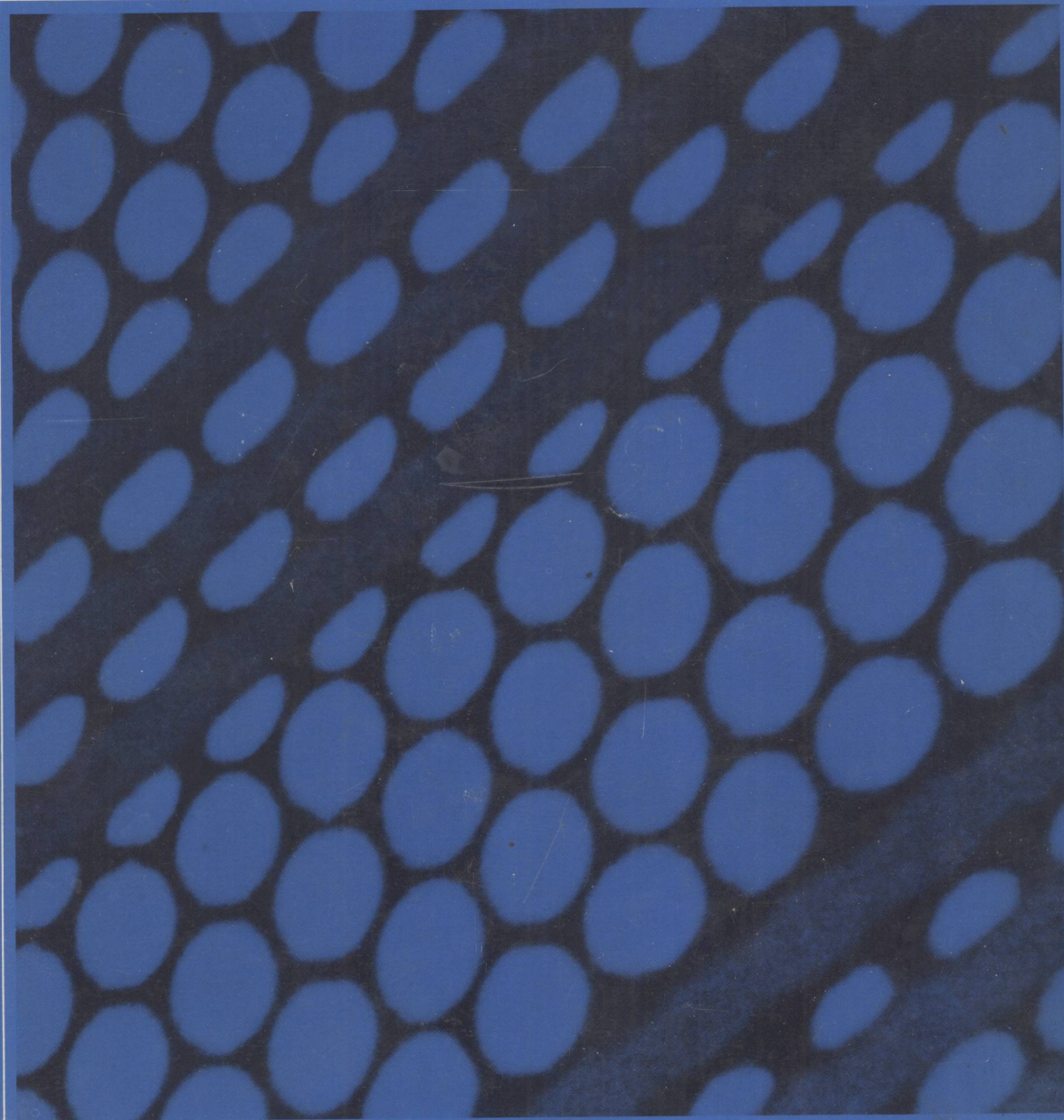


**MODERN
DATA
PROCESSING**

**Third
Edition**

Robert Arnold
Harold Hill
Aylmer Nichols



TP274
A1
E3

7964836

MODERN DATA PROCESSING

Third Edition

Robert R. Arnold

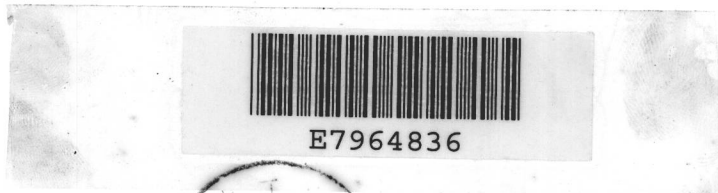
Dean of Instruction, Occupational Education
San Diego Mesa College

Harold C. Hill

Professor of Data Processing
San Diego City College

Aylmer V. Nichols

Director, Electronic Data Processing Services
County of San Diego



John Wiley & Sons

Santa Barbara New York Chichester Brisbane Toronto
A Wiley/Hamilton Publication

Copyright © 1978 by John Wiley & Sons, Inc.
All rights reserved. Published simultaneously in Canada

No part of this book may be reproduced by any means,
nor transmitted, nor translated into a machine language
without the written permission of the publisher.

Library of Congress Cataloging in Publication Data:

Arnold, Robert R
Modern data processing.

"A Wiley/Hamilton publication."

Includes index.

1. Electronic data processing. 2. Computers.

I. Hill, Harold, C., joint author. II. Nichols,
Aylmer V., joint author. III. Title.

QA76.A68 1978 001.6 77-14941

ISBN 0-471-03361-8

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

The Authors

Robert R. Arnold

has been Dean of Instruction, Occupational Education, at San Diego Mesa College since 1966. He previously served for eight years on the business faculty and as Coordinator of Data Processing at San Diego City College. His educational career also includes three years as Coordinator of Business Education for the San Diego Community Colleges which included the coordination of data processing programs and courses in three colleges. Before entering the educational field, Mr. Arnold served in office management and administrative positions in business and government agencies for over ten years.

Harold C. Hill

has been on the faculty of San Diego City College since 1962, serving as professor of data processing and past chairman of the Data Processing Department. He was previously engaged for twenty-five years in administrative, managerial, and data processing positions in military, industrial, and financial organizations. While serving in the United States Navy Mr. Hill participated in the design, installation, and supervision of a number of major data processing facilities. This included major responsibility for the design and installation of a worldwide communications network and data processing system for personnel accounting and distribution. He has also designed and supervised data processing systems for several large industrial and financial organizations.

