Dr. Chapman completed his graduate studies in resource economics at the University of California, Berkeley, in 1969 and has, in the past, served the Social Security Administration and the National Park Service as an economist. Presently he is also an assistant professor of economics at the University of Tennessee.

The Art of Computer Programming, Volume II. By Donald E. Knuth. Addison-Wesley Publishing Company, Reading, Mass. (1969). 624 pp. $18.50.

This book, subtitled "Seminumerical Algorithms," is the second of a proposed series of seven books on *The Art of Computer Programming.* The author indicates in the preface that he has intended to cover the topic of the interrelation of numerical mathematics and computer science. The topics treated are well balanced between rigorous mathematical proofs, and the limitations placed on solving these mathematical problems due to the characteristics of a computer. The material in this book is considerably more mathematically oriented than was Volume I, which has been previously reviewed by W. J. Worlton [*Nucl. Sci. Eng.*, 34, 198 (1968)]. This series of books is perhaps the most ambitious undertaking in this field to date.

The first of the two chapters deals with random numbers which, as the author points out, is a subject often not fully understood by many of the people using random numbers. Knuth has skillfully blended the many aspects of generating and using random numbers into an easily readable and rigorous presentation. The fact that much of the material has appeared previously only in papers exploring specific aspects of the subject should make this book a valuable reference for anyone using random numbers. Numerous techniques for random number generation are explored along with a thorough study of the adequacy of each technique. Also included in this chapter is a collection of techniques for performing tests to determine the randomness of a given set of variables.

The second chapter, entitled "Arithmetic," is a comprehensive study of how the various arithmetic operations are accomplished using a computer. In order to put this chapter into perspective, Knuth begins with a most fascinating history of number systems and works his way through such topics as floating-point arithmetic, multiple-precision calculations, radix conversion, rational arithmetic, polynomial arithmetic, and manipulation of power series. All of these subjects are covered in considerable detail with special attention given to the retention of as much accuracy as possible while carrying out these arithmetic operations.

The subjects discussed are often illustrated by a short computer program written in a language which the author has dubbed MIX. While this language is not the same as one would encounter on any computer now in existence, the transition to an existing computer should be relatively simple. Consequently, any of the given techniques could easily be implemented on most computers with a minimum of effort.

The people who will benefit most from this book are those who are interested in computer design, in compiler systems, and in number and probability theory. This is not to indicate that the casual user of a computer cannot obtain much from the book. The book is written in such a manner as to serve as an excellent text book for computer science studies. Particularly welcome are the 650 exercises which have been graded as to their degree of difficulty. Most of these exercises have detailed answers given which comprise approximately one-fifth of the 624 pages in the book.

The high degree of readability, which has been accomplished by the use of a sense of humor not often found in such technical works, along with the excellent technical content, should insure that this work will find wide acceptance and usage.

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January 13, 1970

About the Reviewer: Elliott Whitesides is Head of the Nuclear Engineering Section of the Oak Ridge Computing Technology Center where he has been located since 1960. He was trained as a Nuclear Engineer at the North Carolina State University. Mr. Whitesides' principal interest is the solution of neutron transport problems arising in nuclear criticality safety analyses to which he has made significant contributions in the application of Monte Carlo methods.

Formal Languages and their Relation to Automata. John E. Hopcroft and Jeffrey D. Ullman, Addison-Wesley, Reading, Massachusetts (1969). 242 pp, $11.95.

This work is an extremely valuable addition to the present short supply of good textbooks available in the realm of the computer sciences. On the whole, the material is presented with extreme clarity. Any student at the senior or graduate level in mathematics should have no trouble following the subject area of this book.

The subject of formal language theory or automata theory, can be made to be quite a complex one, and indeed, a large portion of the literature requires careful concentration on the part of the reader to grasp the more significant facts. It would probably have been much easier for the authors to continue this pattern than to present the material in the way that they actually did.

Bearing this in mind, there are at least four factors which contribute to the clarity of the book and which the reviewer feels are worth mentioning.

1. The proofs of the theorems do not go to an unnecessarily deep level. Acceptance of the proof of a theorem is generally thought to be in the mind of the reader. If he can be made to accept a proof with a minimum of complexity, then this is probably the best possible statement of the proof. The authors have demonstrated a remarkable proficiency to state their proofs in this manner.

2. The notation used by the authors is simple and consistent. The amount of notation is also held to a minimum, further enhancing the clarity.

3. For almost every concept which may be difficult for the reader to grasp, the authors supply an example which usually elucidates the concept.

4. Only the most significant results in the field of formal languages and automata theory are presented, contributing to the conciseness of the work. On the other hand, the work is, to a very satisfactory degree, complete. In this sense, the reader is brought to the threshold of the present-day state-of-the-art.

