



# **INFORMATION PROCESSING AND COMPUTER PROGRAMMING AN INTRODUCTION**

**HAROLD C. HILL  
San Diego City College**



**MELVILLE PUBLISHING COMPANY  
Los Angeles, California**



Copyright © 1973, by John Wiley & Sons, Inc.

Published by Melville Publishing Company, a Division of 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:*

Hill, Harold C.

Information processing and computer programming.

1. Electronic data processing. 2. Electronic digital computers—Programming. I. Title.

QA76.H48            001.6'4            73-1939

ISBN 0-471-39613-3

ISBN 0-471-39614-1 (pbk)

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

# PREFACE

**Information Processing and Computer Programming: An Introduction**— a simply stated but authoritative text, has been specifically oriented with the beginning student in mind. The major concentration of study is directed toward the logic and principles of computers and the use of computers. These concepts are introduced with an actual machine language program, and their relationship with various aspects of computers, including modern data processing devices and programming languages, is presented in a progressive manner. The beginning student's first experience in information processing and computer programming should be both an interesting and rewarding one. To this end the text is designed to permit the student to actively participate in the learning communications. The student involvement study supplement at the end of each chapter is intended to give the student an opportunity to learn by doing, with practical problems, the lessons presented in each chapter. A good understanding of the fundamental principles, as they are presented in each chapter, will insure the student's comprehension of the more complex modern data processing systems and languages.

Chapters 1–3 introduce the student to a brief history of data processing, the need for data processing presented in terms of everyday business applications, and the media and languages used to collect and store the vast amounts of data needed to provide management with decision-making information.

Chapters 4–6 are designed to give the student an early appreciation of the nature of problem solving using available planning aids, good forms design concepts, and effective data organization prior to learning the details of the computer devices used.

Chapter 7 introduces the student to the basic fundamentals of numbering systems used with computing devices.

Chapters 8 and 9 provide the beginning student with the details of flowcharting, program writing and machine operations using an actual business problem. The problem solution is presented in actual or native machine language coding, together with a brief history of the development of symbolic programming systems.

Chapter 10 presents machine- and problem-oriented languages in three separate sections. Section A contains a limited instruction set of IBM System/360 Assembler Language, Section B a limited instruction set of FORTRAN IV, and Section C a limited instruction set of BASIC. Each section is self-supporting with a detailed explanation of every programmed statement for the language presented, a solution illustration, and a study supplement. This method of presentation will permit the instructor or student in a self-study situation to select one, all, or any combination of languages most suited to a particular need.

Chapters 11 and 12 present and describe the latest developments in data processing devices, systems, and programming languages.

Chapters 13 and 14 introduce the student to data communications devices and techniques, source data automation, remote data processing, and time-sharing networks.

Chapter 15 familiarizes the student with advance techniques used by business management to solve the more complex business and industrial problems.

Chapter 16 provides a brief overview of the organization and management of data processing departments.

The Case Study Problem Statement is introduced early in Chapter 4. This permits the student to work the solutions for the same problem as he progresses through each chapter of the text and to visualize in an orderly fashion the relationship of each step in the solution.



All computer concepts, programming illustrations, and study problems are IBM System/360 oriented.

Since the exact sequence of the introduction of unit record machines may vary, the unit record machines have been presented in an appendix so that they may be introduced in whole or in part at any point desired. Appendices A, B, and C introduce the IBM 80-column, UNIVAC 80-column, and IBM 96-column punch card machines.

The glossary at the end of each chapter is included to further fortify the student's knowledge of the terms used in the chapter.

The author expresses his appreciation to the manufacturers who provided information and illustrations used in the text. Specific credit is included with illustrations wherever appropriate.