Aylmer V. Nichols

has been employed in the data processing field for more than thirty years. He is Director of Electronic Data Processing Services for the County of San Diego, a position that he has occupied since 1965. Prior to that time he was engaged in the design of data processing systems and the supervision of data processing installations. He has also served as consultant to state and county government administrators in the justification and selection of electronic data processing equipment and the analysis of data processing systems. He is a pioneer in the field of data processing education, having designed and taught the first data processing course for San Diego City College in 1956. Mr. Nichols has been awarded the Certificate in Data Processing by the Data Processing Management Association.

Preface

Although the text of this edition of *Modern Data Processing* has been reorganized, revised, and augmented, the primary objectives remain unchanged. They are:

1. To provide a comprehensive view of the many data processing techniques and applications for those desiring a general knowledge of this important and dynamic field
2. To provide a good foundation for those planning advanced study in data processing.

The book is designed for use in basic data processing courses or for independent study. No background in data processing or other subjects is required for comprehension.

Although the book still covers the full range of data processing methods and devices, the emphasis given to different topics has changed significantly from previous editions. A single chapter on manual and mechanical data processing has been retained as a result of our continuing belief that the reader should be aware of all commonly used data processing methods. However, punched card data processing is no longer covered in the main text. Punched card machines have ceased to be a major means of processing data, although the punched card itself continues to be an important document in electronic data processing systems. In recognition of the fact that some punched card machines are still in use as auxiliary card-handling devices, a condensed description of the basic punched card machines appears in the Appendix.

