Programming for Problem-solving with C

Formulating algorithms for complex problems

Dr. Kamaldeep

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Dedicated to

My beloved wife

Dr. Deepika

&

My daughter ***Kavya***

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Lastly, sincere thanks to the readers whose interest and support have transformed this project into a reality. Your encouragement has been truly invaluable.

Preface

Welcome to *Programming for Problem-Solving*, a comprehensive guide designed to equip you with the essential skills and knowledge needed to excel in the world of computer programming. This book is a carefully curated journey through the foundational concepts of computer science and problem-solving, with a specific focus on the C programming language. Starting with an exploration of the computer's hardware and software components, we progress through chapters dedicated to problem-solving techniques, the fundamentals of C, operators, decision-making statements, loops, arrays, strings, functions, recursion, structures, unions, searching, sorting, pointers, and the intricacies of console input-output functions. As we delve into advanced topics such as preprocessing, file handling, and the critical understanding of time and space complexity, each chapter is designed to build upon the previous, providing a structured and comprehensive approach to programming. Whether you are a novice seeking a solid foundation or an experienced programmer aiming to refine your problem-solving skills, this book offers clear explanations, practical examples, and hands-on exercises to enhance your programming prowess. Happy coding!

Chapter 1: The Computer – Covers the basic building units of computers. It also includes the classification of computers, computer characteristics, advantages of the computer, limitations of the computer, and applications of the computer. In the end, the conclusion of the chapter, Points to Remember and the important questions are provided

Chapter 2: The CPU and the Memory – Describes the CPU and its components, the memory, and its types. It also focuses on how the instructions are fetched from the memory and executed by the CPU. The memory hierarchy and memory measurement are also discussed in it.

Chapter 3: The Computer Software – Tells about computer software and its classification on various parameters. It also gives a basic introduction to the operating system and its classifications on different parameters like the execution of the program, number of users, and interface. It also gives the basics of malicious programs.

Chapter 4: The Number System – Provides information about the different types of number systems like decimal, binary, octal, and hexadecimal. It also focuses on the conversion of one number system into another. Various operations on binary numbers like Addition, Subtraction, Multiplication, Division, One's complement, 2's complement, and Negation

are given. Some other popular binary codes like ASCII, BCD, EBCDIC, Excess-3, and Gray codes are also discussed.

Chapter 5: Problem-solving Techniques – Focuses on the approach towards problem-solving and different techniques of problem-solving like pseudo-code, algorithms, and flowcharts. It also tells about different computer languages like high level, low level, and assembly level and their language translation tools like the compiler, interpreter, and assembler. It tells the procedure to convert the algorithm into a program.

Chapter 6: Fundamentals of C – Gives the introduction and history of C language. It also focuses on the building blocks of C language, like character sets and the tokens, i.e. keywords, variables, constants, etc. It also tells about the fundamental components of the C program and the method of execution of it. The basic data types and type conversion are also discussed here.

Chapter 7: Operators and Expressions – Discusses the operators and expressions used in C language. These operators are classified on the basis of the number of opcodes, i.e., unary, binary, and ternary operators. Other operators are arithmetic, increment, decrement, relational, logical, bitwise, shift, assignment, comma, sizeof(), conditional, and address operators are also discussed in the chapter.

Chapter 8: Decision-making Statements – Enables the user to write the decision-making statements in their programs. It also discusses their types, i.e. conditional and unconditional. It includes statements like if, if else, else if, and switch under conditional. Also, the statements like goto, break, and continue are given in unconditional statements.

Chapter 9: Loop – Provides the details of loops and their types, which are for, while and do while.

Chapter 10: Array – Provides the details of the array, its types, properties, and applications.

Chapter 11: String – Shows the working with the string and the inbuilt string functions used in the processing of the string like strlen(), strcat(), strcmp(), strcpy(), strrev(), strupr(), strlwr(), strncmp(), strncat() and strncpy(). It also discusses the built-in functions to handle characters.

Chapter 12: Function – Talks about the method of writing the function, the need, the types of functions, and its method of calling by value and reference. It also tells the concept of storage classes.

