forces." He writes later, "It is the aim of the first ten chapters of this book to describe electromagnetic theory in a manner that makes it more accessible to students of medicine, biology, biochemistry, and chemistry than the formal mathematical approach of physics books." That first group of ten chapters makes up part I, The Basic Theory, which represents about 60% of the book. Six to ten problems are appended to the end of each chapter, usually with one worked out in detail.

While the exposition was clear, I judged that this part of the book was "more accessible" only to the extent that it was less ambitious than the electrodynamics texts I have used in teaching advanced undergraduate physics majors. For the most part, the material was treated conventionally, except that no use was made of vector algebra and vector operators. However, the discussion of conductivity, which emphasized ion currents, random-walk processes, and Fick's first law, was an unconventional exception, especially useful for biologists.

In his part II, Applications, about 25% of the book, Edmonds addresses six biological topics in which the introductory physics supposedly plays an important role; chapters 11 through 16 cover, respectively, ions in aqueous solution, the Debye Layer, ions in narrow pores, a magnetic animal compass, ion/ion coport or counterport, and theory of pulsed nuclear magnetic resonance. No problems are appended to these chapters, but references are listed. The book ends with three appendices, on mathematics, on the Boltzmann distribution, and on thermodynamics and the chemical potential. Each is followed by a few pages of hints for solutions and numerical answers to the problems.

Here, I find a disconnect between parts I and II. While part I is a textbook for beginning students, part II seems more a set of somewhat didactic special-topic essays requiring much more sophistication on the part of the student than does the conventional physics of part I. Moreover, the selection of subjects seems to reflect more the author's special interests than matters central to biophysics. While Edmonds devotes a chapter to coport and counterport ion transfer across cell membranes, emphasizing his own important contributions, he mentions voltage-gated ion channels in only one offhand sentence. Surely this aspect of membrane ion transfer is directly electrical and is central to much biology! Conversely, while animal navigation is great fun, and a special interest of mine as well as of Edmonds's, matters like the cable-like signal transmission properties of axons, dendrites, and the like, which are not mentioned, are certainly much more important. Indeed, that discussion of animal navigation is far enough in advance of what we know with certainty that I found it possible to disagree with elements of his essay. And while the discussion of the flow-through ion channels, which touches on Edmonds's recent researches, is elegant, I was disturbed that the Goldman-Hodgkin-Katz description was not even mentioned. Even if Edmonds believes that this half-century-old description is simplistic, it is still central to most discussions of channel flow, and any student should know something of it.

In summary, this text seems like two separate books not happily wed. Part I is a rather conventional electrodynamics text that might be considered for US biology students after their standard elementary physics course. While the exposition of the chosen topics, including Maxwell's equations in their integral form, was clearly presented, I am one of those who would prefer to introduce such students to vectors (described only in a mathematical appendix) and to the notation of vector operators (not mentioned anywhere). I argue that students sophisticated enough to appreciate the biological topics in part II should be comfortable at least with the qualitative meanings of the operators *div*, *grad,* and *curl* that they will meet in research papers.

Part II is a brief, 75-page set of six idiosyncratically chosen essays on a few topics of special interest to Edmonds. (Ten of the forty-six references listed in Part II were to Edmonds's papers.) I enjoyed these essays and learned something myself, but I see no place for this section in the education of undergraduate students in American colleges and universities.

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Nuclear Reactor Physics

Weston M. Stacey
Wiley, New York, 2001. $125.00 (707 pp.). ISBN 0-471-39127-1

Being a nuclear reactor physicist is very difficult. It is not merely the social opprobrium connected with the practice of the craft. (I write in California, where mere rumor that a microcurie of reactor-produced technetium is passing through town, a wisp remaining from the diagnosis of some poor soul's ailing heart, is sufficient to bring the environment mujahedeen into the streets for antinuclear jihad.) It is the essence of the subject, as well; a self-respecting reactor physicist should understand everything going on in the reactor core—and be aware of what is happening in its environs, too.

