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The Physics of Radiotherapy X-rays and Electrons, 3rd Ed. Peter Metcalfe, Tomas Kron, Peter Hoban, Dean Cutajar, and Nicholas Hardcastle. Madison, WI: Medical Physics Publishing, 2023. ISBN: 9781951134105

Reviewed by Jacob Van Dyk

Introduction

When I was asked if I would do this book review, it struck a pang of fear into my heart. It brought back memories of my first book review. It was 1980, and I was preparing for the Canadian College of Physicists in Medicine Fellowship exams. The examiners included Professors Harold Johns and Jack Cunningham of the Princess Margaret Hospital in Toronto. By that time, they had been my superiors for over eight years, and they were also the authors of *The Physics of Radiology*, the classic Medical Physics textbook that every medical physicist "grew up" with in those days. With that exam, my bosses would be able to discover all the shortcomings in my knowledge of medical physics. At that time, they were working on the fourth edition of the Physics of Radiology[1]. Seeing that there were likely to be questions based on the latest advances in medical physics, I asked if I could review their draft text in preparation for the exams. It took me several months of evenings to go through the entire text as well as answer the questions at the end of each chapter. I passed the exams, and I am pleased to be listed in their acknowledgments. I mention this as an introduction since *The Physics of Radiotherapy X-rays and Electrons* by Metcalfe et al serves a similar purpose in that it is a great resource for the early career medical physicist, especially those who are preparing for certification exams, specifically for the radiation oncology medical physicist. The following are my observations, although not based on several months of evenings of review.

Description

The first edition of *The Physics of Radiotherapy X-rays and Electrons* was published in 1997, the second edition in 2007, and this third edition in 2023 - 16 years after the second edition! While the fundamental radiotherapy physics concepts have not changed, clearly, much has changed in the practical and clinical applications of radiotherapy physics in these intervening years, especially as related to the rapidly evolving radiation-related technologies. This edition provides the much-needed update to connect medical physics concepts to the latest technologies.

Purpose

To quote from the preface of the third edition, “The book is designed primarily as a useful reference for radiation oncology physicists, whether in training or established in their careers. The material is also intended to be accessible to radiation oncologists, dosimetrists, and radiation therapists who wish to gain a deeper understanding of the physical principles behind the technology they interact with daily.” This book has successfully accomplished these goals.

Audience

Clearly, this book is for the graduate student or resident who is aspiring to work in the field of radiation oncology medical physics, as well as those practicing medical physicists preparing for their certification exams, like my experience described in the introduction. Furthermore, the medical physicist practicing in the clinic can use this book as a reference guide to help understand the most recent developments and applications in radiation oncology technologies. The authors are well-experienced, well-renowned, and well-respected medical physicists, four of whom live and work in Australia and one in the United Kingdom.

Content and Features

The Physics of Radiotherapy X-rays and Electrons provides a comprehensive treatise on the physical aspects of radiation beams in addition to providing practical applications in the use of these beams to treat cancer patients. When I think of the "physics" of photon and electron beams, I think of how these beams interact with matter. In reality, the book covers much more than the "physics" of radiotherapy. To summarize the contents, it begins by describing the technologies that are used to generate photons and electrons and then looks at how these radiation components interact with matter. From there it moves on to imaging and radiotherapy treatment planning considerations. This is followed by more specific treatment technology aspects including patient-related techniques like patient motion management, adaptive radiation therapy, and stereotactic radiosurgery. Then on to the physics of beam calculation models as used by computerized treatment planning systems, which is followed by the practical determination of radiation dose using radiation measurement detectors. Of course, as part of any program involving patient treatments, comprehensive quality assurance is addressed along with radiation protection concerns. The final chapter goes well beyond "physics" and provides an in-depth description of biological response both for tumors and normal tissues as a result of the interaction of photons and electrons in the patient. All these topics are covered at a depth appropriate for up-and-coming medical physicists as well as those in practice seeking to update their knowledge level to address the most recent technologies.

It is interesting to note how the contents of the book have evolved in the 26 years since the first edition was published. Table 1 provides a summary of the table of contents of each of the three editions, clearly indicating the progress in the field of radiation oncology medical physics. Technically, the book has gone from figures being in black and white in the first edition, to color figure inserts bound in the middle of the book for the second edition, to full color figures throughout the book in the third edition. The book is filled with ample helpful figures to explain concepts. Furthermore, as an aid to the learning process, each chapter ends with five questions, the answers to which are

described in detail in an appendix at the end of the book. In addition, some of the chapters provide worked examples of concepts. These examples are presented in yellow highlighted boxes. Clearly, the book has a focus on the student, the resident, the young medical physicist, as well as those who use this book for teaching purposes. The research radiation oncology medical physicist will be impressed and guided by the ample useful references provided in each chapter. Furthermore, the book has gone from softcover to hardcover, making it more amenable as a durable reference textbook.

