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ABSTRACT

This SMSG study guide is designed to aid the teacher in acquiring familiarity with digital computer concepts or to further his/her knowledge of the field. Suitable references for important topics are categorized as central, peripheral, or advanced. Topics covered include: (1) nature and organization of computers; (2) problem analysis; (3) algorithmic language; (4) additional sources of problems; (5) mathematics of computation; (6) applications of computer systems; (7) computer operation; and (8) non-technical views of the computer field. (MP)

SCHOOL MATHEMATICS STUDY GROUP

STUDY GUIDE IN DIGITAL COMPUTING AND RELATED MATHEMATICS

Financial support for the School Mathematics Study Group has been provided by the National Science Foundation.

1. THE PURPOSE OF THIS GUIDE

Introducing the subject of digital computers into the high schools involves knowledge, materials, and points of view that are at present not normally part of the training of the high school mathematics teacher. In order that the subject be introduced as widely and rapidly as possible, an in-service training program is necessary. Teachers must acquire an understanding of the new concepts to use them effectively and confidently in the classroom.

The purpose of this Study Guide is to aid the teacher in acquiring a familiarity with digital computer concepts or to further his knowledge of the field. The concept of an *algorithm* is stressed in the suggested materials, since it is basic to the mathematical solution of many problems. An algorithm is a list of instructions specifying a finite sequence of operations whose execution will yield the answer to a particular problem or class of problems. Algorithms may be stated in diagrammatic form or as *computer programs*. The programs are themselves sequences of operations for computer processing. Colleges are stressing the algorithmic approach to mathematics. Thus, it is important that the high school student study this concept, whether he writes computer programs or not.

The use of this Guide should not preclude the use of other sources of information. For example, the teacher would profit from a course in computer programming, preferably taught at a college. In such a course he would normally gain laboratory experience with a computer. While contact with the computer is not essential to an understanding of the use of the machine, it greatly enhances the training. In the event the teacher cannot conveniently enroll in a college course to strengthen his study program, he is urged to seek computer time at a nearby college or at a government or industrial research organization.

Professional and scientific organizations, specifically the Association for Computing Machinery, are excellent sources of additional information and advice on professional, educational, and vocational aspects of computing. Members of local chapters of this organization are usually very helpful in providing advice and even computer demonstrations. Further information is available, for example, by writing to

Association for Computing Machinery
211 East 43 Street
New York 17, N. Y.

This Guide may also serve school libraries and mathematics clubs in building a collection of digital computer reference materials.

2. DIGITAL COMPUTER TOPICS

This Guide has been written to answer three questions about digital computing and related mathematics:

a. What are the important topics to be studied?

b. In what order should these be studied?

c. Where can information be found on these topics?

Several topics are suggested as basic to an understanding of digital computers. The first five of these, described in the next paragraph, have been intentionally ordered as they are. If this order is followed, a continuity will be developed that should aid the beginner in this study. These five topics are considered fundamental to a thorough study of the field. The final three topics, described later, may be studied in any sequence and are of lesser importance.

The references begin with material on *The Nature and Organization of Digital Computers.** The capabilities of computers, the manner in which they are organized, and the means whereby information is stored in them are considered. When preparing a problem for computer solution, it is necessary to formulate an algorithm. This process, termed *Problem Analysis*, includes stating the problem, selecting a method, analyzing and visualizing it as a step-by-step sequence of operations. In this latter process, emphasis is placed on a flow-chart representation, i. e., a diagram displaying the sequence of operations comprising a procedure. The selected references stress this approach. Computer programs are written in various programming languages. Some of these languages consist of statements in a notation similar to mathematical formulas and are termed *Algorithmic Languages*. References are given to specific languages of this type. The use of appropriate problems for the expression of computer concepts is an essential part of a course in computers. As *Additional Sources of Problems*, material is selected that contains fully-worked problems for the classroom, showing the relation between algorithms and computer programs. In order to understand the nature of the problems that computers can solve, a *Mathematics of Computation* must be considered. References describe systems of numeration, computer arithmetic, approximations, and methods in arithmetic for the solution of problems too difficult to solve by classical mathematics. These five topics constitute the concepts that should be studied in sequence.

