PAUL A. RUDE • JOHN A. PAGE

INTRODUCTION TO COMPUTERS

PAUL A. RUDE
JOHN A. PAGE

College of Science and Engineering
Loyola Marymount University of Los Angeles

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INTRODUCTION TO COMPUTERS

To our patient and understanding wives
DYANE and ANNE

PREFACE

This programmed text provides the student with an introduction to the digital computer. It is designed to provide a basic understanding of the digital computer through a discussion of the computer in general, the computer units in particular, programming concepts, the computer system, and computer applications. The initial chapters describe techniques used in the analysis of problems and in the preparation of computer programs to solve these problems. The final chapter in the introductory group introduces the student to a simple set of procedure-oriented language instructions. Chapter 3 can be used to introduce the student to FORTRAN, and Appendix A can be used to introduce him to BASIC. The authors believe that in order for the student to make more sophisticated use of the computer, he must have some familiarity with hardware and software. The remaining chapters, grouped in two parts, present an introduction to these computer components. The first group, Chapters 4 through 7, describes typical computer systems and the hardware units that make up these systems. The second group, Chapters 8 through 12, describes the software of the computer. In these chapters, supervisory system concepts and programming languages are described. The chapters on machine language and symbolic language programming utilize a make-believe computer called MABEL. This avoids the need for the use of a specific computer system with this text. (Interpreters have been written, permitting the student to run programs in MABEL's machine and symbolic languages.) To complete this introduction to the digital computer, appendixes describe typical computer applications and careers in the computer and related industries.

The only prerequisite to the use of this book is a knowledge of high school algebra. It is presumed that the student has had no prior experience with computers. The book has been written in a manner that would make it useful to any individual interested in acquiring a basic knowledge of digital computing. There is no restriction concerning the field of work or study of the reader.

HOW TO USE THIS BOOK

This book has been written in programmed text format. Material is presented in brief segments called *frames*. After reading each frame, the student is immediately able to test his understanding of that frame by answering a question. The correct answer to each question is provided on the opposite page. Obviously, while reading the frame and question, the student should cover the response with the MASK provided with the book. Whenever a question or problem arises with a given frame, the student should indicate the difficulty next to the response. Thus, the student will be reminded to discuss the material or the question with his instructor or to reread the previous frames to resolve the difficulty. The programmed format allows the student immediately to test his understanding of the material covered in a given frame and to reinforce the concept introduced in the frame. In addition, the programmed concept allows the student to cover the material at his own rate of comprehension.

This book can be used in one of three ways: (1) as the primary text in a course on computer fundamentals (the book could be supplemented by audiovisual material and a manual on a particular programming language, i.e., ALGOL, BASIC, COBOL, FORTRAN, PL/I, and so forth), (2) as a supplementary text in a course primarily directed toward computer programming, and (3) as a self-study text by any individual desiring or needing a basic knowledge of digital computers.

This book has been used at Loyola Marymount University of Los Angeles in the introductory course in computers. The course has been offered at both the freshman and the sophomore levels, to students of all disciplines. It is the opinion of the authors that the course is best offered just prior to the time the student utilizes the digital computer in his other course work. In the case of students who are in disciplines where they will not use the digital computer, it is recommended that they take the course in their sophomore or junior years. The book has been tested by a number of classes. These classes have included students at the high school, undergraduate, and graduate levels.

At Loyola Marymount University, the material in this book is covered in approximately 24 to 30 class hours. The remaining class time is spent supplementing the text with additional BASIC and FORTRAN programming. Of the approximately 40 class hours, half are given to lecture and the other half to a workshop. The lecture periods provide the instructor with an opportunity to discuss digital computers, usually previewing the material to be covered by the student in the text. In these lecture hours it has been found beneficial to make use of the many films and slides available. The lecture periods are handled in a rather formal fashion, thus permitting the course to be given to large-sized classes. The workshop sessions, restricted to approximately 20 students, provide the student with an opportunity to discuss the material with the instructor (or a teaching assistant), flowchart problems, discuss programming techniques, run assigned problems, and so forth. These are handled more informally. In addition, the workshops are used to discuss the programming languages in much more depth. Thus in a large class, with student interest in several different programming languages, different workshops can be set up to cover each language of interest. This provides great flexibility within the same course structure.

Examinations are given at the end of Chapters 3, 7, and 12. Homework problems which require flowcharting and computer programming are assigned weekly. A computer project is also required of all students. The time-shared terminal has been found to be of extreme value both in the lecture and in the workshop segments of the course.

Paul A. Rude
John A. Page

CONTENTS

1

PROBLEM SOLVING

> The high-speed digital computer has freed man from the need for making laborious and routine numerical calculations and has placed greater emphasis on the creative aspects of his profession. When a problem has been described precisely in a numerical form, a computer can be used to manipulate the numbers with a facility that no human can challenge. This leaves man free to concentrate on the more interesting aspects of problem solving—the definition and formulation of problems and the interpretation of results—and in general to contribute to what might be described as the creative components of problem solving. (Walter C. Johnson, "Creative Problem Solving," *IEEE Student Journal,* September 1968, p.17.)