San Diego, California

Harold C. Hill

**INFORMATION PROCESSING  
AND  
COMPUTER PROGRAMMING  
AN INTRODUCTION**

# CONTENTS

## 1 DATA PROCESSING DEFINED

1

INTRODUCTION

DATA VERSUS INFORMATION

DATA PROCESSING CYCLE Data Origination, Data Recording, Data Arranging, Data Analyzing and Combining, Data Reporting, Data Storage

HISTORY OF DATA PROCESSING Clay Tablets (3000 B.C.), Abacus (2600 B.C.), Notched Sticks (1100 A.D.), Mechanical Calculator (1642 A.D.), Key-Driven Calculators (1872 A.D.), Card-Actuated Machines, Automatic Calculators, Electronic Computers, Computer Generations, First Generation, Second Generation, Third Generation

DATA PROCESSING METHODS, Manual Data Processing, Mechanical Data Processing, Punched Card Data Processing, *Card Punch*, *Verifier*, *Interpreter*, *Sorter*, *Collator*, *Reproducer*, *Calculator*, *Accounting Machine*, Electronic Data Processing, *Input*, *Storage*, *Analyzing and Combining*, *Output*

DATA PROCESSING DEFINITION

SUMMARY

GLOSSARY OF TERMS

DISCUSSION QUESTIONS

STUDY SUPPLEMENT

## 2 THE DATA PROCESSING NEED

27

INTRODUCTION

MANAGERIAL FUNCTIONS

BUSINESS OPERATIONS Buying, Receiving, Stockkeeping, Production, Selling (Retail), Selling (Other Than Retail), Delivery, Billing, Collecting, Disbursing (Payroll), Disbursing (General)

OTHER CONTRIBUTIONS Data Volume, Clerical Cost, Accuracy of Data, Timeliness

SUMMARY

GLOSSARY OF TERMS

DISCUSSION QUESTIONS

STUDY SUPPLEMENT

## 3 DATA RECORDING AND STORAGE

45

INTRODUCTION

PUNCHED CARD 80-Column Card, *Card Fields*, *Card Punch*, *80-Column Card Punch*

PUNCHED PAPER TAPE Eight-Channel Code, Five-Channel Code

MAGNETIC TAPE AND DISK Seven-Track Tape (Binary Coded Decimal, BCD),

vii

Nine-Track Tape (Extended Binary Coded Decimal Interchange Code, EBCDIC),  
Magnetic Disk (Direct Access Storage Device, DASD), Data Recorders, Magnetic  
Tape Cartridges

MAGNETIC INK CHARACTERS    MICR Data Recorders

OPTICAL CHARACTERS

SUMMARY

GLOSSARY OF TERMS

DISCUSSION QUESTIONS

STUDY SUPPLEMENT

#### **4 DATA PROCESSING PLANNING AIDS**

**63**

INTRODUCTION

CARD LAYOUT FORM

RECORDS LAYOUT SHEET

PRINTER SPACING CHART

FLOWCHARTS    Flowchart Template, Flowchart Worksheet

TYPES OF FLOWCHARTS    Systems Flowchart, Procedure Flowchart, Program  
Flowchart, *General Program Flowchart*, *Semidetailed Program Flowchart*, *Detailed  
Program Flowchart*

MACHINE RUN DIAGRAM

SUMMARY

GLOSSARY OF TERMS

DISCUSSION QUESTIONS

CASE STUDY PROBLEM STATEMENT

STUDY SUPPLEMENT

#### **5 SYSTEMS ANALYSIS AND BUSINESS FORMS**

**89**

INTRODUCTION

SYSTEMS ANALYSIS

DEFINITION OF TERMS USED

PROBLEM AREA DETERMINATION

PROBLEM ANALYSIS

PROBLEM REQUIREMENT DETERMINATION    Building the Work Model,  
Testing the Work Model

PROBLEM SOLUTION SYNTHESIS

PROBLEM SOLUTION IMPLEMENTATION

BUSINESS FORMS

FORMS DESIGN CONSIDERATIONS    Forms Design Prerequisites, Forms  
Questionnaire, Forms Design Rules

CLERICAL AND DATA COLLECTION FORMS

PARTS OF A FORM    Identification, Instruction, Introduction, Body, Conclusion

FORMS DESIGN GRID

PUNCHED CARD DESIGN

DUAL CARD DESIGN

CONTINUOUS PRINTER OUTPUT FORMS

SUMMARY

GLOSSARY OF TERMS

DISCUSSION QUESTIONS

STUDY SUPPLEMENT

**6 DATA ORGANIZATION****113**

INTRODUCTION

CHARACTERS

FIELDS AND SUBFIELDS Control Field, Coding Control Field, Statistical Field, Constant Field, Quantitative Field, Reference Field, *Length, Class, Significance, Signs, Decimal Positions*

