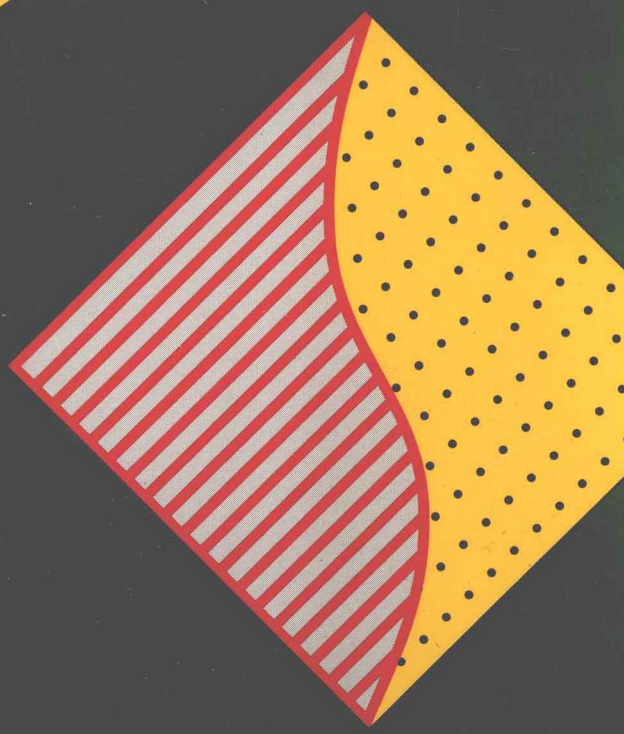
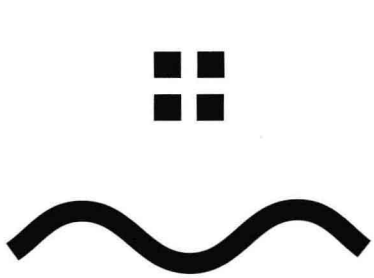
Structured COBOL

THIRD EDITION





Structured COBOL

THIRD EDITION

Gerard A. Paquette

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Preface

This text is written for the student who wants to develop effective problem-solving techniques while learning structured COBOL programming. It contains a number of features that make it stand out from other available texts.

Problem-Solving Procedure

A time-tested problem-solving procedure is presented and explained in the very first chapter, and then the "Turbo Manufacturing Company Employee Listing" program is used immediately to show the procedure in actual use. Every original program presented in the text is also systematically developed following the steps specified in the procedure.

Many textbooks do suggest a systematic approach to programming, but more often than not, the systematic approach is not used later in the text to develop sample programs, no further reference is made to it, and if students use it at all, it is on their own initiative. Since developing an effective approach to problem solving is so crucial to a novice programmer, repeated exposure to a specific method that is used in a consistent manner will go a long way toward achieving that goal. The net result is that the student retains the procedure as a productive "working" tool in later programming situations.

Problem-Oriented Approach

The text follows a problem-oriented approach. This approach allows the development of COBOL statements and features to be presented on a "need to know" basis, where they are applied immediately in the situation being discussed. The sample problems that have been selected as vehicles for the introduction of COBOL language features are presented at the very beginning of the chapter, thus setting the stage for what is to come in the rest of the chapter.

In Chapter 2, the program "Allied Stock Company Phone Sales Report" is presented and developed primarily to expose the students to the major functions of the four divisions of a COBOL program.

In Chapter 3, the same program is used as a vehicle to expand upon the features of the IDENTIFICATION DIVISION, the ENVIRONMENT DIVISION, and the DATA DIVISION. In Chapter 4, it is used to elaborate upon the features of the PROCEDURE DIVISION.

In Chapter 5, a new program, "Reliable Auto Parts Company Payroll Report," is presented and developed as a tool to introduce arithmetic statements, since the preparation of a payroll requires a number of arithmetic operations.

In Chapter 6, the program of Chapter 5 is expanded to prepare a summary payroll report that contains totals and averages for the company. The same program is then revised to include refinements in both the program and the printed report.