Formal Languages and their Relation to Automata is worthwhile reading and is highly recommended for the

collection of every computer scientist. In addition, mathematicians, both pure and applied, should benefit greatly from the reading of this book, if not for the concepts involved, then certainly as a diverse exercise in mathematics for the pure enjoyment of a well-written, well-planned book.

Due to an adequate number of challenging problems, the book is certainly a worth-while textbook for an introductory senior or graduate level course in automata theory, formal languages, or other closely related subject areas. At the end of each chapter, literature references for the concepts introduced in the chapters are presented. A bibliography is provided at the end of the book.

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December 17, 1969

About the Reviewer: James B. Morris received his PhD degree, with a major in computer science, from the University of Texas at Austin in August, 1969. He is currently employed by the computer science research group at the University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico. His special interests include the design of programming language translators and the theory of alogorithm equivalence.

Information Retrieval Systems Characteristics, Testing, and Evaluation. By F. Wilfrid Lancaster. John Wiley & Sons, Inc., New York (1968). 222 pp. $9.19.

The author views his subject through the eyes of a professional librarian actively engaged in lecturing on information retrieval and in evaluating information systems. Methods of measuring, monitoring, and improving the operation of these systems complete the volume.

Persons interested in an introduction to the field will find a clear and concise presentation of the terminology and concepts in the first nine chapters. Mr. Lancaster defines his terms in a scholarly manner and illustrates the concepts introduced with easily understood examples. Chapter 1 distinguishes among document, subdocument, reference, and data retrieval; between system staff who prescribe input and system users who request output information. Chapters 2 and 3 deal with subject indexing and the more general classification process. Historical treatment of Batten's "optical coincidence" retrieval, Mooer's "Zatocoding," and Taube's "Uniterms" is provided, and application of Boolean functions, hierarchical structure, and link and role relationships is described. Organization of the index, or search, file and retrospective, demand, and current awareness (SDI) searching are covered in Chaps. 4 and 5. The two standard quantitative measures of IR system effectiveness—recall and precision ratios—are discussed in the next three chapters together with factors influencing their values, in particular *exhaustivity* of the indexing and *specificity* of the indexing language. System coverage, the amount of user effort and response time required, as well as the form in which system output is provided, are considered as measures of system performance from a user's viewpoint. Chapter 9, a survey-type presentation of the application of computing equipment to information retrieval concludes the first half. This chapter, like several others in the latter half, suffers from the author's attempt to utilize previously published material. It appears to have been hastily updated; there are few references more recent than the original 1964 publication date.

The final seven chapters comprising the second half of the book will be of interest primarily to information scientists, and in particular, those engaged in the design or development of information retrieval systems. In these chapters the evaluation of an information system is considered. Chapters 10 through 12 cover the development of procedures for testing system performance, analysis of the test results, and application of these findings to the creation of an improved system. Economic factors are treated in Chap. 13, with a discussion of personal vs delegated search philosophies, searching strategies, and on-line interactive system considerations in Chaps. 14 and 15. In his conclusion, the author lists the principal steps involved in system design emphasizing the need to tailor individual systems to their environment and to continuously monitor their performance to achieve the optimum system. This reviewer felt a lack of cohesiveness in these chapters, introduced perhaps by the inclusion of the previously published material. The concise presentation of the earlier presentation is missing.

This is one of the volumes in the Wiley Information Science Series. As such, it represents the field from the author's viewpoint. Many of the examples are taken from Mr. Lancaster's work with the ASLIB Cranfield Project at the College of Aeronautics, Cranfield, England, and on the MEDLARS Evaluation Program at the National Library of Medicine, Bethesda, Maryland. Other selections in the series would be more appropriate for those interested in a computer-oriented look at information retrieval. The low level of exhaustivity and specificity of the index hampers the retrieval of the book's excellent definitions as a reference glossary. That's IR jargon and when you've read the book you'll know what it means!

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January 28, 1970

About the Reviewer: Margaret Butler, academically trained at Indiana University and associated with the Argonne National Laboratory since 1948, is in charge of the Argonne Code Center. Mrs. Butler's professional interests are in computer programming and design and in applied mathematics. She is a member of the Society's Publications Committee.

Induced Radioactivity. M. Barbier. North-Holland Publishing Co., Amsterdam (1969). 424 pp. $21.00.

This is an interesting and useful reference book. Discussions of the various topics begin with elementary principles so that one need not be a specialist to use it. The material is presented in a short introduction, seven chapters, and extensive appendixes. There are over 260 drawings of good quality. The introduction covers nuclear reactions, radiations, and modes of decay, and the first chapter deals with generalities such as cross sections, activation formulas, and dose rates. Subsequent chapters include, in order, activation by spallation, fission products and neutron activation, compound nucleus reactions, elec-