DATA RECORDS Data Records, Trailer Records

DATA FILES Types of Data Files, *Master File, Transaction File, History File, Summary File, Trailer File*FILE ORGANIZATION Types of File Organization, *Sequential, Random*

RECORD FORMATS

DATA SEQUENCE CONSIDERATIONS

FILE ORGANIZATION CONSIDERATIONS Sequential vs. Random Organization, *Sequential Advantages, Sequential Disadvantages, Random Advantages*CODES AND CODING Coding Methods, *Sequence Codes, Block Codes, Group Classification Codes, Significant Digit Codes, Mnemonic Codes, Self-Checking Codes*

SUMMARY

GLOSSARY OF TERMS

DISCUSSION QUESTIONS

STUDY SUPPLEMENT

**7 NUMBERING SYSTEMS AND ARITHMETIC LOGIC****129**

INTRODUCTION Decimal System, Binary System, Hexadecimal System

ARITHMETIC Decimal Arithmetic, *Addition, Subtraction*, Binary Arithmetic, *Addition, Subtraction*, Hexadecimal Arithmetic, *Addition, Subtraction*

NUMBER BASE CONVERSION Decimal to Binary Conversion, Decimal to Hexadecimal Conversion, Binary to Decimal Conversion, Hexadecimal to Decimal Conversion, Binary to Hexadecimal Conversion, Hexadecimal to Binary Conversion

COMPLEMENTS 10's Complement, 2's Complement, 16's Complement

ARITHMETIC LOGIC Multiplication, Division, Law of Signs

SUMMARY

GLOSSARY OF TERMS

DISCUSSION QUESTIONS

STUDY SUPPLEMENT

**8 ELECTRONIC DATA PROCESSING SYSTEM DEVICES****149**

INTRODUCTION

TYPES OF COMPUTERS

SIZES OF DATA PROCESSING SYSTEMS Large Data Processing Systems, Medium Data Processing Systems, Small Data Processing Systems

ELECTRONIC DATA PROCESSING SYSTEM

INPUT Input Media, Input Devices, *Card Reader, Paper Tape Reader, Magnetic Tape Reader, Magnetic Ink Character Reader, Optical Character Reader, Magnetic Disk Reader, Page Reader, Tape Cartridge Reader*CENTRAL PROCESSING UNIT Control Section, Arithmetic and Logic Unit (ALU), Primary Storage (Memory), *Magnetic Cores*OUTPUT Output Devices, *Hard Copy Printer, Card Punch, Magnetic Tape Unit, Magnetic Disk Unit, Visual Display Unit, Display Copier, Output Media*



CONTROL CONSOLE    Manual Controls  
AUXILIARY STORAGE    Drum Storage, Disk Storage, Data Cell Storage  
SUMMARY  
GLOSSARY OF TERMS  
DISCUSSION QUESTIONS  
STUDY SUPPLEMENT

## 9    EDP SYSTEM PROGRAMMING

177

INTRODUCTION  
EDP SYSTEM CONFIGURATION AND STORAGE METHODS  
STORAGE METHODS  
PROBLEM SOLVING    Illustration Problem Statement, *Input, Computation, Output*  
PROBLEM ANALYSIS AND PROGRAMMING    Card Layout Form, Printer Spacing Chart, Records and Work Areas Sheet, Flowcharting  
ADDRESSING  
ADDRESS GENERATION    Storage Assignment Determination, Coding, Desk Checking  
PUNCHING THE PROGRAM  
LOADING THE PROGRAM  
EXECUTING THE OBJECT PROGRAM    Instruction Cycle (Flowchart Step 9), Execution Cycle (Flowchart Step 9)  
SUMMARY  
GLOSSARY OF TERMS  
DISCUSSION QUESTIONS  
STUDY SUPPLEMENT

