

Broad scope and fresh approach enrich two reactor texts

Introduction to Nuclear Engineering

J. R. Lamarsh

626 pp. Addison-Wesley, Reading, Mass., 1975. \$19.95

Nuclear engineering concerns the application of the fission process to large-scale power production for the generation of electricity and for propulsion (primarily submarines at present) and to diverse applications in medicine and in industry. While the growth of the nuclear-power industry has not proceeded as rapidly as anticipated because of economic, regulatory and political factors, the general consensus appears to be that nuclear-power reactors will play a significant role for the next few decades.

This book makes an important contribution to this field in that it is a readable, up-to-date text; it includes many topics that have surfaced in recent years. John Lamarsh attempts throughout to impart an intuitive as well as an analytic understanding to the reader. It is an excellent textbook for undergraduates and may be read with profit by those not directly in nuclear engineering who wish to gain an overall understanding of the entire field. Numerous problems intended both to reinforce understanding of the material and to widen the scope of applications, together with the many helpful worked-out problems and the abundant illustrations, make this a valuable classroom textbook.

After the usual review of relevant nuclear physics, there is an extensive chapter on the present status of currently operating and next-generation power reactors. The next few chapters give a somewhat simplified account of what is known as reactor physics (such topics, for example, as diffusion theory, bare and reflected reactors, and control). The important problems of heat removal to produce steam, the main reason for running a power reactor, radiation protection and radiation shielding are given good treatments. The final, extensive chapter covers those topics that have become of particular importance in the last few

years—particularly reactor licensing, safety (with emphasis on safety in design and construction), redundant systems, accident analysis (such as loss-of-coolant accidents), results from the report commonly known as the Rasmussen report and environmental effects both during normal operation and during accident conditions. Several appendices give data on materials relevant to nuclear engineering and supply some mathematical background.

Lamarsh is currently professor of nuclear science and engineering at the

Polytechnic Institute of New York; previously he had held a similar position at New York University. He is the author of the widely used textbook *Introduction to Nuclear Reactor Theory*.

Nuclear-Reactor Analysis

A. F. Henry

547 pp. MIT, Cambridge, Mass., 1975. \$35.00

Nuclear-power reactors are expected to provide a significant fraction of the electricity generation in the next few decades. While there are several good books on nuclear-reactor theory, a book like this with a completely fresh approach to the practical problem of reactor design is indeed a welcome addition to the literature.

Allan Henry was in charge of methods development for most of his 18 years at the Bettis Atomic Power Laboratory, operated by Westinghouse Electric Corp; he is now a professor of nuclear engineering at MIT. His intention here is to provide a firm theoretical foundation in reactor-design methods, starting with simple physical concepts and avoiding both the more esoteric aspects of transport theory and the many prescriptions and loosely defined terms used earlier. The emphasis here is primarily on the underpinnings of the calculational methods applicable to three-dimensional heterogeneous reactors.

The introductory chapters are relatively brief and assume that the reader is already familiar with the relevant nuclear physics. While the pertinent features of fission are described, and some description of reactor types is included, the main intent is to provide precise definitions of nuclear cross sections and of reaction rates.

Reactor physics proper starts with the treatment of an infinite homogeneous multiplying medium over the entire neutron energy range. One of the main unconventional approaches in the book is the author's treatment of the energy dependence of the flux first, instead of the more usual practice of beginning with the spatial part at fixed neutron energy. This approach allows the author to set up an exact equation for the energy dependence



MARK II Triga reactor. This research reactor at Columbia University was denied permission to operate in 1971, and legal and administrative procedures still obstruct its licensing.

The nuclear-reactor volumes by Lamarsh and Henry are both reviewed by Edward Melkoni of Columbia University.

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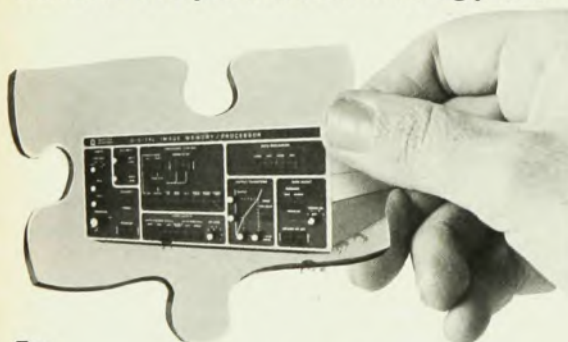
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of the flux, assuming only that the basic nuclear-physics data are known sufficiently accurately. The next step is to break up the continuous energy dependence into a multigroup format with appropriately defined multigroup constants. This is in preparation for solution on digital computing machines. There is, however, no discussion of how such numerical procedures are carried out. At this point Henry proceeds to obtain approximate analytical solutions for some very simple cases, specifically the fission-source range, the intermediate "slowing-down" range and the thermal-energy range. The results are, of course, the same as in other texts. However, the order of presentation here is unconventional in that analytical results are discussed last to provide insights into the way the neutron flux behaves as a function of material composition and neutron energy. By starting with an infinite medium, the author is thus able to introduce fairly early many of the basic concepts of reactor physics, including an orderly development of the four-factor formula with carefully defined components.