Today's computers provide man with a capability to handle the laborious and routine aspects of many varied problems. For the scientist and engineer, the computer has provided the means by which the arithmetic of extremely complex problems can be performed. The computer provides the business man with the means for performing many mundane tasks and for undertaking more complex studies of the business environment. Additionally, many social scientists and humanists have been provided with the means by which the large amounts of data associated with their investigations can be easily manipulated, tabulated, etc.

In every instance of computer usage, the computer could not be used to calculate the problem solution until the method of solution had been prepared in the necessary programmed form. Therefore, to enable you to make use of the computer, it is first necessary to treat the subjects related to the preparation of computer programs. In this chapter, the initial phases of preparing a problem for computer solution will be considered. That is, the preparation of the algorithm upon which the computer program is based is discussed. In Chapters 2 and 3, the processes used in the conversion of the algorithm into a computer program are discussed.

The primary objective of this chapter is to present the concept of an algorithm and the techniques used in its preparation. In particular, after completing the chapter, you will be able to:

Understand the concept of problem solving

Analyze a problem by determining the unknowns, the knowns, the constraints, and the method of solution

Understand the concept of an algorithm

Prepare an algorithm for a given problem

The first section of the chapter will describe the concept of problem solving and the techniques of problem analysis. This section should take you from 20 to 35 minutes to complete.

OBJECTIVES

1 By definition, distinguish between problem solving, problem analysis, and problem computation.

2 List the three steps of the analysis process.

3 Given a problem description, identify the knowns, unknowns, and constraints.

4 State that the first step in the process of determining a method of solution is to ascertain if the problem is immediately familiar or not; if familiar, state what the second step would be.

5 Given a problem statement and sufficient information to familiarize you with the problem, identify the method of solution.

6 Describe what to do in arriving at a method of solution if a problem is unfamiliar.

7 List three techniques for finding the method of solving a problem.

8 Given a problem description, match it with the most appropriate technique for determining the method of solution.

1-1

The solution of any problem can be divided into two parts. First, it is necessary to analyze the problem, identifying the pertinent facts and the method of solution. Second, the computations or operations required to obtain the desired answer are performed. It is in this last step that the digital computer has proven of such great value.

Generally, problem solving can be separated into two parts. They are _____ and _____.

1-2

The first part of problem solving, problem analysis, is creative in nature and, in general, can only be performed by man. This analysis is usually accomplished in a series of steps. These steps include the determination of the unknown quantities, the known quantities, the constraints or conditions affecting the solution, and the method of solution.

Problem analysis is the process of determining the _____, _____, _____, and _____.

1-3

The second part of problem solving is the performing of the operations indicated by the method of solution. These operations may be either arithmetic or logical, depending on the type of problem being solved. (If a computer is used to compute the results, the method of solution will have to be converted into the necessary program format.)

The second part of problem solving, problem computations, is the process of _____.

1-4

In review, associate the definitions listed below with the terms *problem solving*, *problem analysis*, and *problem computations*.

_____ are the calculations required for the determination of the solution.

_____ is the determination of unknowns, knowns, constraints, and the method of solution.

_____ is the determination of unknowns, knowns, constraints, the method of solution, and the calculation of results.

1-1
problem analysis, performance of required computations or operations.

1-2
unknowns, knowns, constraints (or conditions), method of solution.

1-3
computing or calculating the results.

1-4
Problem computations, Problem analysis, Problem solving

1-5

Problem analysis is usually accomplished in three steps. The first step in the analysis process is to read through the complete problem. During this reading, attempt to view the total problem, ignoring details. This initial reading is important. Too often, erroneous solutions result from a misunderstanding of the complete problem.

Second, reread the problem, identifying the unknowns (quantities that comprise the solution), knowns (given data or information), and the constraints (conditions affecting or modifying the method of solving the problem).

The first step of the problem analysis process is to _____

_____.

1-6

After the first reading of the problem statement, the second step in the process is to _____

_____.

1-7

As an example of these two steps, consider the following sales receipt problem: You are given a list of merchandise purchased and the individual cost of each item. Prepare a sales receipt by determining the tax and the total charges. A 1 percent tax is imposed on all the items except food and clothing.

Before reading the next paragraph, reread the statement of the problem and see if you can identify the unknowns, the knowns, and the constraints.

Your analysis of this example problem should have resulted in the following conclusions:

The unknowns are the tax and the total cost of the merchandise.

The knowns are the items purchased, their cost, and the 1 percent tax.

The constraint is that the tax is not imposed on all the items; food and clothing are exempted.