## 10    MACHINE- AND PROBLEM-ORIENTED LANGUAGES

209

INTRODUCTION  
MACHINE-ORIENTED LANGUAGES  
PROBLEM-ORIENTED LANGUAGES  
SYMBOLIC PROGRAMMING SYSTEMS    Definition, Advantages of Symbolic Programming Systems, Processor Program (Translator), Development of Symbolic Programming Systems  
PROGRAMMING LANGUAGE ILLUSTRATIONS  
DISCUSSION QUESTIONS  
PROBLEMS AND EXERCISES  
STUDY SUPPLEMENT  
SECTION A, ASSEMBLER LANGUAGE  
INTRODUCTION  
LIMITED INSTRUCTION SET  
SOURCE LANGUAGE FORMAT    Name Field, Operation Field, Operand Field  
OPERATION CODES    Declarative Operation Codes, Define Storage (DS), Define Constant (DC), File Definition Macros (DTF), Imperative Operation Codes, Input/Output Macro Operations, Pack Instruction (PACK), Unpack Instruction (UNPK), Decision-Making Instructions, Compare Pack (CP), Compare Logical Characters (CLC), Decimal Arithmetic Instructions, Add Decimal (AP), Zero and Add Decimal (AZP), Subtract Decimal (SP), Multiply Decimal (MP), Divide Decimal (DP),

Overflow Condition, Branch Instructions, Conditional Branches, Unconditional Branches, Move Operations, Move Characters (MVC), Move Immediate (MVI), Edit Instruction, Literals, Relative Addressing, Explicit Length Factor, Control Operation Codes, Start Instruction (START), End Instruction (END), Statement Writing  
 AL PROGRAM  
 PROBLEMS AND EXERCISES  
 SECTION B, FORTRAN IV  
 INTRODUCTION  
 LIMITED INSTRUCTION SET    Constants, *Integer Constants*, *Real- and Double-Precision Constants*, Variables, Symbolic Names  
 ARITHMETIC EXPRESSIONS    Arithmetic Operators  
 FORMAT STATEMENT    FORMAT Codes  
 INPUT/OUTPUT STATEMENTS    READ Statement, WRITE Statement, PUNCH Statement  
 ARITHMETIC STATEMENTS  
 CONTROL STATEMENTS    GO TO Statements, Computed GO TO Statement, IF Statement, DO Statement, CONTINUE Statement, STOP Statement, END Statement  
 FORTRAN PROGRAM  
 PROBLEMS AND EXERCISES  
 SECTION C, BASIC  
 INTRODUCTION  
 LIMITED INSTRUCTION SET    Constants, Variable and Symbolic Names, Arithmetic Operators  
 BASIC STATEMENTS    READ Statement, DATA Statement, DATA Statement, PRINT Statement, PRINT USING Statement, END Statement, LET Statement, CONTROL Statement, GO TO Statement, Computed GO TO Statement, IF... THEN Statement, FOR and NEXT Statements, REM Statement, INPUT Statement, FILES Statement  
 SYSTEMS COMMANDS  
 BASIC PROGRAM  
 PROBLEMS AND EXERCISES  
 SUMMARY  
 GLOSSARY OF TERMS

## 11 OTHER PROGRAMMING LANGUAGES

293

INTRODUCTION    Illustration Problem Statement, *Input*, *Calculations*, *Output*  
 COMMON BUSINESS-ORIENTED LANGUAGE (COBOL) PROGRAM    *Identification Division*, *Environmental Division*, *Data Division*, *Procedure Division*  
 REPORT PROGRAM GENERATOR LANGUAGE (RPG) PROGRAM    *File Description Specification*, *Input Specification*, *Calculation Specification*, *Output Format Specification*  
 OPERATING SYSTEM REQUIREMENTS  
 SUMMARY  
 GLOSSARY OF TERMS  
 DISCUSSION QUESTIONS  
 STUDY SUPPLEMENT