There are many *Applications of Computer Systems* in a variety of fields. Material here includes readings in such fields as engineering, physics, the behavioral sciences, law, etc., for the enrichment of a teacher's background. *Computer Operation*, the manner in which a computer operates to solve a problem, is described in the next set of references. Details of the instruction-by-instruction execution of a program and the manner of programming at this level of detail are considered. The final group of materials offers *Non-technical and Historical Views of the Computer Field*, providing popularized or historical literature. These references do not necessarily probe deeply into particular topics. These three topics are considered of less importance than the five mentioned earlier.

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*Italicized phrases in these paragraphs are used as topical headings in the body of this Guide.

Several topics are excluded from this Guide because they are not directly related to the concepts discussed. These include circuit design, Boolean algebra, and circuit components.

3. ORGANIZATION OF THE GUIDE

To aid in the study of each topic, the Guide categorizes suitable references. Each is classified as *central*, *peripheral*, or *advanced*:

a. A *central reference* is one containing material bearing directly on the topic and embracing the concepts described here. This type of reference is further classified:

> A *primary* central reference is one which is expected to be of greatest value to most high school mathematics teachers.
>
> A *secondary* central reference is one of less value to teachers.

b. A *peripheral reference* is one in which the material is specialized or not central to the topic but touches upon it, or is somewhat broader in scope than the topic here defined.

c. An *advanced reference* contains material central to the topic but which is written at a higher or more theoretical level.

At the end of the Study Guide, all books are listed alphabetically by author. It is recognized that the list is not exhaustive. Suggestions for appropriate additions are welcomed.

I. NATURE AND ORGANIZATION OF COMPUTERS

The manner in which a computer is organized, with consideration of major elements.

Central (Primary) References

LEESON AND DIMITRY, **Basic Programming Concepts**, Ch. 1, pp. 1-9
SHERMAN, **Programming and Coding Digital Computers**, Ch. 3, pp. 41-47; pp. 63
SMITH, **Computer Programming Concepts**, Ch. 1
VON NEUMANN, **The Computer and the Brain**, pp. 1-38

Central (Secondary) References

LEESON AND DIMITRY, **Basic Programming Concepts**, Ch. 2, pp. 10-21
NCTM, **Computer Oriented Mathematics**, Ch. 2, pp. 19-27

Peripheral References

GREENBERGER (editor), **Management and the Computer of the Future**, Part 6, pp. 221-248

II. PROBLEM ANALYSIS

Formulation of a method (algorithm) with emphasis on a flow-chart representation.

Central (Primary) References

ARDEN, **An Introduction to Digital Computing**, Ch. 4, pp. 46-52
GALLER, **The Language of Computers**
NCTM, **Computer Oriented Mathematics**, pp. 4-18, 59-101, 120-137
ORGANICK, **A FORTRAN Primer**, pp. 31-80
ORGANICK, **A MAD Primer**, pp. 43-87
SHERMAN, **Programming and Coding Digital Computers**, Ch. 2, pp. 17-40
SMITH, **Computer Programming Concepts**, Ch. 2

Peripheral References

BORKO, **Computer Applications in the Behavioral Sciences**, pp. 114-118
FROESE, **Introduction to Programming the IBM 1620**, pp. 15-16
GREENBERGER (ed.), **Management and the Computer of the Future**, Part 5, pp. 191-193; p. 211

Advanced References

ARDEN, **An Introduction to Digital Computing**
TRAKHTENBROT, **Algorithms and Automatic Computing Machines**

III. ALGORITHMIC LANGUAGE

Introduction to specific languages.

Central (Primary) References

ALGOL

ANDERSEN, **Introduction to ALGOL 60**
BAUMANN et al, **Introduction to ALGOL**
MCCRACKEN, **A Guide to ALGOL Programming**

FORTRAN

HARRIS, FORTRAN II and IV Programming

MCCRACKEN, A Guide to FORTRAN Programming

ORGANICK, A FORTRAN Primer

SMITH, Computer Programming Concepts, Ch. 3, pp. 12-16; Ch. 4-9

SMITH AND JOHNSON, FORTRAN Autotester

OTHERS

GALLER, The Language of Computers (simplified version of MAD)

ORGANICK, A MAD Primer

Central (Secondary) References

ALGOL

SHERMAN, Programming and Coding Digital Computers, Ch. 14

FORTRAN

COLMAN AND SMALLWOOD, Computer Language

GERMAIN, Programming the IBM 1620, Ch. 8-9 (GOTRAN)

LEESON AND DIMITRY, Basic Programming Concepts and the IBM 1620 Computer, pp. 174-220

