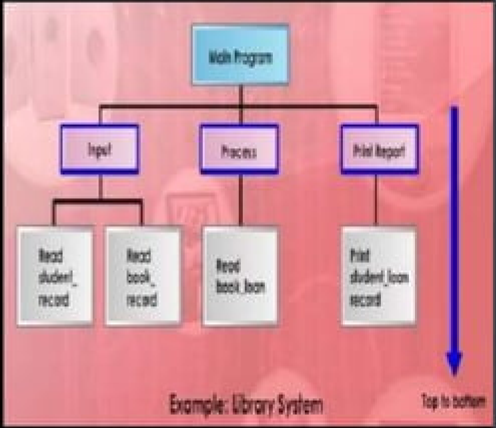
- The 1990's saw the developments of fifth generation languages. A fifth-generation programming language (abbreviated 5GL) is a programming language based around solving problems using constraints given to the program, rather than using an algorithm written by a programmer. Most constraint-based and logic programming languages and some declarative languages are fifth-generation languages.
- Examples include PROLOG, referring to systems used in the field of artificial_intelligence, fuzzy logic and neural networks. This means computers can in the future have the ability to think for themselves and draw their own inferences using programmed information in large databases.
- Complex processes like understanding speech would appear to be trivial using these fast inferences and would make the software seem highly intelligent.

Programming language approaches

- Structured Approach in programming
- Object Oriented Approach in programming

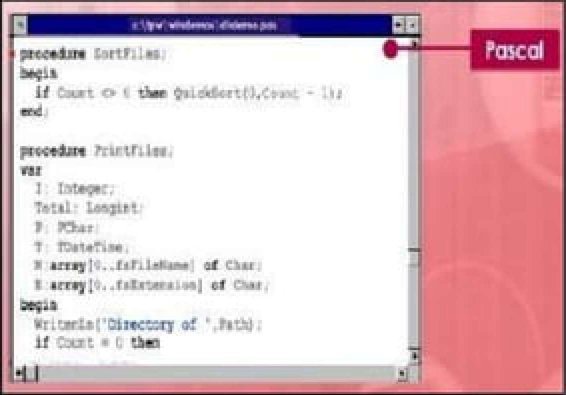
STRUCTURED PROGRAMMING

- often uses a top-down design model where developers map out the overall program structure into separate subsections from top to bottom.
- In the top-down design model, programs are drawn as rectangles.
- A top-down design means that the whole program is broken down into smaller sections that are known as modules. A program may have a module or several modules.



STRUCTURED PROGRAMMING

- Structured programming is beneficial for organising and coding computer
- programs which employ a hierarchy of modules. This means that control is passed downwards only through the hierarchy.
- Examples of structured programming languages include Ada, Pascal and Fortran.

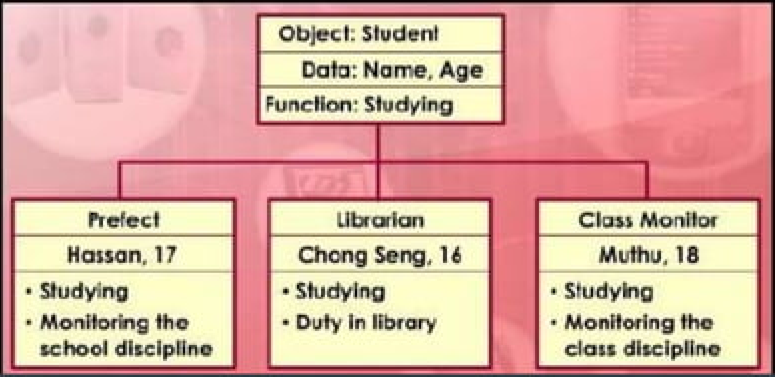


```
procedure SortFiles;
begin
  if Count <> 0 then QuickSort(0,Count - 1);
end;

procedure PrintFiles;
var
  I: Integer;
  Total: Longint;
  P: PChar;
  T: TDateTime;
  N:array[0..fsFileName] of Char;
  E:array[0..fsExtension] of Char;
begin
  Writeln('Directory of ',Path);
  if Count = 0 then
```

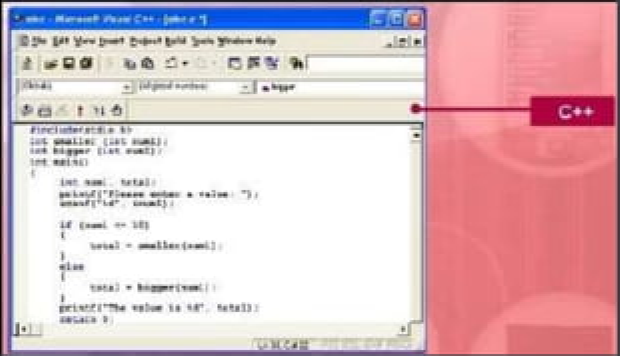
OBJECT-ORIENTED PROGRAMMING

- The object-oriented approach refers to a special type of programming approach that combines data with functions to create objects.