<b>12</b>	<b>MODERN DATA PROCESSING SYSTEMS</b>	<b>307</b>
	INTRODUCTION	
	DESIGN FEATURES	
	INTERRUPTS    Program Interrupt, Input/Output Interrupts, Machine Check Interrupt, Supervisor Call Interrupt, Control Program	
	DATA CHANNELS	
	DATA FORMATS	
	CENTRAL PROCESSING UNIT	
	DATA REPRESENTATION	
	MULTIPROGRAMMING	
	MULTIPROCESSING	
	SOFTWARE	
	CAPACITY AND SPEEDS	
	COMPARATIVE COSTS	
	SUMMARY	
	GLOSSARY OF TERMS	
	DISCUSSION QUESTIONS	
	STUDY SUPPLEMENT	
<b>13</b>	<b>DATA COMMUNICATIONS</b>	<b>319</b>
	INTRODUCTION	
	DATA COMMUNICATION FUNCTIONS    Networks, Channels	
	COMMUNICATION FACILITIES <i>WATS, Wide Area Telephone Service, TELPak, TWX, Teletypewriter Exchange Service, Data-Phone</i>	
	COMMUNICATIONS CONTROL    Message Switching, Circuit Switching, Selective Calling	
	MEDIA AND CODES	
	COMMUNICATION DEVICES    Modulator or Data Set, Sending and/or Receiving Devices, <i>Keyboard Printer, Keyboard Only, Punched Paper Tape Transmission Terminal, Punched Card Transmission Terminal, Computer Transmission Control Terminal, Handwriting and Visual Display Terminal, Audio Response Unit, Portable Audio Terminal</i>	
	SUMMARY	
	GLOSSARY OF TERMS	
	DISCUSSION QUESTIONS	
	STUDY SUPPLEMENT	
<b>14</b>	<b>SOURCE DATA AUTOMATION, REMOTE DATA PROCESSING, AND TIME-SHARING NETWORKS</b>	<b>335</b>
	INTRODUCTION	
	SOURCE DATA AUTOMATION	
	REMOTE DATA PROCESSING	
	TIME-SHARING	
	NETWORK APPLICATION <i>Results Showing Up, Other Units Tie In, Broad- Gauge Benefits, High Reliability, Factor</i>	
	SUMMARY	
	GLOSSARY OF TERMS	
	DISCUSSION QUESTIONS	
	STUDY SUPPLEMENT	

<b>15</b>	<b>PROBLEM-SOLVING TECHNIQUES</b>	<b>349</b>
	INTRODUCTION	
	OPERATIONS RESEARCH (OR) Basic Processes of Operations Research, <i>Judgment Phase, Research and Synthesis Phase, Action Phase</i> , Operations Research Theories, <i>Mathematical Models, Game Theory, Queuing Theory, Monte Carlo Theory, Linear Programming</i>	
	DECISION TABLES (DT), Basic Elements of Decision Tables, <i>Conditions, Actions, Rules, Entries</i>	
	PROGRAM EVALUATION AND REVIEW TECHNIQUES (PERT) Time Estimates, Network Computation	
	SUMMARY	
	GLOSSARY OF TERMS	
	DISCUSSION QUESTIONS	
	STUDY SUPPLEMENT	
<b>16</b>	<b>ORGANIZATION AND MANAGEMENT OF DATA PROCESSING</b>	<b>367</b>
	INTRODUCTION	
	DATA PROCESSING RESPONSIBILITIES Relationship with Other Departments	
	DEPARTMENT ORGANIZATION	
	DEPARTMENT STAFFING	
	SYSTEMS AND PROCEDURES SECTION	
	PROGRAMMING SECTION	
	OPERATIONS SECTION	
	GLOSSARY OF TERMS	
	DISCUSSION QUESTIONS	
	STUDY SUPPLEMENT	
	<b>Appendix A IBM 80-COLUMN PUNCHED CARD MACHINES</b>	<b>373</b>
	INTRODUCTION	
	CARD PUNCHING	
	CARD VERIFYING	
	INTERPRETING	
	SORTING Numeric Sorting, Block Sorting, Alphabetic Sorting, Card Selection	
	COLLATING Selecting, Sequence Checking, Merging, Matching	
	AUTOMATIC PUNCHING Reproducing	
	GANGPUNCHING Combined Reproducing and Gangpunching, End Printing, Summary Punching, Mark-Sensing	
	REPORT PREPARATION Detail-Printing, Group-Printing, Carriage Control, Arithmetic Operations, Storage Units, Summary Punching, Program Control	
	<b>Appendix B UNIVAC 80-COLUMN PUNCHED CARD MACHINES</b>	<b>395</b>
	INTRODUCTION	
	UNIVAC 1701 VERIFYING PUNCH (VP)	
	UNIVAC 1710 VERIFYING INTERPRETING PUNCH (VIP)	
	UNIVAC 1720 SORTER	
	UNIVAC 1001 CARD CONTROLLER	

