BOOKS

Digital Computing and Numerical Methods, B. Carnahan and J. O. Wilkes, Wiley, New York (1974). 477 pages. $13.95.

The title of this book suggests two distinct goals: to teach digital computing and to teach numerical methods. Indeed, the authors have attempted to do exactly that, but the quality of the results is as dichotomous as their purpose. First, elements of digital computer programming are presented in a rambling style with insufficient focus and excessive detail. Then, numerical methods for use in digital computing are explained in as praiseworthy an introduction to the subject as this reviewer has seen.

To be more specific, the latter six chapters of the book are—in the authors' accurate words—"devoted to an introduction to numerical methods, including the solution of single and simultaneous equations, numerical approximation and integration, the solution of ordinary differential equations, and optimization techniques." In addition, the authors anticipate the use of the book as a teaching text and note that the "level is suitable for the early years at a university, and the orientation is toward engineering and applied mathematics." More importantly, and this is the salient virtue of the book, the presentation is by means of clear, succinct descriptions of the use of numerical methods on a digital computer. The often tortuous application of each method is made evident with the aid of concise mathematical notation and carefully documented example programs. Flow charts, provided with the examples, are especially helpful. In fact, this reviewer sees the book, with its precision and simplicity, as an excellent reference work. Many a graduate student or practicing engineer will find it an invaluable guide when he is confronted by an intricate task in numerical programming. In addition, for the beginning student, each chapter includes 20 (usually more) study problems, primarily drawn from diverse areas of chemical engineering.

Occasionally, the book provides shallow coverage of seemingly important subjects; for instance, the existence of round-off error and its related problems are barely acknowledged. Still, more advanced treatises on numerical methods are available and this criticism is minor compared to the impressive merits already described.

On the other hand, the first four chapters of the book, on digital computing, might well have been omitted. It has been this reviewer's teaching experience that novice programmers require considerable instruction on how to start an algorithm, how to develop it into a detailed program, and how to spot its potential and real errors. Yet the present book dispenses an all too glib discussion of basic procedural thinking, a chapter in which algorithms always appear full blown, rather than step-by-step with periodic errors as in real life (especially a student's real life). Two chapters on hardware and operating system organization seem overly laden with minutiae for an introductory text. Worse, another chapter duplicates a whole host of programming manuals by describing in detail the Fortran IV, Watfor, and Watfiv languages and in the process consumes 30% of the book.

To put matters briefly then, most readers of this book will find the first chapters an unimpressive vehicle for learning computer programming. But once past that section, they will find the second part of the book an exemplary guide to the use of numerical techniques on digital computers.

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Radiative Transfer and Interactions with Conduction and Convection, M. N. Ozisik, Wiley, New York (1974). 575 pages. $18.95.

Professor Ozisik has written an excellent book on thermal radiation which covers most of the engineering aspects of the subject. The book encompasses (1) a summary of the basic physics, associated with the thermal radiation (electromagnetic wave and quantum theory) along with a summary of how basic radiation properties can be calculated (Chapters 1, 2); (2) an exposition of the basic engineering computational methods used to calculate radiation exchanges in an enclosure with nonparticipating media (Chapters 3 to 7 inclusive); and (3) a coverage of the more difficult areas of radiation exchange in participating media along with the equations which are necessary to describe coupling with the conservation laws of mass, momentum, and overall energy (Chapters 8 to 14 inclusive) in fluids and the overall energy equation in solids.

This book forms an excellent reference book of thermal radiation. It could be used as a book for a graduate level course. Alternatively, the first two portions could be used for an undergraduate course. However, it would be necessary to supplement the book with homework problems. The background needed for the first two sections of the book would require ordinary differential equations and undergraduate fluid conservation laws although a course in integral equations would be helpful. The third section of the book would require transport phenomena and higher level mathematics courses including partial differential equations.

Each chapter is introduced with a description of why the material in that chapter is of use in engineering problems. This description is followed by a summary of background references for the material in that chapter. The scope of the chapter is described as well as the limits on that scope. References of further information beyond the scope of that chapter are given.

In summary, this is an excellent book on the complex area of thermal radiation.

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Thermodynamics and Its Applications, Michael Modell and Robert C. Reid, Prentice-Hall, Englewood Cliffs, N. J. (1974). 553 pages.

Thermodynamics is both the joy and despair of engineering educators. It is the pre-eminent engineering science, with so elegant and secure a theoretical structure as to be likened, in the words of Lewis and Randall, to a great medieval cathedral. On the other hand, the subtlety of some of the ideas and concepts and the difficulties in reducing practical contexts to forms amenable to thermodynamic analysis usually require that students have two or more formal exposures to the subject before they are reasonably comfortable in solving real problems.

I suspect it is the elegance and subtlety of the theory which leads so many thermodynamicists to try their hands at writing textbooks. And because there are many good textbooks in the field, we must ask why another.