OBJECT-ORIENTED PROGRAMMING

- In an object-oriented program, the object have relationships with one another.
- One of the earliest OOP languages is Smalltalk. Java, Visual Basic and C++ are examples of popular OOP languages.



```
#include<stdio.h>
int smaller (int num1);
int bigger (int num1);
int main()
{
      int num1, total;
      printf("Please enter a value: ");
      scanf("%d", &num1);

      if (num1 <= 10)
      {
            total = smaller(num1);
      }
      else
      {
            total = bigger(num1);
      }
      printf("The value is %d", total);
      return 0;
```

DIFFERENCE BETWEEN STRUCTURED AND OBJECT ORIENTED PROGRAMMING

- Structured programming often uses a top-down design model.
- The object-oriented programming approach uses objects.

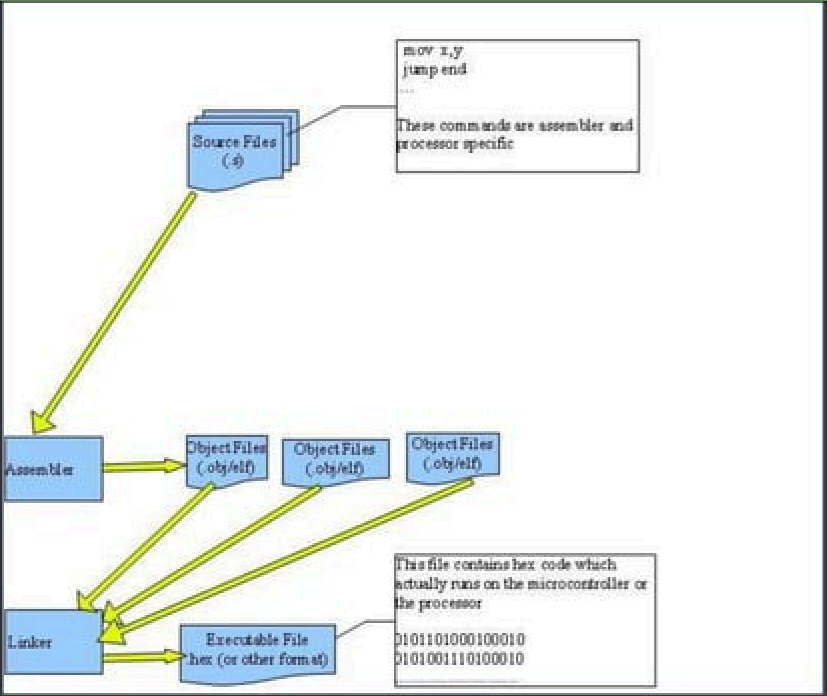
Translators

- Assemblers
- Compilers
- Interpretters

Assembler

- Assembly language is converted into executable machine code by a utility program referred to as an assembler.
- An **assembler** creates object code by translating assembly language instructions into opcodes.

Assembly / Linking


mov x,y
jump end
...
These commands are assembler and processor specific
Source Files (.s)
Assembler
Object Files (.obj/elf)
Object Files (.obj/elf)
Object Files (.obj/elf)
Linker
Executable File .hex (or other format)
This file contains hex code which actually runs on the microcontroller or the processor
0101101000100010
0101001110100010

Compiler

- A computer program which reads source code and outputs assembly code or executable code is called compiler.
- This software, converts the code written in high-level language into object file.
- Compilers translate entire programs into machine code, which can be run later on the target computer.
- Examples of Programming Languages Using compiler :
    - C
    - C++ etc.

Interpreter

- Interpreters translate source code into machine language while a program is running, one line at a time, unlike compiler, which processes everything at once. In this case a single line is executed at a time. It is time consuming.
- Examples of Programming Languages Using Interpreter :
  - Lisp
  - BASIC

Source Code

- Source Code is In the form of Text.
- Source Code is Human Readable.
- Source Code is Generated by Human.
- Source Code is Input Given to Compiler.

Object Code

- Object Code is in the form of Binary Numbers.
- Object Code is in Machine Readable.
- Object Code is Generated by Compiler.
- Object code is Output of Compiler.