<b>Appendix C</b>	<b>IBM 96-COLUMN PUNCHED CARD MACHINES</b>	<b>401</b>
	INTRODUCTION	
	96-COLUMN PUNCHED CARD	
	IBM 5496 CARD DATA RECORDER	
	IBM SYSTEM/3	
	IBM 5410 PROCESSING UNIT	
	IBM 5424 MULTIFUNCTION CARD UNIT	
	IBM 5203 PRINTER	
<b>INDEX</b>		<b>407</b>



# 1 DATA PROCESSING DEFINED

## INTRODUCTION

The functions of and the need for recordkeeping can be traced historically to a point when man first took possession of property. This property reflected his status within the community. Each time a citizen joined a new community, he would bring with him all his worldly possessions. In order to account for his share of the community wealth, the community leader would furnish him with some medium of exchange (pebbles, sea shells, sticks, or coins) to represent his share of the community holdings. The act of determining the amount and size of the medium of exchange to which the citizen was entitled constitutes the origination of data. Data as used here is a general term to denote any or all facts, numbers, letters, or symbols that refer to or describe an object, idea, condition, or situation. The selection of a medium and the determination that the medium was accepted as a means of accounting constitutes the act of recording. Accounting is the theory or system of keeping, analyzing, and interpreting business facts. When the citizen accepted the medium and placed it with his other possessions, he was in effect storing data. When it was necessary to portray his wealth, he would display his medium of exchange according to size and number. This process represents the act of arranging or sorting. Presenting his display to other citizens represents the act of reporting or communicating.

This chapter presents a preliminary overview of the functions and devices used in the processing of data. With this preliminary background as a beginning, subsequent chapters as they relate to the data processing need should become more meaningful.

## DATA VERSUS INFORMATION

At this point a distinction between the terms "data" and "information" should be made. The term "data" is generally used to define letters, numbers, symbols, or pieces of knowledge which, when used alone, do not become useful to management. However, when combined with other letters, numbers, symbols, or pieces of knowledge, the results become information. Information, then, is the result of processing or combining data. This is accomplished in such a way as to produce meaningful management information. For example, in a payroll application, the employee's hours worked as it stands alone is considered to be data. When the employee's hourly rate is multiplied by the employee's hours worked, the result, net pay, is considered to be useful management information in the payroll register. It is important to note that such a fine distinction between these two terms cannot always be made. For instance, in the foregoing example, if the hours worked were used in a purely labor distribution application, hours worked could have been considered to qualify under the definition of information.

## DATA PROCESSING CYCLE

Not unlike the functions performed in the early citizen's data processing system, our modern day data processing systems are composed of a data processing cycle (Figure 1-1). The data processing cycle is composed of the following steps.

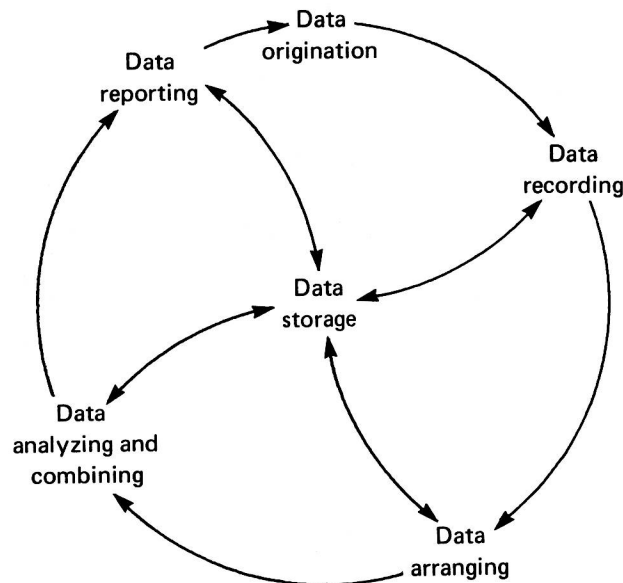


FIGURE 1-1. Data processing cycle.

### Data Origination

Before data can be recorded or entered into a data processing system, the data must be originated or created. Most data is originated by the use of source documents on which data is first recorded in the business organization. As a general rule, source data is handwritten, typed, or printed on a business form (Figure 1-2).

