Introduction (G. L. Shires).[1] Current plant design, operation, reliability, safety, and economics in the electrical generation, nuclear reactor, and petro-chemical industries require a blend of theoretical methods and empirical data, often combined in a computer code. These needs account for the remarkable growth of interest and activity in this field.

The book is divided into four sections: two-phase flow, two-phase heat transfer, hydrodynamic instability, and condensation. A chapter on loss-of-coolant accidents (LOCAs) in nuclear reactors is appended. Two-phase flow (the book addresses the problem of liquid-gas flow analysis, though much of what is contained is applicable to two-component solid-liquid and solid-gas flows) is a three-dimensional, transient, nonequilibrium phenomenon. Therefore, to provide qualitative insight, flow patterns have been identified to describe the interfacial configuration of the phases (Chap. 2, G. F. Hewitt). Since a complete theoretical description of the two-phase flow problem is beyond current capabilities, one-dimensional flow models (Chap. 3, D. Butterworth) have been developed that, in conjunction with empirical pressure drop methods (Chap. 4, D. Butterworth), enable the analyst to reasonably predict system two-phase pressure drops and flows. The latter chapter treats pressure drop methods in a consistent manner by collecting many of the correlations available, beginning with Lockhart-Martinelli, and indicating the interrelationships that exist between them. Chapters 5 and 6 (G. F. Hewitt) introduce the reader to the vertical bubble, slug, and annular flow regimes. Modeling methods are presented; in particular, the drift-flux approach in bubble and slug flow and the separated flow model in annular flow are emphasized. Considerable expansion of the latter is found in later chapters on boiling and condensation.

The succeeding section on two-phase heat transfer begins with a chapter on pool boiling (D. B. R. Kenning). At risk of being self-contradictory, more fundamental detail would have been desirable here. The process of vapor formation and bubble dynamics is central to our understanding of boiling, and has its counterpart in condensation. At an introductory level, the development of this topic in more depth is justifiable. Also, addition of Zuber's CHF model would have been useful for illustrative purposes. This model is based on local flow instabilities, which play a role in other phenomena of interest such as film boiling breakdown, entrainment, and countercurrent flow. Chapter 8 on nucleate boiling in forced convection (D. B. R. Kenning) and Chaps. 9 and 10 on convective heat in annular flow and estimation methods for forced convection boiling (R. A. W. Shock) provide analysis tools for these flow situations. Designers of evaporators and other horizontal tube heat exchanges (e.g., CANDU reactors) will find Chap. 11 (D. Butterworth and J. M. Robertson) of interest and a source of references for further research. Chapters 12, 13, and 14 (G. L. Shires, G. F. Hewitt, and D. H. Lee, respectively) deal with CHF phenomena. The authors have chosen the term burnout in reference to the marked temperature excursion of a heated surface caused by insufficient liquid cooling of the surface. Though mainly a matter of terminology, I believe the term CHF is preferable. It is generic, suggesting the above condition, without implying wall structural failure or a particular mechanism (departure from nucleate boiling versus dryout). The section in Chap. 12 on use of Freon scaling in the laboratory will be of interest to both the experimentalist and the student, to the latter particularly because of its rhetorical value. The last section in Chap. 14 should be of interest to the nuclear engineer, indicating the possible illusory nature of margins to CHF.

Beginning with Chap. 15, the topics are treated on a more advanced level and become of special interest to those already familiar with the field. The material on fouling effects in boiling water systems (R. V. Macbeth) concentrates on the "wick boiling" model, developed at Winfrith, and its application to boiling from crudded surfaces. Chapters 16 and 17 (N. A. Bailey and R. Potter, respectively) describe two-phase flow stability in boiling systems. Those readers familiar with control theory will find in these chapters an interesting extension to hydrodynamic problems and a useful introduction to a more detailed analysis in Lahey and Moody (*The Thermal-Hydraulics of a Boiling Water Nuclear Reactor*, American Nuclear Society, 1977). Chapters 18 and 19 (D. Butterworth) cover the topic of condensation very well. The final chapter (I. Brittain) on LOCAs, which certainly are a compelling motivation for the study of two-phase flow, was probably an ill-advised addition to this introductory work. This space might have been better utilized in developing other topics of interest (some mentioned in the chapter): critical flow, post-CHF heat transfer, or two-component flows.

In general, the book is well written and quite readable, although certain areas could be improved by a more detailed development of fundamentals (e.g., the conservation equations and the aforementioned section on boiling). The lack of illustrative examples and problems is a definite disadvantage for the student and general reader, leading this reviewer to suggest Collier (*Convective Boiling and Condensation*, 1972) as a possible alternative for classroom use.

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Foundations of Nuclear Engineering. By Thomas J. Connolly. John Wiley and Sons, Inc., New York (1978). $21.95.

This book is aimed at engineers and scientists other than those specializing in nuclear engineering, although I also consider it to be a useful reference for an introductory course in nuclear engineering. Microscopic details of the nuclear reactions important to the exploitation of nuclear energy are adequately presented in elementary terms. Then, the energy-producing reactions—radioactive decay, fission, and fusion—are systematically surveyed for their potential as resources.