In Chapter 7, the program "Jocelyn Originals Company Annual District Sales Report" prepares a summary report by district. Because the records of the input file are in alphabetical order, the district code must be tested so that the sales figures can be added to the appropriate district accumulators. This leads into a discussion of conditional statements—simple, compound, and nested. Once the report has been produced, an alternative approach is developed to illustrate the use of CORRESPONDING statements and qualification of data names. Since the setting of the problem remains the same, students can more easily concentrate their attention on the new features.

In Chapter 8, two programs are presented to illustrate important applications of conditional statements. The "Sportsman Company Sales Analysis Report" program serves as an introduction to control

breaks. One-level control breaks are examined first, and the program is then expanded to illustrate two-level control breaks. The "Sportsman Company Data Validation Report" program is then developed to examine various data validation procedures.

In Chapter 9, the "Monster Burger Stores Weekly Payroll Report" program has been designed to require the use of input-loaded and hard-coded tables. Its development leads into discussions of table organizations, levels in a table, table-loading procedures, and table-data retrieval procedures.

In Chapter 10, variations of the "Sportsman Company Sales Report" program are used to illustrate all the possible combinations of options of the SORT statement. PROCEDURE DIVISION sections are introduced in relation to the SORT statement. A final program is used to illustrate the MERGE statement.

In Chapter 11, the Jocelyn Originals Company provides a setting for the development of programs that create master files on tape or on disks. These files have sequential organization. Indexed files and relative files are also introduced, but complete programs are not included since the sequel to this book examines these two file organizations in detail.

■ Structured Programming Tools

Built into the design phase of the problem-solving procedure is the use of tools that result in structured programs. The system flowchart specifies the overall task of the program, in addition to identifying the required files. The structure chart begins with the overall task as its primary module, and then breaks it down into major subtasks, one per module. These major subtasks are further subdivided as needed, until the question "What has to be done?" is completely answered. The program pseudocode or the program flowchart then details the procedures that answer the question "How is the task to be done?"

In the structure chart, the first-level, or primary, module is numbered 100, the second-level modules are numbered consecutively from left to right in the 200s using increments of 10, the third-level modules are similarly numbered in the 300s, and so on for the remaining levels. If a particular module is needed at different levels in the structure chart, every occurrence of the module is assigned the number of the lowest level where it is needed, and the upper right-hand corner is darkened to clearly indicate its repetitive nature.

The paragraphs of the pseudocode and the modules in the flowchart retain the numeric prefixes and names first assigned in the structure chart. The paragraph names in the PROCEDURE DIVISION are then the same as those of the pseudocode or flowchart. Furthermore, by coding the paragraphs in ascending order of their numeric prefixes, program debugging is greatly facilitated, since the programmer can quickly scan margin A to locate a particular paragraph.

■ COBOL '85 Standards

The text implements the standards of COBOL '85. A student who learns the language as presented in this text will be well-prepared to write programs that include up-to-date syntax and structure. However, since most of COBOL '74 is still supported in the COBOL '85 standards, and since the new features are identified as such within the text, this text remains appropriate for use by students who are currently using a COBOL '74 compiler, and these students will have a handy reference when they first encounter a COBOL '85 compiler. Naturally, the new features cannot be incorporated in programs to be compiled by a '74 compiler, and features that are currently labeled as obsolete may be required entries. (Obsolete entries are not used in the sample programs of this text.)

■ Debugging Activities

Debugging exercises have been included at the end of every chapter. They are listed following the more traditional "review and practice" exercises and before the programming exercises. They include debugging data entry errors, misaligned entries on a printed report, data description errors that do not conform to prepared layouts, compiler-generated syntax errors, coding errors that do not represent the logic specified in either pseudocode or flowchart form, numeric and/or numeric-edited data description coding errors, errors in mathematical statements or expressions, errors related to missing data or incorrect values on a printed report, printed report errors related to incorrect handling of control breaks, coding errors related to table definitions, table loading, and data retrieval, sorting errors due to improperly sequenced keys, and control errors related to the use of sections within the PROCEDURE DIVISION.

