



Introduction to Computer Programming

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Computer Programs

- Software refers to programs that make the computer perform some task.
- A *program* is a set of instructions that tells the computer what to do.
- When you have written a program, the computer will behave exactly as you have instructed it. It will do no more or no less than what is contained in your specific instructions.



Writing Programs

- Learning to write programs requires two skills.
 - You need to use specific terminology and punctuation that can be understood by the machine; that is, you need to learn a programming language.
 - You need to develop a plan for solving a particular problem. This plan—or algorithm—is a sequence of steps that, when followed, will lead to a solution of the problem.



Solving Problems

- Initially, you may think that learning a language is the more difficult task because your problems will have relatively easy solutions. Nothing could be further from the truth!
- **The single most important thing you can do as a student of computer science is to develop the skill to solve problems.**
- Once you have this skill, you can learn to write programs in several different languages.



What Is a Computer Language?

- A microprocessor is designed to “understand” a set of commands called an “*instruction set*”
- All instructions must be provided to the CPU in its native language, called *machine language*.
- All data transmission, manipulation, storage, and retrieval is done by the machine using electrical pulses representing sequences of binary digits.
- If eight-digit binary codes are used, there are 256 numbered instructions from 00000000 to 11111111.



Machine Language

- Instructions for adding two numbers would consist of a sequence of these eight-digit codes from 00000000 to 11111111.
- Instructions written in this form are referred to as *machine language*.
- It is the native language that the CPU “speaks” and “understands”.
- It is possible to write an entire program in machine language. However, this is very time consuming and difficult to read and understand.

Programming Languages

- Fortunately, special languages have been developed that are more easily understood (than machine language).
- These special languages are called *programming languages*.
- These languages provide a way to write computer programs that are understood by both computers and people.
- Programming languages have their own vocabulary and rules of usage.
- Some languages are very technical, while others are similar to English.

Assembly Language

- The programming language that is most like machine language is *assembly language*.
- Assembly language uses letters and numbers to represent machine language instructions.
- An *assembler* is a program that reads the codes the programmer writes in assembly language and “assembles” a machine language program based on those codes.
- However, assembly language is still difficult to read.

Comparing Machine Language & Assembly Language

- For example, the machine code for adding two integers might be:

010000110011101000111101010000010010101101000010

- While the assembly language code might be:

LOAD A

ADD B

STORE C

- This causes the number in A to be added to the number in B, and the result is stored for later use in C.

Low Level Languages

- Machine Language and Assembly Language are both called *low-level languages*.
- In a low-level language, it is necessary for the programmer to know the instruction set of the CPU in order to program the computer.
- Each instruction in a low-level language corresponds to **one** or only a **few** microprocessor instructions.

High Level Languages

- A *high-level language* is any programming language that uses words and symbols to make it relatively easy to read and write a computer program.
- In a high-level language, instructions do not necessarily correspond one-to-one with the instruction set of the CPU.
- One command in a high-level language may correspond to **many** microprocessor instructions.

High Level Languages 2

- Many *high-level languages* have been developed. These include:
- FORTRAN, COBOL, BASIC, Logo, Pascal, C, C++, Java, Python, and others.
- These languages simplify even further the terminology and symbolism necessary for directing the machine to perform various manipulations of data.

Advantages Of High Level Languages

- High Level Languages:
 - Reduce the number of instructions that must be written.
 - Allow programs to be written in a shorter amount of time than a low-level language would take.
 - Reduce the number of errors that are made, because...
 - The instructions are easier to read.
 - Are more portable (the programs are easier to move among computers with different microprocessors).

Advantages Of Low Level Languages

- Low Level Languages:
 - Instructions can be written to enable the computer to do anything that the hardware will follow.
 - Require less memory
 - Run more quickly



High Level Language Examples

- Consider the following programs that add two numbers together:

BASIC

```
10 I = 3
20 J = 2
30 K = I + J
```

Pascal

```
program AddIt;
var
  i, j, k : integer;
begin
  i := 3;
  j := 2;
  k := i + j;
end.
```

C++

```
int main()
{
  int i, j, k;
  i = 3;
  j = 2;
  k = i + j;
  return 0;
}
```

LOGO

```
to add :I :J :K
  MAKE "I :3
  MAKE "J :2
  MAKE "K :I + :J
end
```


High Level Language Examples 2

Java

```
public class AddTwoNumbers{  
    public static void main(String[] args){  
        int i, j, k;  
        i = 3;  
        j = 2;  
        k = i + j;  
    }  
}
```

Python

```
i = 3  
j = 2  
k = i + j
```


Interpreters and Compilers

- Programmers writing in a high-level language enter the program's instructions into a text editor.
- The files saved in this format are called *text files*.
- A program written in a high-level language is called *source code*.
- The programs are translated into machine language by interpreters or compilers.
- The resulting machine language code is known as *object code (or byte code - Java)*.