The emphasis on computers has been increased by the addition of two new chapters covering minicomputers and microcomputers and the social and economic effects of computers.

Other revisions in the third edition of the text are:

1. Updating of all chapters to reflect the latest technological developments
2. A revised and expanded chapter on recording data for computer processing
3. Reorganization of electronic data processing chapters to facilitate understanding
4. Relocation of the data communications chapter immediately following the electronic data processing chapters
5. Relocation of the systems chapters so that they follow the discussion

- of data processing methods, devices, and operations
6. The addition of a preview outline at the beginning of each chapter
 7. The addition of important words and phrases at the end of each chapter
 8. An expanded glossary.

The text is organized as follows: Chapter 1 presents an overview of data processing that serves as a general introduction and frame of reference to assist in comprehending and relating the topics in succeeding chapters. Chapter 2 outlines the history of data processing from ancient recording and computing techniques to modern mechanical and electronic devices. Chapter 3 presents a survey of data processing applications in various fields, with emphasis on business. This chapter also includes a brief description of basic business operations to aid in understanding the main sources of data and common data processing applications. Chapter 4 surveys manual and mechanical data processing methods and devices—some conventional and others newly developed.

Chapter 5 describes the most commonly used codes, media, and devices used to record data for computer processing. Chapters 6 to 10 are concerned with electronic data processing, including a survey of computer characteristics, physical elements and functions of a computer system, and numbering systems. Data communications is discussed in Chapter 11. Chapters 12 to 16 cover electronic data processing program development, programming systems, the BASIC programming system, problem-oriented programming languages, and electronic data processing operations.

Chapters 17 and 18 are devoted to systems study and design. Systems study aids are described in Chapter 17, and principles of systems study and design are covered in Chapter 18. The uses of computers in industrial automation are outlined in Chapter 19. Chapter 20 surveys the social and economic effects of computers.

End-of-chapter review questions and lists of important data processing words and phrases are furnished as a guide in reviewing important text material and as a basis for discussion. The glossary contains definitions of terms that appear in this book, or that the reader is likely to encounter in supplementary reading. A discussion of basic punched card machines appears in the Appendix. A workbook containing lists of terms, review questions, and exercises is available to reinforce the text.

We express appreciation to the many individuals and companies who provided information and illustrations for this book, or who otherwise assisted in its preparation. Specific credit is included with illustrations wherever appropriate.

Robert R. Arnold
Harold H. Hill
Aylmer V. Nichols

Contents

1 FUNDAMENTALS OF DATA PROCESSING 1

Chapter Preview	1
Definition of Data	2
Data Versus Information	2
The Need for Data Processing	3
The Need for Improved Data Processing Techniques	4
Volume of Data	4
Clerical Costs	4
Accuracy Requirements	4
The Need for More Timely Information	4
The Data Processing Cycle	5
Origination of Data	5
Recording Data	6
Manipulation of Data	9
Summarizing and Report Preparation	10
Data Communications	10
Data Storage	10
Methods of Processing Data	11
Manual and Mechanical	12
Punched Card Machines	12
Electronic Data Processing	13
Conclusion	15
Important Words and Phrases	15
Review Questions	15

2 HISTORY OF DATA PROCESSING 17

Chapter Preview	17
History of Recording Techniques	17
Evolution of Computing Devices	23
History of Punched Card Machines	29
Development of Electronic Computers	33

Important Words and Phrases	38
Review Questions	38



3 DATA PROCESSING APPLICATIONS 39

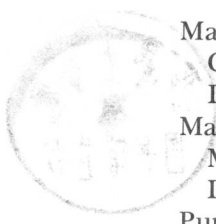
Chapter Preview	39
Business	39
Basic Business Operations and Sources of Data	39
Major Business Applications	50
Management Information Systems	51
Data Processing in the Organizational Structure	52
Government	54
Other Applications	56
Important Words and Phrases	58
Review Questions	58