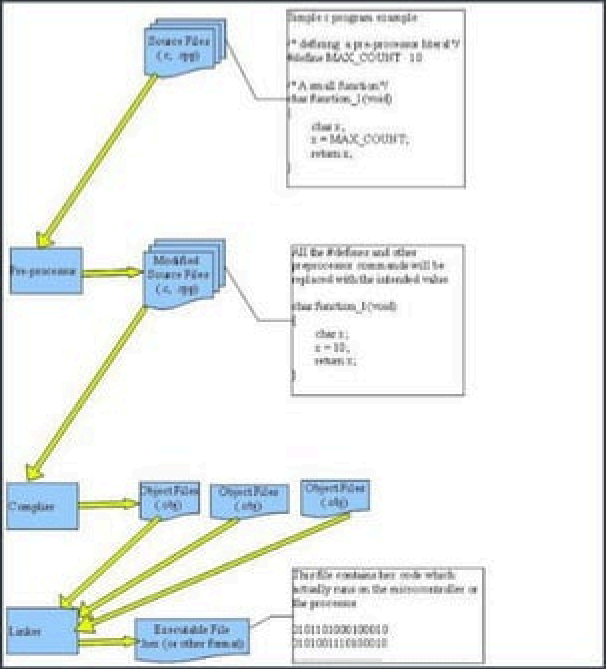
Preprocessor

- All the preprocessor commands written in a high level language are processed by the preprocessor before compiler takes over. Example: "#define MAX_ROWS 10" Preprocessor finds all the places and replaces MAX_ROWS with 10 in the files of the project.

Linker

- Linker uses the object files created by the compiler and then uses the predefined library objects to create an executable.

Following figure shows step by step process for converting a human understandable source file into machine understandable executable file.



```
Simple c program example

/* defining a pre-processor literal */
#define MAX_COUNT 10

/* A small function */
char function_1(void)
{
        char x;
        x = MAX_COUNT;
        return x;
}
```

All the #defines and other preprocessor commands will be replaced with the intended value

```
char function_1(void)
{
        char x;
        x = 10;
        return x;
}
```

This file contains hex code which actually runs on the microcontroller or the processor

```
0101101000100010
0101001110000010
```

Plain text files vs. word processor files

- There are important differences between plain text files created by a text editor, and document files created by word processors such as Microsoft Word, WordPerfect etc.
- A plain text file uses a simple character set such as ASCII to represent numbers, letters, and a small number of symbols. The only non-printing characters in the file, usable to format the text, are newline, tab, and formfeed.
- Word processor documents generally contain formatted text, adding content that enables text to appear in boldface and italics, to use multiple fonts, and to be structured into columns and tables.
- Word processors were developed to aid in formatting text for presentation on a printed page, while text editors treat text as data.
- When both formats are available, the user must select with care. Saving a plain text file in a word-processor format will add formatting information that could disturb the machine-readability of the text. Saving a word-processor document as a text file will lose formatting information.
- Unix and Unix-like operating systems have the vi editor (or a variant), but many also include the Emacs editor. Microsoft Windows systems come with the simple Notepad.

Program Development Cycle

- The program development cycle consists of four basic steps to follow when planning a computer program. However, often there are two more steps included in this cycle. By following this step-by-step process, the chance of making mistakes is minimal. We are going to take a look at each step in the cycle and what it is used for as well as why it is important when it comes to programming.

- The first step in the cycle is analyzing. Analyzing basically defines the problem. This is a very important step in the process in order to develop an appropriate solution. At this time, an outline is made which defines the entire process including the program's input, output, and processing components.

- The second step in the cycle is design. At this time, any problems found during the analysis are broken down. The method and appropriate programming language are chosen during this process. Structured design allows the problem to be broken down into sections called modules. This can be done so that each routine performs a single task. The structured design is important because it turns the main routine into smaller ones which helps the programmers locate any problems easily and stay organized.

- The third step in the process is validating the design. This is done by computer programmers who code the design into a programming language.
- Implementing the design is step four. This is when the code to translate the design into a program is written. The new system is installed at this time.

- Steps five and six are testing and documenting the solution. The program is maintained and if any changes are needed, the cycle begins again.
- The program development cycle is in fact called a cycle because any phase can lead to the previous or next step in the process. This normally happens only if an error is found. It is also referred to as a cycle because once it ends it begins again.

- Besides the programmer, there are many other people involved in the stages of the program development cycle. System analysts, designers, system architects, coders and testers are also involved in the cycle. They are all important when it comes to developing a successful program.