Chapter 13: Recursion – Talks about recursion and the various examples that are solved by it, like finding factorials, the Fibonacci series, the Ackerman function, etc. The sorting through recursion, like quick sort and merge sort, is also given here.

Chapter 14: Structure and Union – This chapter provides two special user-defined data types, i.e. structure and union. It also illustrates the use of a pointer in accessing the content of the structure.

Chapter 15: Searching and Sorting – This chapter gives the basic idea of searching and sorting. Two popular techniques, i.e., linear and interval searching, are discussed. The sorting techniques like bubble, insertion, and selection are also given.

Chapter 16: Pointers – This chapter introduces the pointer and its application in various fields of programming like in the creation of self-referential structures, for example, the link list

Chapter 17: The Console Input-output Functions – This chapter shows the inbuilt input-output function of the console. There are two types of input and output functions: formatted and unformatted. The formatted functions mainly include printf() and scanf() functions, and the unformatted ones include functions like getch(), putch(), getchar(), putchar() and getche(), etc.

Chapter 18: Preprocessor – This chapter explains the preprocessor directives in detail. It includes various types of preprocessing directives like file inclusion directives, macro expansion directives, conditional directives, and miscellaneous directives.

Chapter 19: File Handling in C – This chapter enables the readers to deal with files, which include various operations on the file, starting from creating the file, reading the content of the file, updating the content, etc, with the help of inbuilt file functions provided in C language. Also, it elucidates the concept of dynamic memory allocation with the help of various functions like malloc(), calloc() realloc() and free().

Chapter 20: Time and Space Complexity – This chapter introduces the concept of space and time complexity, which are used to measure the performance of the algorithms. It also discusses asymptotic notations like Big-Oh, Big Omega, and Theta. Various examples are also provided for the calculation of time complexity for different program statements like loops, conditional, etc.

Code Bundle and Coloured Images

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Code Bundle and the ***Coloured Images*** of the book:

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Chapter 1
The Computer

Introduction

This chapter explores the fundamental aspects of computers. Understanding computers' core components and concepts is essential in the digital age. This chapter will explore the building blocks of a computer, the distinctions among various computer types, and the key characteristics that make computers indispensable in our lives. We will delve into the advantages and limitations of these electronic marvels' diverse applications and summarize the chapter's key points and important questions for further exploration. Let us embark on this enlightening journey into the world of computers.

Structure

In this chapter, we will be discussing the following topics:

- Block diagram of functional units/components of the computer
- Data and information
- Classification of computers
    - Classification based on time generation or historical development
    - Classification based on the purpose

  - Classification based on the technology used
  - Classification based on the number of users
- Computer characteristics
  - Automatic
  - Speed
  - Accuracy
  - Versatile
  - Diligence
  - Zero IQ
  - Memory
  - Economical
- Advantages of the computer
- Limitations of computer
- Applications of computer
- Conclusion
- Points to remember
- Important questions

Objectives

This chapter aims to provide a comprehensive understanding of computers and their integral components. We will explore data, computer classifications, and essential characteristics, along with the advantages and limitations of these machines. Additionally, we will examine their diverse applications, culminating in a conclusion and offering key takeaways and important questions for a deeper grasp of the subject matter.

The computer

The term *computer* was derived from the word *compute*. A computer is an *electronic device* that takes data and a *set of instructions* as input from the user, processes the data, and produces information as output. This complete cycle is known as the *input–process–output* cycle, as shown in *Figure 1.1:*

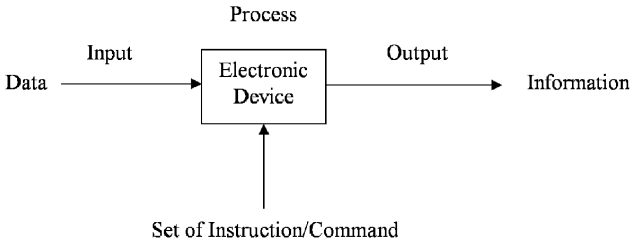

Figure 1.1: *Input process output cycle*

The instructions are the commands to the computer given by the user to perform the task. The *set of instructions* is known as the program. The set of programs is known as the software. The *electronic device* is known as hardware. Hence, a computer is a collection of hardware and software. *Figure 1.2* shows the computer components:

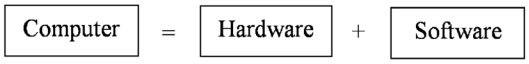

Figure 1.2: *Computer components*

Block diagram of functional units/components of the computer

Generally, the computer consists of four functional units which are interconnected to each other to form a computer. These units are given as follows:

- Input unit
- Output unit
- Processing unit
- Storage/memory unit

All the preceding units are connected with each other via the system buses (wires). There are three main buses: the data bus, the control bus, and the instruction bus. The data bus is responsible for carrying data from one unit to another; the control bus carries the control signals generated by the CU, and the instruction bus carries the instructions (commands). The block diagram of the computer with its functional units is given in *Figure 1.3*:

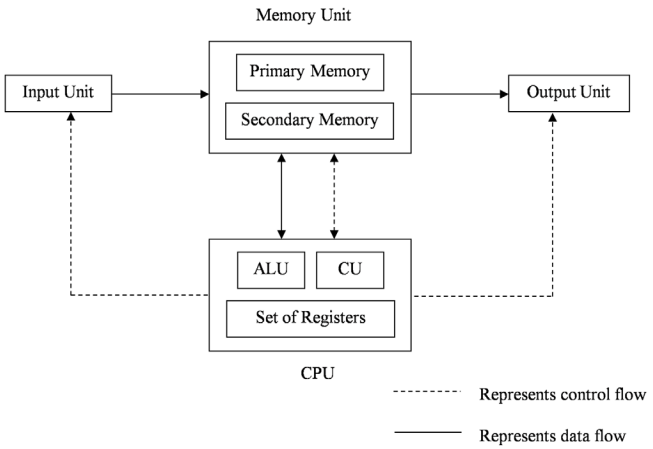

Figure 1.3: *Block diagram of a computer with its functional unit*

Input unit

The input unit gets the data or program from the user or other media (device). An input unit is responsible for reading the input. The input unit functions are done by various devices known as input devices, such as:

- Keyboard
- Mouse
- Joysticks
- Touch Screen
- Scanner

The input unit generally performs three main functions, which are as follows:

- It accepts input from users in a human-readable form that is in the English language.
- It converts the human-readable form into a computer-readable format (binary language).
- It supplies the converted data to the computer system for further processing.

Output unit

The output unit accepts the processed result from the computer and makes it available to the end user. The output unit function is performed by some devices, which are known as output devices, such as:

- Monitor
- Printer
- Speaker
- Plotter, and so on

The output unit generally performs three main functions, which are as follows:

- It accepts the processed results from the computer in computer-readable form (Binary data is a form of signal).
- It converts the computer-readable form into human-readable form (English, Hindi, audio, video, and so on).
- It supplies the converted result to end users.

The output devices are broadly categorized into two types, shown in *Figure 1.4:*

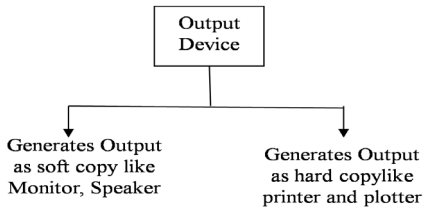

Figure 1.4: *Output devices category*

- **Generates output as soft copy**: These devices generate an electronic version of the output. For example, a monitor generates an image on the screen, the speaker generates the sound signals, a file is stored on a hard disk, and so on.
- **Generates output as hard copy**: These devices generate a physical version of the output. For example, a printer generates the content of a file on a page (printout), a plotter plots a high-definition drawing on a paper sheet, and so on.

Processing unit

The process of performing operations on the data as per the command given by the user is called processing. The central processing unit (CPU) works as a processing unit in a computer. It performs the calculations and data processing operations on the data entered by the input device. It is also termed the brain as the computer. The major components of the CPU are as follows:

- **Arithmetic and logical unit** (**ALU**)
- **Control unit** (**CU**)
- Set of registers