These exercises are designed to draw attention to common errors and some less common ones. Students who successfully complete these exercises should be able to avoid making the same types of errors in their own programs.

Programming Assignments

There are four programming assignments at the end of each chapter, beginning with Chapter 3. In the spirit of "leading the student by the hand," the student is presented with the completed design phase of the problem-solving procedure in the first assignment; that is, the input record layout form and the printer spacing chart are prepared, and the system flowchart, the structure chart, and the program pseudocode and flowchart are completely developed. After studying these aids, the student can quickly move to the completion of the task—coding the program, debugging it as needed, and running it with a sample data file.

In the second assignment, the design phase of the problem-solving procedure is completed for the student except for the program pseudocode and the program flowchart. The student's task is to complete the design phase, and then implement the design.

The third and fourth assignments are full-scale assignments. The student must design the program "from scratch," and then carry out the implementation of the design.

Data sets for all programming assignments are provided in Appendix C, and are also available on magnetic disks for the convenience of instructors and students.

Program Documentation

All sample programs contain a number of documentation paragraphs in the IDENTIFICATION DIVISION. The student is aided in verbalizing the nature of the task that the program must accomplish by being expected to properly document the listing of the program. The better the task is defined, the easier it is to map out an appropriate strategy. Few textbooks provide this type of documentation or encourage students to do so.

Listing of Rules

Whenever COBOL language elements and statements are introduced, explained, and illustrated in a section of a chapter, all of the applicable rules are collected and summarized within that same section under a title beginning with "Rules Governing Use of. . . ." Students will find these sections convenient because everything they need to know about the feature or statement is there, assembled in one place. A list of these rules sections, complete with page references, is printed at the front of the book on page ix. The colored tabs that are visible on page edges mark the locations of these rules in the text.

Course Organization

There is ample material in this text for a quarter or a semester's work in a course that might be entitled "Structured COBOL Programming I." It is not intended as a complete treatment of the COBOL language, but rather as an effective teaching/learning tool for the developing programmer. The sequel to this text, *Advanced Structured COBOL,* takes the student into more advanced table handling, file organizations, master file updating procedures, subprograms and nested programs, and also introduces on-line interactive COBOL programs, even though a screen-handling facility is not yet included in ANSI COBOL Standards. A Report Writer supplement is also available upon request.

Ancillaries

The following ancillary materials have been prepared for the convenience of instructors using this text:

a. An Instructor's Manual that contains, for each chapter, an overview of the chapter, a discussion of the particularly significant topics of the chapter, some suggested coordinated activities for the student, answers to all the chapter exercises, solutions to all the debugging activities, and a complete set of solutions for all the programming exercises.

b. A complete set of transparency masters.

c. TestPak, a computerized testing program that an instructor can use in constructing class tests quickly and efficiently. TestPak is a computerized system that enables you to make up customized exams quickly and easily. For each exam, you can select up to 250 questions from the file and either print the test yourself or have Business and Educational Technologies print it.

d. A Data Disk that contains the data files used in the chapter sample programs and in the debugging activities programs, and data files that can be used as test data for all the programming exercises.

e. Source code disks that contain:

i. The source code for all the chapter sample programs.

ii. The source code for the programs used in the debugging activities at the end of each chapter. The source code for the completely debugged programs are also included.

iii. The source code for the programs that must be developed in the programming exercises at the end of each chapter.

These source code disks allow instructors to make changes to existing programs, thereby customizing the programs to their own needs without a major effort on their part.