Interpreters

- An interpreter is a program that translates the source code of a high-level language into machine language.
- Each instruction is interpreted from the programming language as needed (line by line of code).
- Every time the program is run, the interpreter must translate each instruction again.
- **In order to “run” the program, the interpreter must be loaded into the computer’s memory.**

Compilers

- A compiler is another program that translates a high-level language into machine language.
- A compiler makes the translation once so that the source code don't have to be translated each time the program is run.
 - The source code is translated into a file called an *object file*.
 - A program called a *linker* is used to create an *executable program*.
 - Most modern compilers let you compile and link in a single operation, and have an “IDE” (Integrated Development Environment) to enter text, debug, compile, link, and run programs.

Debug

- Bug: An error in coding or logic that causes a program to malfunction or to produce incorrect results.
- Debug: To detect, locate, and correct logical or syntactical errors in a program.
- Folklore attributes the first use of the term “bug” to a problem in one of the first electronic computers that was traced to a moth caught between the contacts of a relay in the machine.



Programming Languages: First Generation

- Generation 1 – Late 1940s to Early 1950s:
Machine Languages
 - Programmers entered programs and data directly into RAM using 1s and 0s
 - Several disadvantages existed:
 - Coding was error prone, tedious, and slow
 - Modifying programs was extremely difficult
 - It was nearly impossible for a person to decipher someone else's program
 - Programs were not portable

Programming Languages: Second Generation

- Generation 2 – Early 1950s to Present:
Assembly Languages
 - Uses mnemonic symbols to represent instructions and data
 - Assembly language is:
 - More programmer friendly than machine language
 - Tedious to use and difficult to modify
 - Since each type of computer has its own unique assembly language, it is not portable

Programming Languages: Third Generation

- Generation 3 – Mid-1950s to Present: High-Level Languages
 - Designed to be human friendly – easy to read, write, and understand
 - Each instruction corresponds to many instructions in machine language
 - Translation to machine language occurs through a program called an interpreter or compiler.
 - Examples: FORTRAN, COBOL, BASIC, LOGO, C, Pascal, C++, Java, and Python.

Basic Approaches of Programming

- High-level programming languages utilize two different approaches
 - Procedural approach
 - Examples: COBOL, FORTRAN, BASIC, Pascal, C, C++, LOGO, and Python.
 - Object-Oriented Programming approach
 - Examples: Smalltalk, C++, Java, and Python

What Is a Program?

- Program
 - A list of instructions written in a special code, or language.
 - The program tells the computer which operations to perform,
 - and in what sequence to perform them.
 - Garbage In, Garbage Out (G.I.G.O.)
 - Get what you asked for, not necessarily what you want.



Why Programming?



- To Develop Problem Solving Skills
 - It is very important to develop problem solving skills. Programming is all about solving problems.
 - Requires creativity and careful thought.
 - Analyze the problem and break it down into manageable parts (modules, procedures, functions)
- It's also rewarding!



Program Development

- Planning is a critical issue
 - Don't type in code “off the top of your head”
- Programming Takes Time
 - Plan on writing several revisions
 - Debugging your program
- Programming requires precision
 - One misplaced semi-colon (or colon - Python) will stop the program



Exercise in Frustration

- Plan well (using paper and pencil)
- Start early
- Be patient
- Handle Frustration
- Work Hard
- Don't let someone else do part of the program for you.
- Understand the Concepts Yourself!
- Solve the problem yourself!



Step 1

Good Programming Habits

- 1. Analysis
 - Is the computer the appropriate tool for solving this problem?
 - Would the problem be better solved with human interaction or paper and pencil?
 - Sometimes human judgment is preferable.



Step 2

Good Programming Habits

- 2. Specification of the Problem
 - Formulate a clear and precise statement of what is to be done (clear and unambiguous).
 - Know what data are available
 - Know what may be assumed
 - Know what output is desired & the form it should take
 - Divide the problem into sub problems
 - Doesn't discuss "how to" solve the problem yet.

Step 3

Good Programming Habits

- 3. Develop an Algorithm
 - Algorithm:
 - a finite sequence of effective statements that when applied to the problem, will solve it.
 - Effective Statement:
 - a clear unambiguous instruction that can be carried out.
 - Algorithms should have:
 - specific beginning and ending that is reached in a reasonable amount of time (a finite amount of time).
 - This is done before sitting down at the computer.

