BOOK REVIEW

Selection of books for review is based on the editor's opinions regarding possible reader interest and on the availability of the book to the editor. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

Fundamentals of Nuclear Science and Engineering

Author J. Kenneth Shultis and Richard E. Faw

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Fundamentals of Nuclear Science and Engineering, by J. Kenneth Shultis and Richard E. Faw, is a text that aims at initiating undergraduate students into the field of nuclear engineering. It can also be used as an introductory text for graduate students in fields such as health physics and medical physics who do not have an appropriate background in nuclear physics concepts. The text was first published in 2002. The second edition of this text appeared in 2007.

Chapters 1 through 7 cover the fundamental concepts of modern and nuclear physics, radioactive decay, nuclear reactions, radiation interactions, and radiation detection. This group of chapters is well suited for a one-semester course at the sophomore level. Students who had three semesters of college-level calculus and two semesters of college-level physics will be sufficiently prepared for this course. In general, the material in these chapters is self-contained. The discussion of modern physics concepts (Chapter 2) represents a good summary of the subject. However, for students who are being introduced to such concepts (e.g., special relativity, wave-particle duality, etc.) for the first time, care must be taken by potential instructors to elaborate as deemed necessary to provide the appropriate coverage. Furthermore, if it is anticipated that this text can be used in a course that may replace a traditional class in modern physics, then coverage should be expanded to include the basics of wave mechanics and the Schrödinger equation, elements of which appear in brief sections within Chapter 2.

Chapters 3 and 4 provide a survey of some of the basics of nuclear physics and related conservation concepts that are needed to analyze nuclear reactions. A progression of the understanding of nuclear models is presented. The concept of the Q value of nuclear reactions is introduced. In addition, these chapters give a good presentation of the ideas of nuclear stability and can be used by the instructor as a logical starting point to initiate the discussion on radioactivity and radioactive decay.

The subject of radioactive decay (Chapter 5) is covered in a sufficiently detailed fashion. For this material, the instructor can, in general, follow the text. Various types of nuclear decay are presented and analyzed using fundamental conservation principles. The discussion is initiated with the concept of material balance, which will continue to appear as the students ascend in their studies. The various scenarios for the evolution of decay chains are presented and discussed. The text presents key results and equations, while the instructor is expected to fill the gaps and provide the appropriate derivations as needed.

Binary nuclear reactions are discussed in Chapter 6. In addition, this chapter includes a discussion of nuclear fission. This chapter is presented using the laboratory frame of reference with peripheral mention of coordinate transformations and the center-of-mass reference frame. Nevertheless, this seems to work reasonably well for undergraduate students at this level, especially if the instructor derives in detail the main relationships that appear in the text and provides a careful interpretation of the results.

The interaction of radiation with matter is presented in Chapter 7. The discussion in this chapter introduces the fundamental concept of exponential attenuation. In addition, important concepts such as the particle flux, the interaction cross section, and the reaction rate are presented in this chapter. For X-ray and gamma-ray interactions, the three dominant interaction modes (photoelectric, Compton, and pair production) are discussed. A survey of neutron and charged particle interactions is presented. However, it will be up to the instructor to augment the text's material with the needed discussion that would facilitate the acceptance of the main conclusions by the students.

Chapter 8 represents a good introduction to the subject of radiation detection and the related concepts. It presents the various classes of radiation detectors and discusses their operation and applications. It also discusses ideas relevant to the statistical analysis of radiation measurements. Coverage of this chapter is more meaningful if the course includes laboratory exercises that are designed to demonstrate the concepts discussed in earlier chapters.

Chapter 9 presents the topic of radiation protection and dosimetry. Chapter 10 is an introduction to nuclear reactor theory. These chapters initiate the extension of the text into the application areas. In Chapter 9, the basic ideas necessary to medical and health applications are presented. In Chapter 10, a presentation is made of the basic neutronics and kinetics relevant to nuclear reactor design and operation. If the instructor chooses, either (or both) of these chapters can be a good substitute to Chapter 8 in the one-semester course scenario.

The remainder of the text (i.e., Chapters 11 through 14) presents a survey of potential application areas (nuclear power, and industrial and medical applications) that are based on the concepts discussed in previous chapters. These chapters allow the instructor to extend the course beyond the fundamentals and into practical applications. For example, an undergraduate course designed to focus on nuclear power can cover the basic set of chapters (Chapters 1 through 7) and then include Chapters 10 and 11. A course designed for students in a medical field can substitute Chapters 9 and 14.

In general, I have found this text very useful and easy to read. Each chapter ends with a set of problems that are appropriate for homework assignments. A solutions manual is provided for these problems. The text is well capable of motivating the students of nuclear science and engineering to think beyond the confines of the classroom. This is especially true if the instructor aids the students by highlighting the important material and providing the needed insights and interpretations that would allow the formation of a coherent picture.

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