Software

Structured COBOL can be purchased with the following excellent software packages:

a. The RM/COBOL-85 Educational Version Compiler, which offers complete language functionality, screen handling capabilities, and an application development environment. A Convenience Disk is included in the textbook for students who also purchase the RM/COBOL-85 Compiler for use on their personal computer. This disk contains the source code for the programs in the debugging exercises at the end of each chapter. It also contains all the data sets used in the chapter sample programs and the data sets needed for the programming exercises at the end of each chapter.

b. Micro Focus Personal COBOL, a full-featured, PC-based package that allows students to write, compile, debug, and test complete COBOL programs.

A Final Note

I wish to thank the staff of the Computer Center at the University of Massachusetts–Lowell for their cooperation whenever their technical assistance was needed.

I also wish to thank the members of my family for their patient understanding during the long development process, and in particular, my wife, Vivian, for her constant encouragement and support.

Notes on My Computer

1. Computer name: _____ Operating system: _____

2. Nonnumeric literals must be enclosed in _____ (quotation marks or apostrophes).

3. Implementor-names to be used in the ASSIGN clause are:

_____

_____

_____

4. ANSI COBOL compiler: _____ (1985 or 1974)

5. Procedures to log on to my system:

_____

_____

_____

_____

6. System commands to edit a file:

_____

_____

_____

7. Commands to "run" a program:

_____

_____

_____

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Structured COBOL

■ Introduction

In this introduction, we take a brief look at the historical development of the modern computer and the COBOL programming language. We identify the major computer components and various languages that programmers use in giving instructions to computers.

If you are now undertaking your first course in computer programming, or if you feel a need to review the topics just listed, you are encouraged to spend an hour browsing through this introduction. ■

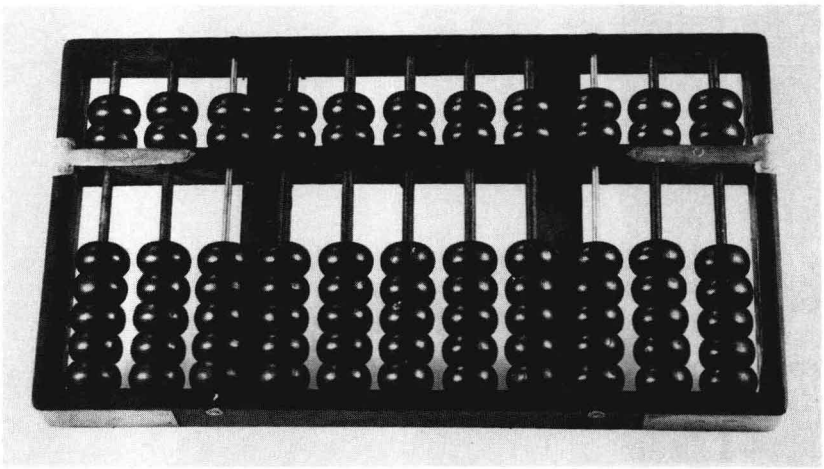
Historical Development of Computers

From time immemorial, people have had a need to gather and disseminate data. The caveman kept a record of his kill by carving notches in his spear; wise men preserved scientific observations for posterity by engraving in clay tablets; and the monks of old transcribed thousands of documents by hand. The development of the printing press greatly increased the speed by which accounts could be disseminated; and now, radio and television with the help of orbiting satellites make it possible to collect data and relay it immediately to any point on the globe.