The discipline demands competence in nuclear physics, with emphasis on fission physics and neutron-induced reactions, and an understanding of the interaction of every variety of radiation with matter, from radiation damage to core material to "Is it safe to eat an irradiated strawberry?" Also required is an appreciation of the interaction of thermal neutrons with liquid and solid moderating materials—on so small a scale that the neutron "field" or distribution is described by the mathematics of neutron (and photon) transport theory, a branch of nonequilibrium statistical mechanics. At another level, the reactor is a macroscopic object and its macroscopic behavior is described—overall—by challenging nonlinear equations that describe subtle feedback mechanisms—often complicated by stochastic sources. Finally, since one tries to answer questions as well as possible, the reactor physicist attempts to master the latest and best numerical schemes for solving the complex equations one encounters.

Much of this material is treated in *Nuclear Reactor Physics*, by Weston Stacey. The book is 700 pages long, packed densely with text and equations and rich charts and tables and graphs. It is encyclopedic; the prose is clear, its style is relentless. One finds, along with the expected displays of cross-sections and coordinate systems, figures titled "Predicted frequency of fatality due to accidents from a number of technologies" and "Risk factor for LWR spent fuel without recycle." The book treats—in addition to the conventional material—topics like the R-matrix representation of neutron cross-sections, fuel processing and recycling, transverse integrated nodal integral transport theory models (TINITMo), and what happened at Chernobyl and at Three Mile Island.

The author's command of this diverse material is awesome. But the book has a point of view, an "attitude," which I think of as the MIT tilt: One's efforts should be directed towards the solution of "real" (rather than "academic") problems; one's goal is to build a machine, not to waltz in the complex plane. Hence the strong emphasis on computational methods that one finds throughout the book.

Nuclear Reactor Physics is presented as two textbooks. It is designed so that the first half, some three hundred pages, may be used for an undergraduate or beginning graduate course; the second half, a collection of chapters dealing with special topics, furnishes the material for an advanced course. At $125.00, the price crosses the three-digit barrier—not unusual these days. The book's publisher is John Wiley & Sons Inc, a firm that has been optimistic about the future of nuclear energy for several decades. One might think of *Nuclear Reactor Physics* as the successor to James J. Duderstadt and Louis J. Hamilton's *Nuclear Reactor Analysis*, a Wiley success that celebrated its 25th birthday in 2001.

Indeed, references to Duderstadt and Hamilton are sprinkled throughout Stacey. A comparison shows *Nuclear Reactor Analysis* to be relaxed, chatty, and careful, as one needs to be with beginners. The tradeoff is reduced coverage. (Perhaps its easy style stems from its origin: an early version, a set of illustrated course notes, which was described by some as "the only X-rated book on reactor theory in the Western world.")

Nuclear Reactor Physics treats much, perhaps too much, in its Part I, and its treatment of several academic issues suffers. As examples, the definition of cross-section is surely hurried and a bit puzzling, and the definition of the importance function as a probability cannot be correct. And I cannot imagine an undergraduate breezing through the section on the Rossi technique. Understanding those clever experiments requires an understanding of stochastic processes that is not immediate.

The second half of the book, part II, titled "Advanced Reactor Physics," begins by devoting almost 100 pages to a chapter on neutron transport theory, treated in a nontraditional manner. If this is to be the student's first (and only?) encounter with transport theory, it will be an unusual one. The essay tilts away from mathematical elegance and physical insight toward facility in numerical calculation in "real" situations. Nowhere is there reference to the classic Milne Problem or to the beautiful work of Kenneth Case and Paul Zweifel and their students. It is as though in writing a text one dropped Mozart in favor of an extended treatment of electronic music. The second and third chapters of Part II, dealing with slowing-down theory and resonance absorption, maintain the tone. (Newcomers using the book will not discover Robert Marshak's classic, precomputer, essay on slowing-down theory.) Other chapters in Part II deal with powerful and impressive computational techniques, TINITMo, its diffusion-based cousin, TINDTM, homogenization, nodal and synthesis methods, finite element coarse-mesh methods, and more, all dedicated to determining criticality, power distributions, and other features of both the static and the dynamic reactor. The text concludes with a 12-page section on stochastic kinetics—for the strong.