Table 1. Comparison of the tables of content of the three editions of the Physics of Radiotherapy X-rays and Electrons.

Chapter Number	1st Edition (1997)		2nd Edition (2007)		3rd Edition (2023)	
	Title	# Pages	Title	# Pages	Title	# Pages
1	Medical Linear Accelerators	38	Medical Linear Accelerators	54	Medical Linear Accelerators	40
2	Interaction Properties of X-rays and Electrons	52	Interaction Properties of X-rays and Electrons	54	Interaction Properties of X-rays and Electrons	52
3	Dosimetry of Therapeutic X-rays	138	Dosimetry of Megavoltage X-rays and Electrons	142	X-ray Beam Properties	48
4	Linear Accelerator Beam Properties	64	X-ray Beam Properties	68	Linear Accelerator Electron Beam Properties	54
5	Radiotherapy Treatment Planning	72	Linear Accelerator Electron Beam Properties	58	Imaging for Radiotherapy Treatment Planning	34
6	Photon Beam Modeling and Inhomogeneity Corrections	30	Radiotherapy Treatment Planning: X-rays	62	Radiotherapy Treatment Planning: X-rays	44
7	Monte Carlo and Convolution Methods	40	Special Procedures: Stereotactic Radiotherapy and IMRT	72	Image-guided Radiation Therapy and Motion Management	32
8	Tumor and Normal Tissue Response	43	Calibration of Megavoltage	62	Adaptive Radiation Therapy (ART)	20

			Photon and Electron Beams			
9			Beam Models: Part I	46	Stereotactic Radiosurgery	50
10			Beam Models: Part II	54	Beam Models	58
11			Quality Assurance in Radiotherapy	54	Dosimetry of Megavoltage X-rays and Electrons	108
12			Patient Immobilization and Image Guidance	38	Quality Assurance in Treatment Delivery	20
13			Radiation Protection and Room Shielding	32	Radiation Protection	32
14			Tumor and Normal Tissue Response	54	Tumor and Normal Tissue Response	56
	Total Number of pages in book	493		905		683

The book goes well beyond what is offered by its title, *The Physics of Radiotherapy X-rays and Electrons*. For example, the chapter addressing radiation interactions includes a section on *Protons*; the chapter on *Linear Accelerator Electron Beam Properties* includes a section entitled *A Few Comments on Protons*; the chapter on *Beam Models* contains a section on *Brachytherapy Dose Calculations* and the final chapter addresses clinical radiobiological matters in significant depth. This is not a criticism; it is a manifestation that the book delivers more than the title promises.

Assessment and Comparison

In summary, this book is a very useful learning tool for young medical physicists entering the field of radiotherapy physics, especially those who are in graduate or residency programs, or those individuals preparing for their board certification exams. It is not the basic radiation physics text for undergraduate or graduate students, which includes things like radioactive decay, diagnostic radiology, and nuclear medicine. These can be found in books like the latest update of the Johns and Cunningham *The Physics of Radiology*[2]*,* the older version of which I described above, or the Podgorsak book *Radiation Physics for Medical Physicists*[3], which is primarily for graduate students.

The book with a closely aligned title by McDermott and Orton *The Physics & Technology of Radiation Therapy*[4] is largely geared at the medical radiation oncology resident. My own four volumes on *The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists*[5] deal more with the latest developments, trends and issues of modern interest related to the radiation oncology medical physicist and radiation oncologist but assume a certain amount of background knowledge such as that provided by *The Physics of Radiotherapy X-rays and Electrons.* Thus, the Metcalfe *et al.* book provides the fundamental physics and practical concepts associated with the vast majority of technologies used in a modern radiation therapy department at a level that should be understood by a medical radiation therapy physicist. Kudos to the authors for producing a very significant and practical tome for the modern medical physicist specializing in radiation therapy.

Book Reviewer Biography:

Jacob (Jake) Van Dyk is Professor Emeritus in the Departments of Oncology and Medical Biophysics at Western University, London, Ontario, Canada. He has more than 40 years of radiation oncology medical physics experience in Toronto (1971-1995) and London (1995-2009). He served as a consultant at the IAEA in Vienna (2009-2011) and is the main founder of Medical Physics for World Benefit (www.mpwb.org) (2015), an organization devoted to supporting medical physicists globally. He is the editor of four volumes of "The Modern Technology of Radiation Oncology" (1999-2020), and "True Tales of Medical Physics" (2022), a book for a broader audience to describe what medical physicists do.

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