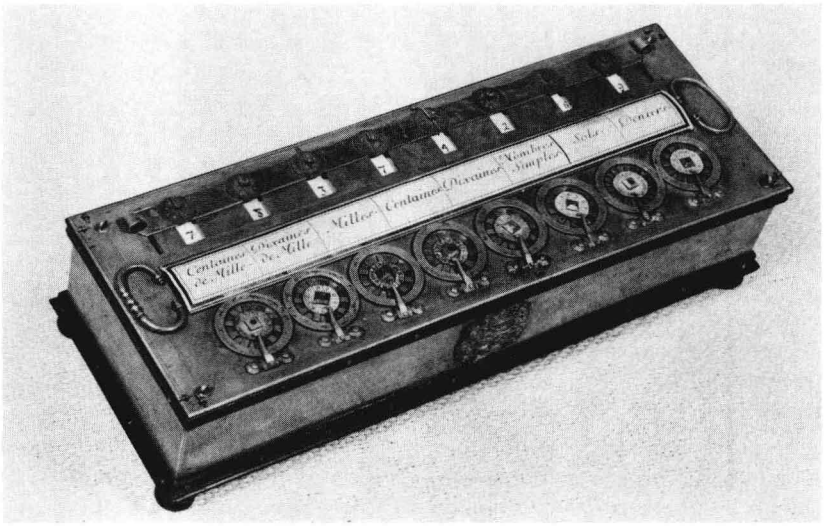
In our need to collect and transmit data, we are constantly searching for better tools that enable us to accomplish our objectives. Historically, the collecting, processing, and dissemination of data have progressed through three stages: manual, mechanical, and now electronic. The earliest simple manual tool used for counting was the abacus, which is still in use today. In an effort to increase the capability of the abacus, the French mathematician Blaise Pascal developed the first mechanical calculator in about 1642. A few years later, the German mathematician Gottfried von Leibnitz also worked on a mechanical calculator that performed all the basic operations of arithmetic. By the mid-1800s, Charles Babbage partially constructed an automatic machine to perform calculations, but it was not until 1885 that William Burroughs developed the first useful and practical automatic calculator. These mechanical calculators had to be operated manually by a crank. They were improved and developed into electrical calculators.

By the mid to late 1930s, the threat of World War II provided additional impetus, and, very importantly, funding for research in the planning and development of electronic machines. Dr. Howard