The fourth chapter of Part II is somewhat special in that it treats neutron thermalization, a subject rich in physics. The discussion is rather similar to that in Duderstadt and Hamilton. True to tone, much of the academic "fun"—the developments of the 1960s—is omitted, and there are a few misstatements about the physics. But it gave me particular pleasure to see graphs displaying "Calculated and Measured Cross-Sections . . ." Measurement and Calculation! Good, old-fashioned physics! For, rarely does one see the results of the elaborate computational schemes described in the other chapters set against good experimental data. Where are the data? Which calculation fits the better, TINITMo, or TINDTM? Why? Indeed, the lack of such comparison suggests that the book be titled "Nuclear Reactor Design" or "Nuclear Reactor Analysis," rather than *Nuclear Reactor Physics*.

I hope that publication of this impressive text, whose strength lies in its breadth and its modernity, will accompany a renewed interest in nuclear power expressed through fission reactors. And may that interest produce a new band of enthusiastic students, comfortable with both physics and applied mathematics, who will enjoy studying, designing, and perfecting these elegant machines!

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Low Temperature Electronics: Physics, Devices, Circuits, and Applications

Edmundo A. Gutiérrez-D., M. Jamal Deen, and Cor L. Claeys
Academic Press, San Diego, Calif., 2001, $299.00 (964 pp.).
ISBN 0-12-310675-3

The subject of *Low Temperature Electronics* by Edmundo A. Gutiérrez-D., M. Jamal Deen, and Cor L. Claeys is often referred to as "cold electronics" or "cryoelectronics." It has to do with the behavior at cryogenic temperatures of electronic and superconducting devices (from DC to microwaves), optoelectronic devices (including solid-state lasers), and circuits incorporating those devices. Although many journal articles and conferences have dealt with the field, the majority in the past 20 years, it has been 15 years since the appearance of the most recent book (*Cryoelectronics*, R. K. Kirschman, ed. IEEE Press, 1986), itself a collection of published papers.

Gutiérrez-D., Deen, and Claeys, assisted by six of their colleagues, have assembled in one comprehensive volume an array of the best material from the intervening years. They include an annotated bibliography of close to 2000 references, an astonishing number for any book.

Three broad cryogenic temperature regimes are covered in the book: from room temperature down to 77 K—the liquid nitrogen region, where commercial applications of cold electronics flourish; between 77 K and the liquid helium range, 4.2 K, where there are fewer applications—but these applications may be added to as cryocoolers are improved; and from 4.2 K down to the millikelvin range, where, for example, dilution refrigerators are used to cool bolometers and other devices. These lowest temperatures are most often involved in research.

Often the most effective way to sense the breadth of a book's coverage is to scan the chapter titles. I think that is the case here, at least for the first seven chapters: Physics of Silicon at Cryogenic Temperatures; Silicon Devices and Circuits; Reliability Aspects of Cryogenic Silicon Technologies; Radiation Effects and Low-Frequency Noise in Silicon Technologies; Heterostructure and Compound Semiconductor Devices; Compound Heterostructure Semiconductor Lasers and Photodiodes; and High-Temperature Superconductor/Semiconductor Hybrid Microwave Devices and Circuits.

The bibliography and associated discussions extending back to the 1970s, uncover an interesting history, one that is especially memorable to those of us who worked in the field through those early days. We can recall the efforts of the researchers who discovered that the performance of silicon and then gallium arsenide bipolar transistors was unsatisfactory at low temperatures. The authors discuss the reason that was so, and the reason that the technology improved so markedly