Now analyze the following census-type problem: Determine from census data the number of men between the ages of 40 and 50 living in the state of Nevada.

Before answering the following questions, reread the problem statement.

The unknown is _____.

The knowns are _____.

The constraints are _____.

1-8

In the previous frames, the first two steps of the analysis process were described; i.e., reading the problem statement thoroughly, then rereading the problem, identifying the unknowns, knowns, and constraints. The third step in the analysis process is that of determining the method of solution.

Before proceeding to the next frame, for review, list the three steps of the analysis process. They are:

1 _____.

2 _____.

3 _____.

1-5
read (thoroughly) the problem statement.

1-6
reread the problem statement identifying unknowns, knowns, and constraints.

1-7
the number of a specified group of men.

the census data.

that only census data for men, living in Nevada, whose ages lie between 40 and 50, are to be used.

1-8
1 Read the problem statement thoroughly.

2 Reread the problem statement, and identify the unknowns, the knowns, and the constraints.

3 Determine the method of solution.

1-9

Before discussing procedures for determining methods of solution, describe how you would solve the sales receipt problem of frame 1-7.

_____

_____

_____

_____.

1-10

Most likely, you were able to devise a method of solving the sales receipt problem. If so, how were you able to determine the method? Probably, it was because you have seen this problem solved many times by salespeople who have sold you merchandise, or you may have had to solve the problem yourself. In either instance, you were able to determine a method of solution because you were familiar with the problem or the type of problem. This prior experience can be useful and can provide insight into methods of solving problems.

This discussion should suggest to you the first step in the process of determining a method of solving a problem.

This first step is to determine if the problem or type of problem is _____.

1-11

Often, when a problem seems familiar, it is because you have solved a similar, rather than the same, problem. If this is the case, the similarities and differences between the prior and present problem must be considered in determining the method of solution. In these instances, when problems are recognized as familiar, the next step is to complete the analysis process by specifying the method of solution. The previous experience with the similar problem can provide the basis for determining the method of solving the current problem.

When you have recognized a familiar problem or type of problem, the next step of the analysis process is to

_____.

1-12

Reread the census problem of frame 1-7. Attempt to think of a similar problem or type of problem. Describe this problem below.

_____

_____

_____

_____.

1-9
One method of solution is to sum the costs of the taxable items, calculate the tax, and combine this result with the costs of the nontaxable items.

1-10
familiar.

1-11
specify (or determine) the method of solution.

1-12
The problem that came to mind should be of the "sorting" type. Typical examples include the stamp collector sorting his stamps by country of origin or the cashier sorting the day's receipts (bills and coins) by denomination.

1-13

Recognizing the census problem as a sorting-type problem, suggest a method of solution. (*Note:* The census problem differs from those examples given in the response to frame 1-12. The difference is that the examples involve sorting by a single characteristic, while the census problem requires that a number of characteristics be considered.)

1 _____

2 _____

_____

3 _____

_____

_____

1-14

In the above frames, you were able to recognize problems as being familiar. This prior knowledge provided the basis for specifying the method of solution. In some instances, you will not be able to readily recognize a problem. In these cases, there are several procedures that might prove useful. Briefly, they can be described as relating characteristics of the unknowns and knowns, subdividing the problem into smaller (simpler) problems, and modifying some of the problem constraints.

The first procedure entails relating characteristics of the unknowns with those of the knowns. Although you may not be able to visualize any obvious method of solution, certain characteristics of the knowns and the unknowns may be relatable and may suggest a method of solution.

As an example, apply this procedure to the following problem involving the automatic sorting of coins: In your business you collect a large number of coins. You wish to separate them by denomination. What characteristic other than value can be used to distinguish one denomination of coin from all the others? Knowing this, how can the problem be solved?

_____

_____

_____

1-15

The next procedure that might be used for the determination of a method of solution is to subdivide the problem into several smaller and simpler parts. Solutions can then be attempted for each individual part. Often, the solution of one of the parts of the problem leads to the solution of the whole problem.

An example of this procedure involves the establishing of the processes required for the handling of savings accounts in a bank. Based on prior experience, one realizes that the problem can be subdivided into four smaller parts. In this instance, the overall method of solution or process is obtained by combining the four parts. Complete the following list of subdivisions for this problem:

1 Opening an account

2 Handling daily _____

3 Periodic computation of _____

4 Closing an account

1-13

1 Separate from the total census records those satisfying one of the characteristics, e.g., Nevada residence.

2 Separate from the census records for Nevada residents those records satisfying a second characteristic, e.g., male residents.

3 Separate from the records of the male, Nevada residents, those whose ages fall between 40 and 50 years. The number of records in the final group is the answer to the problem.

1-14

The obvious characteristic is size. That is, the coins of different value are of different size. Thus this problem can be solved by designing a machine that will sort coins by size.

1-15

2 transactions

3 interest