■ An abacus

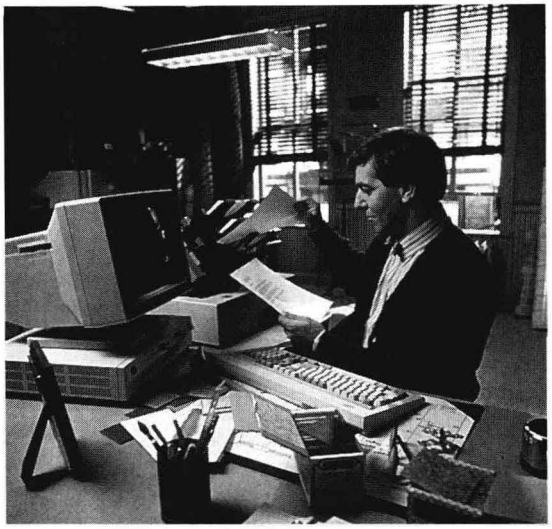


■ Pascal's mechanical calculator

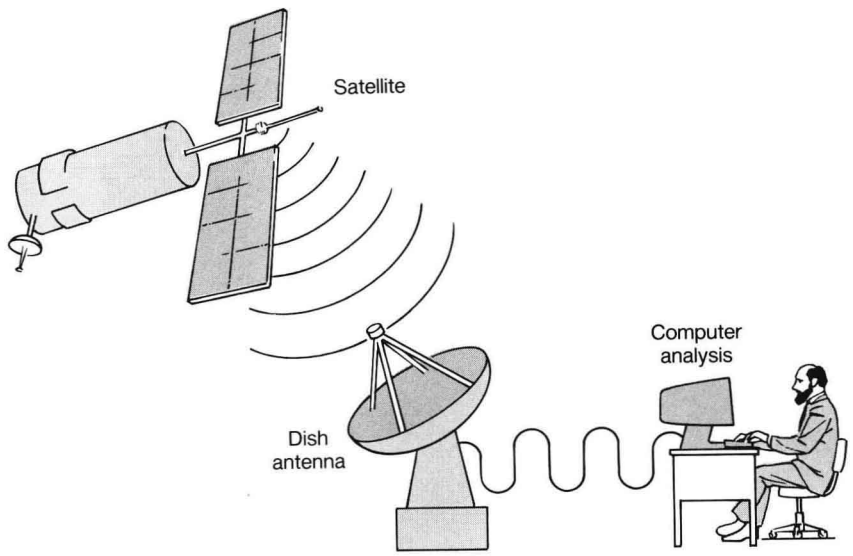


■ Burroughs automatic calculator

■ An IBM personal system/2



■ Transmission of data to and from the computer via satellite



Aiken of Harvard University developed the Mark I in 1944. Dr. John Atanasoff of Iowa State University, with the help of his graduate student Clifford Berry, developed the ABC computer. But it was not until 1946 that the first electronic calculator, known as ENIAC, was produced by J. P. Echert and J. W. Mauchly at the University of Pennsylvania. (It became known much later that the key ideas developed by Mauchly had been obtained from Atanasoff.) From this time on, the development of computers has been so rapid and fantastic that it boggles the mind. John von Neumann developed the concept of *stored programs;* that is, how to keep programs (sets of instructions to the computer) in the computer's memory. Echert and Mauchly produced the first commercial computer, UNIVAC I, in 1950. (The head programmer of the UNIVAC was Dr. Grace Hopper, who later made very important contributions to the development of the COBOL language.)

As the technology improved, hundreds of vacuum tubes were replaced by tiny transistors, miles of wiring were replaced by printed circuits, and room-size computers were replaced by hand-held calculators. Today, the state of the art is still changing and leaping forward.

Historical Development of COBOL

The rapid technological advances of the 1950s made it necessary to increase the efficiency of programming languages. When computers were first brought on the market, all programming was written in *machine language.* This language is heavily dependent on the electronic makeup of a particular computer; hence, programs had to be written for specific computers. Programs prepared for one computer could not be used on another without substantial rewriting at substantial additional expense. Institutions could not share programs unless they had identical computers. If an industry updated its computer hardware, its applications programs had to be rewritten. Such a state of affairs was obviously unacceptable.

In 1959, a number of computer professionals representing the interests of the U.S. government, the world of finance, universities, the insurance industry, and a variety of commercial industries and computer manufacturers agreed to meet for the express purpose of developing a business-oriented programming language that would be machine-independent. This group was called the Conference on Data Systems Languages (CODASYL). Its efforts culminated in the publication in the latter part of 1960 of the first version of COBOL. The word *COBOL* is an acronym for COmmon Business-Oriented Language. Some of the important features CODASYL wanted to incorporate in this language were the following:

1. It was to be machine-independent, thus allowing the same program to be processed on more than one computer. This objective was achieved to a remarkable degree, as you will learn in subsequent chapters.
2. It was to be easily maintainable. It was to allow for expansion, and for the inclusion of additional features to take advantage of technological improvements anticipated in later-generation computers. The subsequent versions COBOL-61, COBOL-61 extended (1963), COBOL Edition 65 (1965), COBOL Edition 1974, and COBOL Edition 1985 attest to the success of this feature.
3. It was to be free of mathematical and scientific symbols. In fact, the syntax, as developed, looks very much like the English language. It has a sentence structure and uses verbs, names, phrases, and clauses. This structure, along with a great versatility in the selection of names, allows programs to be largely self-documenting.

Though CODASYL still assumes the responsibility to update and maintain the COBOL language, the American National Standards Institute (ANSI) entered the picture in 1968, when it established COBOL as a standard language. The versions of COBOL as specified by ANSI are referred to as ANS COBOL. Most computer manufacturers provide COBOL compilers for their computers that comply with the specifications established by ANSI, but they also include extended features that capitalize on the unique features of their hardware configurations.

In programming establishments throughout the country, the 1974 version of COBOL is gradually being replaced by the 1985 version. This text generally adheres to the newest version.

Computers

Today, there are computer systems of all sizes and capabilities. Microprocessors are used in cars to increase efficiency, minimize fuel consumption, display road maps, and control passenger area climate (see Figure i.1). Other microprocessors are used in home heating systems, controlling the amount of heat to be produced in relation to ambient outdoor temperatures according to a programmed time schedule.