The scope of this work is considerably in excess of that implied by the title. The foundations of nuclear engineering—nuclear structure, nuclear reactions, photon interactions with nuclei and electrons—are described, albeit occasionally unevenly and of necessity somewhat superficially; but the rest of the edifice is revealed to a useful extent as well. There are informative sections concerning

[1]Names in parentheses refer to chapter authors.

fission power systems and an important inclusion of some of the facts, definitions, and standards encountered in radiobiology. Though the emphasis is on fission power, radioactive decay power and fusion power are not neglected.

The first few chapters serve as an introduction to the concepts, nomenclature, and units underlying any discussion of energetics and nuclear reactions. Then follows a detailed discussion of the three major energy-producing nuclear reactions—radioactive decay, fission, and fusion—with some estimation of their practical importance as energy resources. A chapter on the interactions of radiation in matter introduces and explains quite nicely such concepts as the microscopic and macroscopic cross section, mean-free-path, attenuation coefficient, and charged particle range. Then, the environmental impact of the exploitation of nuclear energy sources is brought under discussion—particularly the impact of nuclear radiation (neutrons, charged particles, gamma rays) on the biological environment. The notion of dose and the relation between dose and biological damage are introduced and cautiously quantified. Next is the presentation of some details of fission product decay chains, with emphasis on their importance to fission power system design because of delayed neutrons, fission product poisoning, and decay thermal power. Finally, there is a long chapter leading to a description of various kinds of fission power systems (fast versus thermal, water cooled versus gas cooled, etc.) followed by a brief, but adequate, chapter devoted to the speculative magnetic and inertial confinement fusion power systems.

The book is replete with sample problems designed to help the reader comprehend new concepts as they are introduced. Each chapter ends with a problem set, thus enhancing the value of the book as a text. The level of presentation of technical material and the selection of content make this work particularly suitable for use in sophomore- or junior-level survey courses offered to non-nuclear engineers and other applied scientists. In my opinion and as the author suggests, this book should also serve as a useful reference for practicing engineers and scientists not specifically versed in nuclear engineering.

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Computational Methods in Engineering and Science. By S. Nakamura. John Wiley and Sons, Inc. (1977). 457 pp. $25.00.

Numerical analysis plays an extremely important role in the design and analysis of nuclear systems. For many years, nuclear engineering programs have sought to include more material on numerical methods and digital computing in their curricula. Unfortunately, existing texts that treat the application of numerical methods to nuclear systems are either quite dated (e.g., Clark and Hansen's *Numerical Methods of Reactor Analysis* or Bell and Glasstone's *Nuclear Reactor Theory*) or far too advanced for the typical engineering student (e.g., Wachspress's *Iterative Solution of Elliptic Systems*). Shoichiro Nakamura's new text, *Computational Methods in Engineering and Science*, addresses this need by developing the principal methods of numerical analysis used in the design of nuclear systems at a level suitable for senior or first-year graduate nuclear engineering students.

Nakamura's text is particularly noteworthy in treating computational methods for fluid dynamics with the same thoroughness as the more traditional subject of numerical methods for solving the neutron diffusion equation, in recognition of the importance of thermal-hydraulics analysis in modern nuclear systems design. After a brief introduction to the usual topics in numerical analysis, the author proceeds to develop the more popular numerical methods for the analysis of ordinary and partial differential equations, with particular emphasis on eigenvalue problems, iterative methods for solving elliptic partial differential equations, parabolic partial differential equations, and the hydrodynamics equations. Additional topics include weighted residual and variational methods, finite element methods, coarse-mesh rebalancing, Monte Carlo methods, and several advanced topics in transonic aerodynamic flow. The text is distinguished by its extensive use of detailed examples to illustrate mathematical concepts as they arise. Nakamura has also provided a comprehensive set of problems for each chapter.

We were particularly impressed by the appearance of a number of topics that play a vital role in modern methods of nuclear analysis but that rarely are encountered in textbooks. Among these subjects are the use of both cell-centered and cell-cornered mesh structures for deriving difference equations, the control volume approach to fluid systems, a careful discussion of implicit versus explicit methods for solving time-dependent problems, finite element methods for both diffusion and fluid flow problems, and advanced methods such as the strongly implicit procedure (SIP) methods for solving elliptic partial differential equations. We were somewhat disappointed at the absence of a discussion of discrete-ordinates methods (particularly since a chapter was devoted to Monte Carlo methods). We would also question the devotion of entire chapters to both coarse-mesh rebalancing methods and transonic aerodynamic flow (although we recognize that the author has made very significant research contributions to each of these areas).

We are somewhat concerned about the background necessary for an adequate appreciation of the material included in the text. Although the author states in the preface that only a preliminary knowledge of linear algebra and matrices is necessary, early in the first chapter he assumes as well a background in basic numerical analysis. Furthermore, it is apparent that the reader must have had a thorough course in nuclear reactor analysis (including multigroup diffusion and source iteration methods), along with some exposure to fluid dynamics (to the level of the Navier-Stokes equations) to appreciate the material covered in the text.

Although the text could serve as a primary text in a specialized course on numerical methods in nuclear systems analysis, we believe that its most effective use would be as a supplementary reference in advanced courses on nuclear analysis and design at the graduate level. The degree to which the text is oriented to nuclear systems analysis would seem to inhibit its effective use outside of nuclear engineering programs.

We would recommend Nakamura's text as a bridge between the more thorough and rigorous (and necessary)