4 MANUAL AND MECHANICAL DATA PROCESSING 59

Chapter Preview	59
Recording Techniques	60
Special Forms	60
Accounting Board	62
Document Control Register	63
Typewriters	64
Reproducing Processes	67
Manipulation of Data	69
Sorting	69
Calculating and Summarizing	73
Data Storage	77
Filing Systems and Equipment	77
Limitations of Manual and Mechanical Devices	84
Important Words and Phrases	85
Review Questions	85

5 RECORDING DATA FOR COMPUTER PROCESSING 87

Chapter Preview	87
Punched Cards	89
Card Structure, Material, and Codes	89
Card Punching	93
Punched Tape	96
Codes	96
Tape-Punching Devices	100



Magnetic Tape	100
Codes	100
Data Recorders	102
Magnetic Diskette	104
Medium	104
Data Stations	104
Punched Tags	104
Optical Characters	106
Magnetic Ink Characters	108
Optical Mark Recognition	109
Bar Codes	109
Data Conversion	112
Important Words and Phrases	113
Review Questions	113

6 ELECTRONIC DATA PROCESSING: INTRODUCTION 115

Chapter Preview	115
Classification of Computers	116
Purpose	116
Type	116
Capacity	117
Computer Functions	120
Data Representation	121
Binary Numbering System	122
Other Computer Codes	124
Important Words and Phrases	128
Review Questions	129

7 EDP CENTRAL PROCESSING UNIT 130

Chapter Preview	130
Control Unit	130
Arithmetic-Logical Unit	132
Arithmetic Operations	132
Logical Operations	136
Functional Elements	137
Register	137
Adder	138
Main Storage	138
Magnetic Core Storage	138
Monolithic Storage	139

Computer Numbering Systems and Arithmetic	141
Binary Computations	142
Hexadecimal Numbering System	144
Hexadecimal Computations	145
Important Words and Phrases	146
Review Questions	146

8 EDP AUXILIARY STORAGE 147

Chapter Preview	147
Types of Auxiliary Storage	147
Magnetic Disk Storage	148
Magnetic Drum Storage	149
Magnetic Bubble Storage	151
Magnetic Tape Storage	152
File Organization and Processing Methods	155
Records	155
Characteristics of Files	155
File Organization Methods	156
Techniques of File Processing	160
Data Management Systems	162
Data Base	162
Data Base Management System	163
Important Words and Phrases	163
Review Questions	164

9 EDP INPUT-OUTPUT DEVICES 165

Chapter Preview	165
Input-Output Functions	166
Input-Output Devices	166
Punched Card Readers and Punches	167
Punched Tape Readers and Punches	167
Magnetic Tape Units	169
Printers	170
Remote Job Entry Units	172
Microfilm Systems	172
Magnetic Ink Character Readers	172
Optical Character Readers	173
Transaction Recorders	175
Point-of-Sale Devices	176
Typewriter Terminals	176
Display Stations	177

Voice Response Systems	178
Console	179
Important Words and Phrases	180
Review Questions	180

10 MINICOMPUTERS AND MICROCOMPUTERS 181

Chapter Preview	181
Minicomputers	181
Minicomputer Characteristics	182
Minicomputer Applications	183
Future of Minicomputers	187
Microcomputers	187
Microcomputer Characteristics	187
Microcomputer Applications	189
Important Words and Phrases	190
Review Questions	191

11 DATA COMMUNICATIONS 192

Chapter Preview	192
Significance of Data Communications	193
Data Communications in Government	193
Data Communications in Business	195
Functions of Data Communications	197
Communications Media and Codes	199
Data Communications Equipment	200
Input-Output	200
Transmitting-Receiving Terminals	201
Data Transmission Terminal Equipment	202
Communications Facilities	213
Common Carriers	213
Communications Channels	213
Communications Services	215
Communications Switching	218
Important Words and Phrases	219
Review Questions	219