MCCRACKEN AND DORN, Numerical Methods and FORTRAN Programming, Ch. 1, 7, 9, and Appendix 1

SHERMAN, Programming and Coding Digital Computers, Ch. 14

OTHERS

MCGEE, The Formulation of Data Processing Problems for Computers (in ALT, Vol. 4, pp. 3-21) (COBOL)

NCTM, Computer Oriented Mathematics, Ch. 2 (hypothetical language)

Peripheral References

FORTRAN

BORKO, Computer Applications in the Behavioral Sciences, Ch. 7, pp. 124-132

LEESON AND DIMITRY, Basic Programming Concepts and the IBM 1620 Computer, pp. 326-353

Advanced References

ALGOL

DIJKSTRA, A Primer of ALGOL 60 Programming

FORTRAN

MCCRACKEN AND DORN, Numerical Methods and FORTRAN Programming, Ch. 2-6, 8, 10, 11

OTHER

ARDEN, An Introduction to Digital Computing (MAD)

IV. ADDITIONAL SOURCES OF PROBLEMS

Mathematical problems displayed with algorithmic language programs for their solution.

Central (Primary) References

ARDEN, An Introduction to Digital Computing, Ch. 4, pp. 46-52

GALLER, The Language of Computers

JOHNSTON et al, **An Introduction to Mathematics**, Ch. 1, pp. 46-152
NCTM, **Computer Oriented Mathematics**, Ch. 3
ORGANICK, **A FORTRAN Primer**, pp. 109-155
ORGANICK, **A MAD Primer**, pp. 181-238
SHERMAN, **Programming and Coding Digital Computers**
SMITH, **Computer Programming Concepts**, Ch. 10 (Vol. 1), all of Vol. 2

Central (Secondary) References

GRUENBERGER AND MCCRACKEN, **Introduction to Electronic Computers**, (good examples scattered throughout book, but done in 1620 machine code)
LARSSON, **Equalities and Approximations with FORTRAN Programming**, pp. 60-62; p. 104; p. 144

Advanced References

ARDEN, **An Introduction to Digital Computing**, Ch. 10, pp. 131-147; Ch. 12-18, pp. 161-344

V. MATHEMATICS OF COMPUTATION

Numerical methods; error anaiysis; approximations; computer arithmetic; systems of numeration.

Central (Primary) References

ARDEN, **An Introduction to Digital Computing**, Ch. 7-8, pp. 87-112
HARRIS, **Numerical Methods Using FORTRAN**, Ch. 8-9
NCTM, **Computer Oriented Mathematics**, Appendix A

Central (Secondary) References

BORKO, **Computer Applications in the Behavioral Sciences**, Ch. 6, pp. 62-111
NCTM, **Computer Oriented Mathematics**, Appendix B

Peripheral Reference

FROESE, **Introduction to Programming the IBM 1620**, pp. 11-12

Advanced References

ARDEN, **An Introduction to Digital Computing**, Ch. 7-10, Ch. 12-16
FOX, **Introduction to Numerical Linear Algebra**

VI. APPLICATIONS OF COMPUTER SYSTEMS

Examples of the use of computers in such fields as engineering, sociology, physics, etc.

Central (Primary) References

BAR-HILLEL, **The Present Status of Automatic Translation of Languages** (in ALT, Vol. 1, pp. 92-157)
BORKO, **Computer Applications in the Behavioral Sciences**, Ch. 4, 9, 10, 13, 14, 23, 24
GOTLIEB, **General-purpose programming for business applications** (in ALT, Vol. 1; pp. 1-42)
GREEN, **Digital Computers in Research**, Ch. 8-13
LAWLOR, **Information technology and the Law** (in ALT, Vol. 3, pp. 299-352)

McGEE, The formulation of data processing problems for computers (in ALT, Vol. 4, pp. 1-52)

SAMUEL, Programming computers to play games (in ALT, Vol. 1, pp. 165-192)

SKRAMSTAD, Combined analog-digital techniques in simulation (in ALT, Vol. 3, pp. 275-298)

Peripheral References

GASS, Recent developments in linear programming (in ALT, Vol. 2, pp. 296-377)

GREENBERGER, Management and the Computer of the Future, Ch. 2, pp. 36-91 (decision making); Ch. 3, pp. 94-130 (simulation of human thinking); Ch. 4, pp. 135-178 (information search and retrieval)

Advanced References

BORKO, Computer Applications in the Behavioral Sciences, Ch. 11, 12, 15-22

FEIGENBAUM, Computers and Thought

VII. COMPUTER OPERATION

The manner in which a digital computer operates to solve a problem. Machine-language concepts and programming are included.