Finite media are then treated with the introduction of diffusion theory based on the assumption of Fick's Law. The derivation of this law is deferred to the chapter on transport theory. (The author thus avoids the conventional one-speed derivation, which he considers to be misleading.) For a bare finite reactor the results of the infinite-medium case are directly applicable provided a leakage term is added to the absorption term. Generalizations to multiregion reactors are then made. Here again, as is the case throughout the book, the unconventional procedure is followed: general equations first, then preparation in a form suitable for computer calculations and finally some analytical results applied to simple cases to provide insight into the importance of various parameters in determining the flux distribution.

In the realistic case of heterogeneous reactors with resonance absorbers, methods are provided for the determination of "equivalent homogenized" few-group constants. Treatment of the consequences of fuel depletion, including conversion and the effects of Xe^{135} and Sm^{149} buildup, follows. Reactor kinetics is treated in a manner much closer to the conventional approach than applies to the rest of the book.

Transport theory is introduced to provide a derivation of Fick's Law as an approximation and to treat those cases where this law is not valid. Group-diffusion theory is then derived on the basis of transport theory.

The book concludes with a chapter on the generation of equivalent diffusion-theory parameters for realistic cases and a chapter on advanced methods for reactor analysis, such as several synthesis methods, variational techniques and the

finite-element method, among others.

This book is the basis of a sequence of three one-term graduate courses in reactor theory at MIT. The author claims that the standard undergraduate-mathematics preparation is adequate and that previous knowledge of reactor theory is not necessary. This may be literally so, but in my opinion considerable mathematical sophistication is needed to follow the various developments. Similarly, the rigorous development and insights provided can be appreciated only by one who is already somewhat familiar with the basic features of reactor theory.

Other features that argue against this book as an introductory text are its relatively few diagrams (for instance, a graph of the thermal flux peaking in the reflector, resulting from a two-group calculation, would be helpful), the lack of worked-out problems and the omission of the customary appendices giving tables of various parameters of interest and summaries on various special functions. On the other hand, for the better prepared student there are many interesting problems at the end of each chapter, frequent summaries throughout the text to "help the reader to distinguish the forest from the trees" and indications on how some of the parameters encountered may be determined experimentally, as well as good motivation throughout.

In addition to use as a classroom textbook, this book will be of value to nuclear-reactor designers and to reactor analysts, giving them a clear idea of the virtues and limitations inherent in the theoretical methods in use. Indeed, this book can be read with profit by one already familiar with reactor physics who wishes to obtain a coherent account of the subject and to get the author's insights and interesting viewpoints.

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Edward Melkonian, Columbia University Professor of Nuclear Science and Engineering, has done research in neutron and fission physics and taught nuclear physics and methods.

Atmospheric Diffusion, 2nd edition

F. Pasquill
429 pp. Halsted, New York, 1974. \$39.75

There is little doubt that the levels of air pollution that now exist in industrial countries cause significant human-health effects, substantial property damage and serious environmental degradation. In order to be able to make rational choices among various technological options that face society, it is necessary to be able to predict air-pollution levels that would result.

The major tools for such predictions, and their scientific bases, are discussed in

this book, which is a substantial revision of the first edition, published in 1961.

The author, Frank Pasquill, is a British meteorologist who has recently retired from a distinguished research career; he is a past president of the Royal Meteorological Society and a former editor of the *Quarterly Journal of the Royal Meteorological Society*, and he has held a number of leadership positions. He is currently an active consultant. This book, in spite of the rather inflated price, should be available to all serious workers in air-pollution meteorology.

The earlier chapters review experimental information on atmospheric diffusion, survey theoretical approaches used to describe diffusion and describe what is known about turbulence in the atmosphere. It is of course turbulence that controls the dispersion of material, and Pasquill's chapter on this subject and the associated micrometeorology is outstanding.

The strength of this book is the manner in which the underlying foundation of the methodology is developed. Chapter 5 discusses many of the complications associated with the release of pollutants at elevated temperatures from industrial stacks, the removal of particulate-matter deposition, precipitation removal, effects of terrain and various other practical considerations. A rather concise but reasonably complete summary of what is known is given here. One topic that receives rather sketchy treatment is the effect of chemical reactions on pollutants, and little mention is made of the effect of atmospheric conditions upon reaction rates—this omission largely reflects the lack of available information. The methods available for predicting long-distance transport could have been given a more complete treatment.

As the author states, Chapter 6 "deals with the application of all the ideas, results and experiences which has been discussed in the preceding chapters." In this final chapter he sets forth "engineering" procedures designed to allow one to calculate the expected pollutant concentration given the release rate, the nature of the terrain and the meteorological conditions. This is indeed a tall order given the complexity of the ever-changing turbulent atmosphere through which pollutants are transported. Pasquill understands, and explains well, the complexities and possible pitfalls.

I disagree with the author's suggestion that the final chapter might be studied and used without reference to the preceding chapters. Studied, perhaps; but used alone, only at one's own peril! Environmental-impact statements, safety-analysis reports and various other studies have all too many silly errors because someone felt that a handbook, summary or final chapter could be used without understanding the basic atmospheric processes that control the transport and