Step 3.5

Good Programming Habits

- 3.5 Document the Program
 - Programming Style
 - Upper / Lower Case, Indenting, format
 - Comments
 - Descriptive Identifier Names
 - Variables, Constants, Procedures, Functions
 - Pre & Post Conditions
 - For each Procedure and Function
 - Output

Step 4

Good Programming Habits

- 4. Code the Program
 - After algorithms are correct
 - Desk check your program
 - Without the computer, just paper and pencil
- 4.1 Type and Run the Program
 - Look for errors
 - Syntax Errors (semi colon missing, etc.)
 - Logic Errors (divide by zero, etc.)



Step 4.2

Good Programming Habits

- 4.2 Test the Results
 - Does it produce the correct solution?
 - Check results with paper and pencil.
 - Does it work for all cases?
 - Border, Edge, Extreme Cases
 - Revise the program if not correct.
 - The coding process is not completed until the program has been tested thoroughly and works properly (recheck the specifications).



Step 5

Good Programming Habits

- 5. Interpretation

- The program may execute without any obvious errors.

- It may not produce the results which solve the problem.

- G.I.G.O Get what you ask for, not what you want.

- Recheck your program with the original specifications

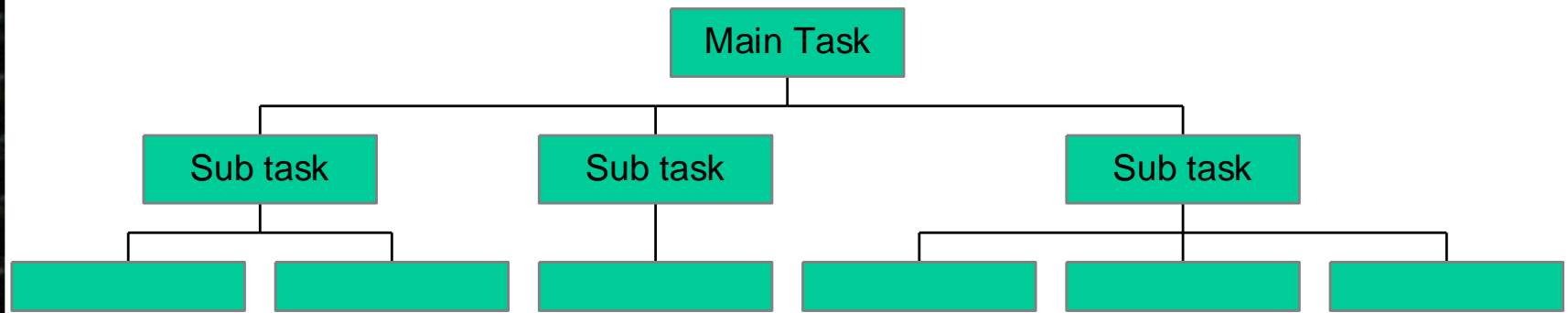


Top Down Design

- Subdivide the problem into major tasks
 - Subdivide each major task into smaller tasks
 - Keep subdividing until each task is easily solved.
- Each subdivision is called stepwise refinement.
- Each task is called a module
- We can use a structure chart to show relationships between modules.

Top Down Design 2

Structure Chart



Top Down Design 3

- Pseudocode
 - is written in English with programming language like sentence structure and indentations.
 - Major Tasks are numbered with whole numbers
 - Subtasks use decimal points for outline.

Top Down Design 4

1. Get Information
 - 1.1. Get starting balance
 - 1.2. Get transaction type
 - 1.3. Get transaction amount
2. Perform computations
 - 2.1. If deposit then
 add to balance
 - Else
 subtract from balance
3. Display the results
 - 3.1. Display starting balance
 - 3.2. Display transaction
 - 3.2.1. Display transaction type
 - 3.2.2. Display transaction amount
 - 3.3. Display ending balance

Writing Programs

- Vocabulary
 - reserved words
 - have a predefined meaning that can't be changed
 - library identifiers
 - words defined in standard libraries
 - programmer supplied identifiers
 - defined by the programmer following a well defined set of rules

Writing Programs 2

- Words are CaSe SeNsItIvE
 - For constants use ALL CAPS (UPPERCASE)
 - For reserved words and identifiers use lowercase
- Syntax
 - rules for construction of valid statements, including
 - order of words
 - punctuation

Writing Code

- Executable Statement
 - basic unit of grammar
 - library identifiers, programmer defined identifiers, reserved words, numbers and/or characters
 - A semicolon terminates a statement in many programming languages
- Programs should be readable

[noformat.cpp](#)

[format.cpp](#)

The Use of Comments

- Comments should be included to help make the program more clear to someone reading the code other than the author.
- Use comments after the header to explain the function of the program, & throughout the program

Test Programs

- Test programs are short programs written to provide an answer to a specific question.
- You can try something out
- Practice the programming language
- Ask “what if” questions
- Experiment: try and see