Central (Primary) References

BORKO, Computer Applications in the Behavioral Sciences, Ch. 5

DODES, IBM 1620 Programming for Science and Mathematics, Parts II-III, Appendices

FROESE, Introduction to Programming the IBM 1620 (machine language and SPS)

GERMAIN, Programming the IBM 1620

LEESON AND DIMITRY, Basic Programming Concepts and the IBM 1620 Computer, Ch. 2-14, pp. 22-173

NCTM, Computer Oriented Mathematics, Appendix A, pp. 138-153

SHERMAN, Programming and Coding Digital Computers, Ch. 3, pp. 47-60

Central (Secondary) References

ARDEN, An Introduction to Digital Computing, Ch. 1, 5, 6

McCORMICK, Digital Computer Primer (hypothetical computer)

NCTM, Computer Oriented Mathematics, Ch. 2, pp. 27-40 (hypothetical computer)

SMITH, Computer Programming Concepts, Ch. 3

Peripheral References

CODD, Multiprogramming (in ALT, Vol. 3, pp. 78-153)

CURTIN, Multiple computer operations (in ALT, Vol. 4, pp. 245-303)

ENGELBART, Games that teach the fundamentals of computer operation

GREEN, Digital Computers in Research, Ch. 15

GRUENBERGER AND McCRACKEN, Introduction to Electronic Computers

Advanced References

MCNAUGHTON, The theory of automata, a survey (in ALT, Vol. 2, pp. 379-421)

VIII. NON-TECHNICAL AND HISTORICAL VIEWS OF THE COMPUTER FIELD

Popularized or historical literature in the field.

Central (Primary) References

BERNSTEIN, The Analytical Engine: Computers — Past, Present and Future

BORKO, Computer Applications in the Behavioral Sciences, Ch. 3 (history)

NCTM, Computer Oriented Mathematics, Appendix E, pp. 198-200 (short history)

TOMPKINS, Computer education (in ALT, Vol. 4, pp. 135-168)

VON NEUMANN, The Computer and the Brain, Part 2, pp. 39-82 (the human nervous system)

Central (Secondary) References

DARNOWSKI, Computers — Theory and Uses, Vol. 1, pp. 1-29, 61-70

Peripheral References

GREENBERGER, Management and the Computer of the Future, Ch. 1, pp. 2-34; Ch. 8, pp. 291-324

Advanced References

SHOULDERS, Micro-electronics using electron-beam-activated machining techniques (in ALT, Vol. 2, pp. 137-293)

ANNOTATED BIBLIOGRAPHY

ALT, F. L. (editor), **Advances in Computers, Vols. 1-4.** New York: Academic Press, 1960-1963. The articles in these books range from introductions for certain fields and summaries of existing work in a particular field to quite technical papers to be read only with an appropriate background. The following selection of twelve of these articles has been chosen as particularly suitable for the high school teacher.

BAR-HILLEL, Y., **The present status of automatic translation of languages (Vol. 1, pp. 92-157).** A survey of the field of translation of natural languages, e. g., French, describing the accomplishments of a number of workers. Some of the problems encountered in natural language translation are described in an appendix.

GOTLIEB, C. C., **General-purpose programming for business applications (Vol. 1, pp. 1-42).** A rapid, extensive overview of the business data processing field containing a short introduction to programming systems; characteristics of data processing problems; typical data processing operations (sorting, merging, file handling).

SAMUEL, A. L., **Programming computers to play games (Vol. 1, pp. 165-192).** Written in general terms without giving details of algorithms, this article deals primarily with computer checker-playing, although it also discusses several approaches to computer chess-playing.

GASS, S. I., **Recent developments in linear programming (Vol. 2, pp. 296-377).** A survey of the field of linear programming (minimization of a linear function of several variables over a region defined by boundaries specified by linear equations). Several specific programming languages and some applications are described.

MCNAUGHTON, R., **The theory of automata, a survey (Vol. 2, pp. 379-421).** Automata theory (excluding such topics as switching theory, theory of computability, and artificial intelligence) is treated starting from a basic level, defining fundamental concepts, and proceeding at a level appropriate for most teachers.