Programming tips: Five qualities of a good program

- A good program is not necessarily a powerful application but at the very least, it must pass certain criteria so that it can stand out among other programs in the market. If you are a programmer by profession, your main goal in creating programs is and should always be to satisfy the requirements of your clients. Aside from attaining this goal, you should also take the following qualities into consideration when you create your program:
- 1) It should be free from bugs.
  - Program errors normally occur no matter how careful the programmer is in constructing the program. Even commercially released applications are not spared from this buggy predicament. The best thing a programmer can do is to constantly find bugs in the program or for large-scale applications, enlist the aid of beta testers. This will not necessarily eliminate every program error but at least it would minimize the occurrence of such bugs.

- 2) It must run in an accurate and efficient manner.
  - During quality control, a program must be tested for its accuracy and efficiency. Not all programs are created equal. Some programs are not sophisticated enough to successfully complete multiple tasks. Others have a slew of powerful features but they take too long to load. As a programmer, it should be your priority to satisfy your client's needs without neglecting accuracy and efficiency. You must not compromise one for the other, instead, you should set some kind of equilibrium point which balances the two qualities.
- 3) The program's interface must be accessible and user-friendly.
  - No matter how good a program's features are, a cluttered user interface will most likely drag it down. Don't risk it. Potential users will steer clear from your program unless you have a comprehensive help file to go along with the messy UI.

- 4) It should be easy to maintain and doesn't hog system resources.
  - What good is a program if it bogs down the entire computer system? Sometimes, you must carefully consider an average user's system specifications. If you're creating a program in a high-end computer and you notice that it runs really smoothly, you should also make the effort to test it in a system with only the barest necessities. Remember that there are still people out there who use relatively low-end computers, so if you don't want to alienate them, try to put yourself in their shoes. Of course, you should not sacrifice a program's quality in the process. You must strike a balance in this criterion as well.
- 5) The source code is well-organized and optimized for the best performance.
  - If your main goal is to share bits and pieces of your code to the community to showcase your skills as a programmer, then you should clean it up and trim down excess code. It is advisable to organize your code in such a manner that they will understand your program's flow.

CHARACTERISTICS OF A GOOD PROGRAM

- Every computer requires appropriate instruction set (programs) to perform the required task. The quality of the processing depends upon the given instructions. If the instructions are improper or incorrect, then it is obvious that the result will be superfluous. Therefore, proper and correct instructions should be provided to the computer so that it can provide the desired output. Hence, a program should be developed in such a way that it ensures proper functionality of the computer. In addition, a program should be written in such a manner that it is easier to understand the underlying logic. A few important characteristics that a computer program should possess are as follows:
- **Portability:** Portability refers to the ability of an application to run on different platforms (operating systems) with or without minimal changes. Due to rapid development in the hardware and the software, nowadays platform change is a common phenomenon. Hence, if a program is developed for a particular platform, then the life span of the program is severely affected.

- **Readability:** The program should be written in such a way that it makes other programmers or users to follow the logic of the program without much effort. If a program is written structurally, it helps the programmers to understand their own program in a better way. Even if some computational efficiency needs to be sacrificed for better readability, it is advisable to use a more user-friendly approach, unless the processing of an application is of utmost importance.
- **Efficiency:** Every program requires certain processing time and memory to process the instructions and data. As the processing power and memory are the most precious resources of a computer, a program should be laid out in such a manner that it utilizes the least amount of memory and processing time.

- **Structural:** To develop a program, the task must be broken down into a number of subtasks. These subtasks are developed independently, and each subtask is able to perform the assigned job without the help of any other subtask. If a program is developed structurally, it becomes more readable, and the testing and documentation process also gets easier.
- **Flexibility:** A program should be flexible enough to handle most of the changes without having to rewrite the entire program. Most of the programs are developed for a certain period and they require modifications from time to time. For example, in case of payroll management, as the time progresses, some employees may leave the company while some others may join. Hence, the payroll application should be flexible enough to incorporate all the changes without having to reconstruct the entire application.

- **Generality:** Apart from flexibility, the program should also be general. Generality means that if a program is developed for a particular task, then it should also be used for all similar tasks of the same domain. For example, if a program is developed for a particular organization, then it should suit all the other similar organizations.
- **Documentation:** Documentation is one of the most important components of an application development. Even if a program is developed following the best programming practices, it will be rendered useless if the end user is not able to fully utilize the functionality of the application. A well-documented application is also useful for other programmers because even in the absence of the author, they can understand it.