12 EDP PROGRAM DEVELOPMENT 221

Chapter Preview	222
Analyzing the Problem	222

Preparing Program Flowcharts	222
Program Flowchart Symbols	222
Flowchart Procedures	225
Stored Program Instructions	229
Instruction Format	230
Instruction Classifications	230
Writing the Program	234
Types of Source Program Statements	235
Coding Forms	235
Program Coding	238
Assembling or Compiling the Object Program	243
Testing and Correcting the Program	245
Preparing the Program for Production	246
Important Words and Phrases	249
Review Questions	249

13 PROGRAMMING SYSTEMS 250

Chapter Preview	250
Elements of Programming Systems	251
Programming Language	251
Processor	251
Programming System Aids	252
Subroutines	253
Macro Instructions	254
Input-Output Control Systems	256
Sort and Merge Programs	257
Utility Programs	260
Types of Programming Languages	261
Machine-Oriented Programming Languages	261
Problem-Oriented Programming Languages	261
Important Words and Phrases	262
Review Questions	262

14 BASIC PROGRAMMING SYSTEM 264

Chapter Preview	264
Time-Sharing	264
Terminal Operating Procedures	265
The BASIC Programming Language	266
Fundamentals of Coding and Compilation	266
Writing Statements	267
Program Errors	272

BASIC Programs	272
Important Words and Phrases	285
Review Questions	285

15 PROBLEM-ORIENTED PROGRAMMING LANGUAGES 286

Chapter Preview	286
Fortran	286
Cobol	290
Programming Language I	297
Report Program Generator	302
Important Words and Phrases	306
Review Questions	306

16 ELECTRONIC DATA PROCESSING OPERATIONS 307

Chapter Preview	307
The Data Processing Facility	308
Data Flow	308
Input Preparation and Control	308
Input Handling Procedures	308
Output Handling Procedures	310
Storage of Computer-Language Data	311
Scheduling	312
Console Operation	313
Console Operating Procedures	315
Operation of Input-Output Units	318
Card Readers and Punches	318
Magnetic Tape Units	318
Disk Storage Units	319
Magnetic Character Readers	320
Printers	320
The Operator's Duties	320
EDP Operating Systems	322
Operating System Functions	323
The Operating System in Operation	324
Multiprogramming with the Operating System	325
Remote Message Processing with the Operating System	326
Virtual Storage Operating System	327
EDP Operations Organization	327
Job Descriptions	327
Important Words and Phrases	331
Review Questions	331

17 SYSTEMS STUDY AND DESIGN: TOOLS AND TECHNIQUES 322

Chapter Preview	332
Evolution of Business Systems	332
The Systems Analyst	333
Systems Study Aids	335
Organization Charts	335
Flowcharts	335
Hipo	344
Decision Tables	349
Important Words and Phrases	351
Review Questions	351

18 SYSTEMS STUDY AND DESIGN: PRINCIPLES 352

Chapter Preview	352
Objectives of Systems Study and Design	352
Planning the Systems Study	355
Analyzing the Present System	356
Defining Systems Requirements	357
Designing the New System	358
Determining Input, Operational, and Output Methods	358
Selecting Equipment	358
Selecting Codes	359
Designing Forms	361
New System Proposal	362
New System Plan	363
New System in Operation	364
Important Words and Phrases	364
Review Questions	365

19 COMPUTERS AND AUTOMATION 366

Chapter Preview	366
Production Planning and Control	366
Industrial Automation	367
The Foundations of Industrial Automation	368
Mechanization	368
Continuous Process	368
Automatic Control	369
Computers and Automatic Control	370
Numerical Control of Machine Tools	370
Process Control	374