SHOULDERS, K. R., **Micro-electronics using electron-beam-activated machining techniques (Vol. 2, pp. 137-293).** A lengthy (150-page) report on devices that may have considerable impact on computer design technology. Thin film circuitry is described in great detail with emphasis on novel manufacturing techniques.

CODD, E. F., **Multiprogramming (Vol. 3, pp. 78-153).** Multiprogramming is concerned with concurrency of operations within computer systems. This article offers a thorough, relatively non-technical introduction to the subject. It requires no particular background in a specific programming language.

LAWLOR, R. C., **Information technology and the law (Vol. 3, pp. 299-352).** This article provides a brief look at the possible utilization of computers to aid in information retrieval in the field of law. In addition, the article shows how Supreme Court decisions might be predicted by the computer, using information on past decisions.

SKRAMSTAD, H. K., **Combined analog-digital techniques in simulation** (Vol. 3, pp. 275-298). The kinds of problems best handled on such a system are described; some equations are solved on each of the two types. Examples are given. The problems with such a system are described.

CURTIN, W. A., **Multiple computer operations** (Vol. 4, pp. 245-303). A description of general concepts for the design, programming, and scheduling of multiple computer systems. Existing multiple computer systems are reviewed.

MCGEE, W. C., **The formulation of data processing problems for computers** (Vol. 4, pp. 1-52). A review of recent developments in certain areas of data processing: the characteristics of data processing languages (COBOL et al), organization and description of data, and some beginning attempts at a theory of data processing.

TOMPKINS, H. E., **Computer education** (Vol. 4, pp. 135-168). A description of the efforts toward computer education at the college and high school levels with emphasis on the former. A few comments are given on programmed instruction.

ANDERSEN, C. **An Introduction to ALGOL 60.** Reading, Mass.: Addison-Wesley, 1964. A clear and very brief description of the language ALGOL. The reader is assumed to have a basic knowledge of step-by-step logical processes and repetitive operations. The features of the language are introduced gradually and in a natural and convenient order. Individual features are illustrated well by examples.

ARDEN, B. W. **An Introduction to Digital Computing.** Reading, Mass.: Addison-Wesley, 1963. This book for the scientifically-minded reader is an excellent introduction to digital computing. About one-half of the book is devoted to a detailed exposition of the subject of numerical analysis. Many numerical techniques are illustrated by algorithms expressed in the MAD language. The book also contains an excellent chapter on numerical methods and a final chapter which describes the programming of "a simple compiler". In addition to an introduction to MAD, a basic approach to machine organization is given.

BAUMANN, FELICIANO, BAUER AND SAMELSON. **Introduction to ALGOL.** Englewood Cliffs, N. J. Prentice-Hall, Inc., 1964. An excellent, exceptionally clear and concise textbook on the language ALGOL; well-suited for use as a reference work as well (includes revised report on ALGOL 60 as appendix). Assumes a knowledge of the basic ideas of step-by-step logical procedures and repetitive processes.

BERNSTEIN, J. **The Analytical Engine: Computers — Past, Present and Future.** New York: Random House, 1964. This highly readable little book (103 pages) first appeared as a series of articles in the *New Yorker*. Any reasonably literate person could enjoy it as popular historical background.

BORKO, H. (editor) **Computer Applications in the Behavioral Sciences.** Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962. Although comprised principally of a collection of 17 reports covering a wide variety of computer ap-

plications to the behavioral sciences, this book also contains a 140-page introduction to computing which presupposes no prior knowledge. The research reports, while not easy reading, should be rewarding for the teacher who wishes to delve further into any of the topics.

COLMAN AND SMALLWOOD. **Computer Language — An Auto-instructional Introduction to FORTRAN.** New York: McGraw-Hill, 1962. An introductory manual (in a rather unusual format) to a subset of the language FORTRAN.

DARNOWSKI, V. S. **Computers—Theory and Uses** (teaching unit and teachers' guide). Washington, D.C.: National Science Teachers Association, 1964. Limited editions—revised edition to be offered for sale at a later date.

DIJKSTRA, E. W. **A Primer of ALGOL 60 Programming.** New York: Academic Press, 1962. A brief, well-written, readable presentation of ALGOL 60 to readers already familiar with some compiler language. Special features of the implementation of the language for the Mathematical Centre, Amsterdam are presented.

DODES, I. A. **IBM 1620 Programming for Science and Mathematics.** New York: Hayden Book Co., 1963. Of interest primarily to those who have access to a 1620 computer, this is a text in 1620 programming for good 12th grade students. It is not an introduction to the overall field of computing, but treats numerical analysis, machine language and symbolic programming, and —briefly—FORTRAN.