Modell and Reid answer, and rightly, that there is no advanced level textbook dealing with the applications of thermodynamics in chemical engineering. They seek to close the gap between theory and practice without shortchanging the treatment of relevant theory, and they succeed quite well. The principal medium of their success is the set of problems comprising some 75 examples and nearly 200 problems, none trivial and most derived from broad industrial experience.

The book is well suited to a one-term graduate level course in chemical engineering thermodynamics although there is more material than can be covered in one term. It is equally well suited to the practicing engineer who wishes to upgrade his prowess in dealing with realistic problems. The style of writing is clear and graceful, and difficult areas are dealt with at sufficient length to assume comprehension.

The authors suffer from the disease (endemic to chemical engineers?) of using nonwords like *directionality* and *functionality,* but these are minor lapses in a well-written book which fills a very real need in our literature.

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Professor Leon Lapidus, a member of the Journal Editorial Board, solicited the review for this book.

Identification and System Parameter Estimation: Parts 1 and 2, Proceedings of the 3rd IFAC Symposium, The Hague/Delft, The Netherlands, 1973, P. Eykhoff, Editor. North Holland, Amsterdam (1973).

System identification has experienced vigorous growth since its early days when a process was modeled by a first- or second-order transfer function solely by means of graphical techniques. Once the statistical nature of the problem became recognized, many concepts and techniques hitherto hidden in statistics textbooks and journals started being used. Matrix theory and the theory of linear differential equations, under the name "linear systems theory," and optimization theory also provided techniques useful to system identification.

The combination of concepts and techniques from statistics, linear systems theory, and optimization evolved to a large variety of identification techniques many of which have already accumulated a voluminous specialized literature. This is hardly surprising in view of the diverse types of physical processes under consideration, the type, amount and quality of data and the objective of identification. The diverse background and interests of research workers has further added to the proliferation of identification methods. At present the variety of the methods available, and their abstract mathematical formulation are bewildering to the nonspecialist, for example, the research and development engineer or the practical control engineer who are called upon to apply identification. What tests to carry out, what type of model to use, and which identification method to apply are important decisions that he has to make in the presence of many alternatives. The "Identification and System Parameter Estimation" proceedings of the 3rd IFAC Symposium are useful in this respect because they display the state of the art in the field, provide a useful selection of review articles by some of the foremost specialists, and offer a series of papers dealing with specific applications which should be of great value to the practicing engineer. In this review we shall first discuss the theoretical papers contained mainly in Volume II of the proceedings and then the papers dealing with specific applications contained mainly in Volume I.

GENERAL PAPERS ON THEORY AND APPLICATIONS

As emphasized throughout the proceedings, the type of model (linear or nonlinear, lumped or distributed parameter) used in identification depends on its ultimate utilization. If control (regulation) is the objective, a linear model describing small variations about the steady state is usually sufficient. If the modeling aims at understanding the process for the purpose of design, optimization, etc., then a nonlinear model constructed on the basis of physical laws will be necessary.

Identification Methods for Linear Lumped Parameter Systems

In spite of the extensive literature available, the identification by means of linear models is still a lively research field, as evidenced by the contents of the proceedings.

Correlation Techniques. A review paper by Marchand (p. 591) deals with the identification of linear multivariable systems from frequency response data. The data from sinusoidal testing can be used to obtain the transfer function at a discrete set of frequencies using standard statistical correlation techniques. From such frequency response data, one can obtain either an analytical expression for the transfer function or the coefficients of the differential equations, in both cases by maximum likelihood or least squares fitting. The difficulties of practically producing sinusoidal test signals are well known. An alternative and more convenient test signal that can be used in conjunction with correlation techniques is the pseudo random binary sequence (PRBS) as discussed in the paper by Nougaret et al. (p. 1023). Finally, the application of correlation techniques to a process excited by random inputs is discussed in an interesting and practical paper by Gerdin (p. 759).

Least Squares—Maximum Likelihood. Most successful and general among system identification and parameter estimation methods are the closely related least squares, generalized least squares, and maximum likelihood methods. An important paper by Söderström (p. 691) deals with the convergence properties of generalized least squares and provides examples with simulated and plant data. Two other papers, Pandya and Pagurek (p. 701) and Talmon and van den Boom (p. 711), also deal with the estimation of system and noise parameters by generalized least squares. A paper by Merhav and Gabay (p. 745) deals with the effect of modeling error in parameter estimation by least squares or generalized least squares. A paper by Finigan and Rowe (p. 729) is concerned with a modification of instrumental variables, a technique akin to generalized least squares but attempting to avoid the estimation of noise parameters.

Since the methods of generalized least squares and maximum likelihood are statistically optimal and practically workable, they must become better known among chemical engineers interested in process modeling and control. For this purpose we strongly recommend the excellent review of Åström and Eykhoff (*Automatica,* 7, p. 123, 1971).

Other Techniques. The proceedings include contributions to several other techniques, for example, the stochastic approximation technique, which however are of less general interest and need not be discussed here.

System Order Determination, Canonical Structures, and Order Reduction

An important part of system identification is the determination of system order. This problem has received attention only during the last few years and the proceedings include