Cybernation	376
Integration of Business and Process Control Systems	377
Important Words and Phrases	378
Review Questions	378

20 SOCIAL AND ECONOMIC EFFECTS OF COMPUTERS 379

Chapter Preview	379
The Effects of Computers on Employment	380
Reduced Clerical Employment	381
Occupational Adjustments	381
The Individual and the Computer	382
Human-Machine Interface	382
Invasion of Privacy	382
Impact on Business Organizations	385
Overcoming Credit Losses	385
Computer Crimes	386
The Threat of New Competition	387
Social Resistance to Technological Changes	389
Remote Automated Tellers	389
Automated Payroll Deposits	390
Preauthorized Bill Payments	390
Point-of-Sale Transfers	391
Automated Checkout Systems	391
Conclusion	392
Important Words and Phrases	392
Review Questions	393
Appendix	
Punched Card Machines	394
Glossary	410
Index	429

FUNDAMENTALS OF DATA PROCESSING

CHAPTER PREVIEW

- Definition of Data
- Data versus Information
- The Need for Data Processing
- The Need for Improved Data Processing Techniques
 - Volume of Data
 - Clerical Costs
 - Accuracy Requirements
 - The Need for More Timely Information
- The Data Processing Cycle
 - Origination of Data
 - Recording Data
 - Manipulation of Data
 - Summarizing and Report Preparation
 - Data Communications
 - Data Storage
- Methods of Processing Data
 - Manual and Mechanical
 - Punched Card Machines
 - Electronic Data Processing
- Conclusion
- Important Words and Phrases
- Review Questions

Although the term “data processing” is of relatively recent origin, the activity itself is not new. On the contrary, there is evidence that the need to process data originated as far back as the beginning of recorded history, when people’s activities first exceeded their ability to remember the details of their actions. Throughout history, commercial and governmental activities have created the need to process data of one kind or another.

In its broadest sense, data processing refers to the recording and handling of data that are necessary to convert it into a more refined or useful form. In the past these tasks were referred to as record keeping or paperwork. They were accepted as a routine clerical activity. Recently,

with the advent of more sophisticated electromechanical and electronic business machines, the terms “paperwork” and “record keeping” have been replaced by the phrase “data processing.” In addition, the volume of data has grown to such proportions that data processing has become a major activity attracting a great deal of interest. This interest is justifiable, but it should not lead to the conclusion that data processing is an end in itself. It is rather a means of achieving objectives that are almost as varied as the nature of data.

DEFINITION OF DATA

Because of the widespread application of new data processing techniques to banking operations, billing, and other financial situations, there is a tendency to assume that the term “data” refers primarily to accounting or other business functions. Actually, data can include any facts, figures, letters, words, charts, or symbols that represent an idea, object, condition, or situation. Thus, data can include such diverse things as completed election ballots, inventory figures, gas meter readings, school attendance records, medical statistics, engineering performance reports, and production figures. In fact, this list could continue for pages because examples of data can be found in every field of activity.

There are, of course, differences in the types of data handled in various fields. In science, for example, chemists, physicists, and mathematicians find it necessary to perform vast calculations on relatively limited amounts of data. This is also true of the many fields of engineering, where extremely complex design and performance calculations must be made.

In business and government operations the situation is usually quite different. Here the data is voluminous and repetitive, but processing requirements, although varied, are generally less complex. In this book attention will be focused mainly on this type of data processing, although the techniques to be discussed will be found to some extent in virtually every field.

DATA VERSUS INFORMATION

There is a significant difference between data and information that can be described by one word: *usefulness*. No compilation of data, regardless of how vast, can be called information unless it has been organized in a meaningful way and is useful to someone. In other words, data becomes information when it achieves relevance.

Thus, data is the raw material used to produce information. Information consists of *selected data*—data selected and organized with respect to user, problem, time, place, and function. The conversion of data to information is a primary function of data processing (Figure 1-1).