ENGLEBART, D. C. **Games that teach the fundamentals of computer operation, IRE Transactions, Vol. E.C.-10, No. 1,** March 1960. This paper instructs a teacher in the rules for playing a game using up to 20 students for simulating various kinds of simple computer elements. Each individual watches the up-down hand position of one or two others and adjusts his hand position to a response task which is equivalent to an AND, OR, NOT, or flip-flop. Counters, shift registers, and adders may be organized in this way.

FEIGENBAUM AND FELDMAN **Computers and Thought.** New York: McGraw-Hill, 1963. A fine collection of twenty research reports on Artificial Intelligence (programming computers to perform intellectual tasks such as game-playing, theorem-proving etc., in the same way that persons might perform these tasks) and Simulation of Cognitive Processes (construction of computer models to aid in understanding the information processes underlying human behavior).

FOX, L. **Introduction to Numerical Linear Algebra.** Oxford: Oxford University Press, 1964. A sound, readable account, mostly at the level of intermediate algebra, of the numerical methods used in the solution of linear equations, matrix inversion, and the eigenvalue problem.

FROESE, C. **Introduction to Programming the IBM 1620.** Reading, Mass.: Addison-Wesley, 1964. Of interest only for those who have access to an IBM 1620 computer. Emphasis on operation, feeding information into the machine, machine language and symbolic programming.

GALLER, B. A. **The Language of Computers.** New York: McGraw-Hill, 1962. An excellent introduction to the structure and use of a machine-independent algorithmic language (a simplified version of MAD). The language is introduced gradually, employing examples together with solutions given both by flow-chart and MAD program. A complete answer book is available on request from the publisher.

GERMAIN, C. B. **Programming the IBM 1620.** Englewood Cliffs, N.J.: Prentice-Hall, 1962. A text for a first course in programming with emphasis upon the operation of the 1620 (assumed to be available) and the use of machine language and symbolic coding.

GREEN, B. F., JR. **Digital Computers in Research.** New York: McGraw-Hill, 1963. This book is of interest principally for the applications in Part III. Many of these problems in the behavioral sciences are treated rather lightly and can be profitably read without attention to parts I and II.

GREENBERGER, M. (editor) **Management and the Computer of the Future.** Cambridge, Mass.: M.I.T. Press, 1962. In spite of its misleading title, this collection of eight lectures (with accompanying discussion) contains much background material of special interest to high school teachers and students. (Not a textbook.)

GRUENBERGER AND MCCRACKEN. **Introduction to Electronic Computers.** New York: John Wiley, 1963. A good IBM 1620 machine-language programming text suitable for 12th grade students having access to a 1620 computer. A very good presentation of basic and important (but highly machine-oriented) material.

HARRIS, L. D. **FORTRAN II and IV Programming.** Columbus, Ohio: Charles E. Merrill, 1964. This book contains a brief introduction to FORTRAN. Emphasis is on a simple subset of FORTRAN. This material is reprinted in the same author's text, *Numerical Methods Using FORTRAN.*

HARRIS, L. D. **Numerical Methods Using FORTRAN.** Columbus, Ohio: Charles E. Merrill, 1964. This book attempts a marriage of programming and numerical methods for the engineer or scientist. Although the presentation of FORTRAN is quite readable, the book is primarily of interest for the problems in Chapters 8 and 9.

JOHNSTON, PRICE AND VAN VLECK. **An Introduction to Mathematics, Vol. 1, Parts 1 and 2.** Lawrence, Kansas; Department of Mathematics, The University of Kansas, 1963. This book is part of a mathematics text for the University freshman. Only pages 46-152 are of interest to this study guide. In that segment of the book the basic concepts of flow charting and programming an algorithm (in an informal language similar to ALGOL) are presented in the context of solving systems of linear equations: 2x2, 4x5, and m x n. This section is recommended as an example of a quite detailed algorithmic solution of a problem, not as a text.

LARSSON, R. D. **Equalities and Approximations: With FORTRAN Programming.** New York: John Wiley and Sons, Inc., 1963. The teacher who knows FORTRAN can find in this book a few problems in mathematics programmed in FORTRAN (basic formatless FORTRAN for the IBM 1620).