### Data Recording

While data written on business forms is in fact recorded by some means (usually by pencil or typewriter), the term "data recording," when used with reference to electromechanical or electronic devices, is the act of recording the data in some machine-readable form. This would include punch cards, paper tape, magnetic tape, as well as other types of recording media. Punched cards, paper tape, and magnetic tape as a recording media will be presented in detail in a later chapter. The term "media" is used to denote the material or configuration on which data are recorded. The act of data origination and recording could be combined. The use of such tools as the Port-a-Punch permits the origination and recording of data at the same time (Figure 1-3).

### Data Arranging

Most data is not recorded in the same sequence in which it is to be stored and/or used in the preparation of reports. Data therefore must be rearranged into an acceptable sequence (Figure 1-4, see p. 4).

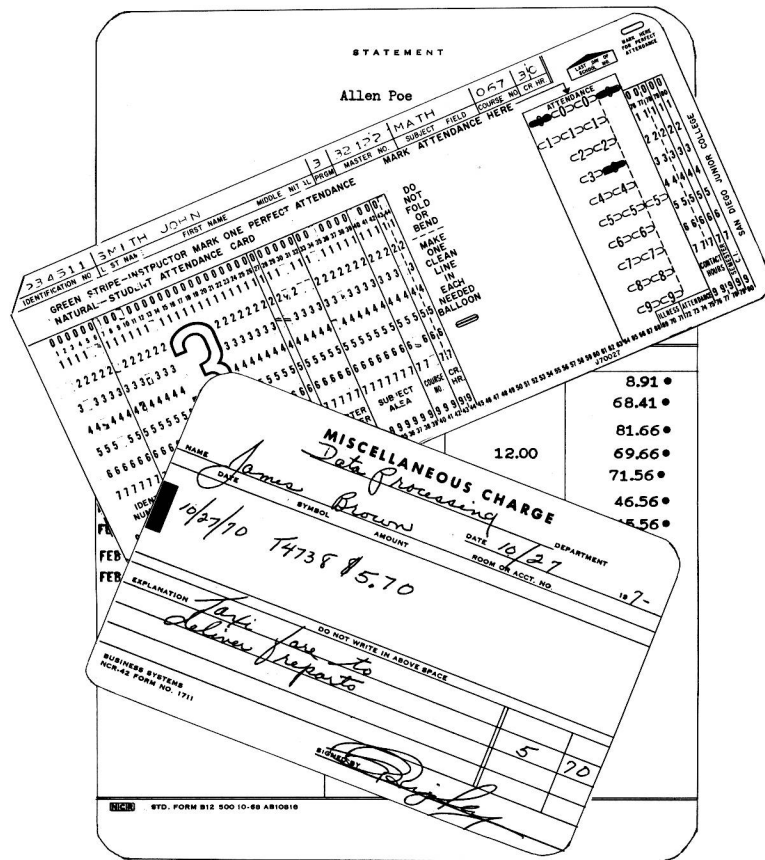


FIGURE 1-2. Various business forms on which data may be recorded in a business organization.

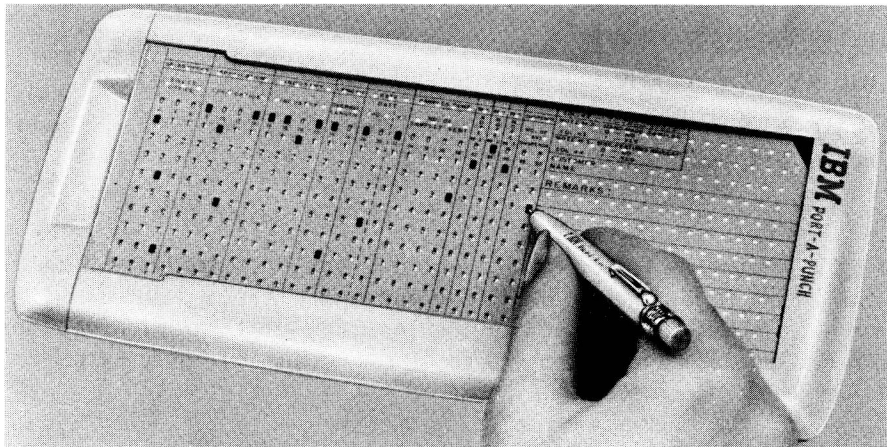


FIGURE 1-3. IBM Port-A-Punch. Prescored punch cards can be inserted into the holder and punched out with a stylus. (Courtesy International Business Machines Corporation.)