LEESON AND DIMITRY. **Basic Programming Concepts and the IBM 1620 Computer.** New York: Holt Rinehart and Winston, 1962. This text is a complete treatment of programming the 1620 with detailed emphasis on machine language and symbolic coding. A brief (probably *too* brief for use by a beginner) but accurate presentation of 1620 FORTRAN I is given.

MCCORMICK, E. M. **Digital Computer Primer.** New York: McGraw-Hill Book Co., 1959. The person already competent in the area of programming and who wishes to delve into how computers work internally and how they are designed can find in this book a brief treatment of arithmetic and logical units, input-output devices and related topics.

MCCRACKEN, D. D. **A Guide to ALGOL Programming.** New York: John Wiley and Sons, Inc., 1962. This is a well-organized introduction to the language ALGOL, including nine-case-study examples, each carrying a problem from the original statement through the completed ALGOL program.

MCCRACKEN, D. D. **A Guide to FORTRAN Programming.** New York: John Wiley, 1961. A brief (88 pages) introduction to FORTRAN programming for the person who wants to get a rapid grasp of the language.

MCCRACKEN AND DORN. **Numerical Methods and FORTRAN Programming.** New York: John Wiley, 1964. A very readable book providing an adequate description of FORTRAN and a good introduction to a well-selected set of topics in numerical analysis. Aimed at under-graduates in science and engineering, many parts of the book are likely to be too advanced to suit the needs of the high school teacher. However, the teacher with adequate mathematical background will find much of the material useful for his own enrichment even though most of it will be beyond the reach of his students.

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS. **Computer Oriented Mathematics, An Introduction for Teachers.** Washington, D.C.; N.C.T.M., 1963. This book has an excellent plan as an introduction for teachers. Its purpose is not to teach the idea of a computer as an end in itself, but rather to motivate the study of mathematics by drawing upon the appeal and power of computers. In order to attain this goal, certain problems of mathematics are selected which can be solved appropriately on a computer. Emphasis is placed on the organization of solutions into logical step-by-step processes, the use of flow-charts, and on the repetitive capabilities of computers.

ORGANICK, E. I. **A FORTRAN Primer.** Reading, Mass.: Addison-Wesley, 1963. This is one of the most complete and well-organized FORTRAN texts available. It uses a comprehensive set of examples and drill exercises independent of any discipline. Its completeness and thoroughness in treating the differences between FORTRAN processors on various machines may make this book more suitable for a course taught by a teacher with previous knowledge of FORTRAN than for self-study.

ORGANICK, E. I. **A MAD Primer.** Ann Arbor, Mich.: Ulrich's Book Store, 1964. This book does for the MAD language precisely what the author's A FORTRAN Primer does for FORTRAN.

SHERMAN, P. M. **Programming and Coding for Digital Computers.** New York: John Wiley, 1962. An excellent comprehensive source book of in-

formation on basic computer concepts and on computer programming, including numerical scientific applications, business data processing, and non-numerical applications. Probably more useful to the high school teacher as a reference work than as a text.

SMITH, R. E. **Computer Programming Concepts.** Vol. 1 (Reference material), Vol. 2 (Problem exercises). Minneapolis, Minn.; Control Data Corp., 1963. An excellent introduction to the basic concepts of computers at a level easily understood by high school students. Emphasis is on FORTRAN as used with the Control Data 160-A Computer. Well-selected examples with a liberal sprinkling of humor.

SMITH AND JOHNSON. **FORTRAN Autotester.** New York; John Wiley, 1961. An excellent introduction to FORTRAN, particularly if a computer is not available for program check-out during the course of study. Minimal use of flow-charts. Exceptionally well-suited to a brief self-instructional initiation to the FORTRAN language.

TRAKHTENBROT, B. A. **Algorithms and Automatic Computing Machines.** (Translated from the Russian edition—1960). Boston: D. C. Heath and Co., 1963. This book is concerned with the theory of algorithms. It requires no specific information from other branches of mathematics beyond intermediate algebra. The subject matter is deep and the treatment is rigorous, requiring the reader to follow a rather complex train of logical thought, but the author has done an excellent job of making the ideas as accessible as possible. The basic ideas are introduced very carefully and gradually, and they are very well motivated. Recommended for the teacher who would like to follow up some of the logical and philosophical implications of computing.

VON NEUMANN, J. **The Computer and the Brain.** New Haven: Yale University Press, 1958. This excellent book, although not intended as a textbook, is recommended to the teacher as an historically oriented account of the organization of computing machines. The second part of the book discusses analogous properties of the human nervous system.