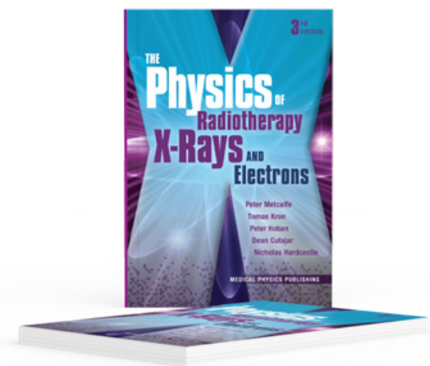
BOOK REVIEW

Book Review: "The Physics of Radiotherapy X-rays and Electrons"

The Physics of Radiotherapy X-rays and Electrons by Peter Metcalfe, Tomas Kron, Peter Hoban, Dean Cutajar and Nicholas Hardcastle, Third Edition, Medical Physics Publishing (2023), 704 pages. Hardcover: ISBN 978-1-951134-10-5, eBook: ISBN 978-1-951134-11-2, price: US$ 185.



Written by Peter Metcalfe, Tomas Kron, Peter Hoban, Dean Cutajar, and Nicholas Hardcastle, the book "The Physics of Radiotherapy X-rays and Electrons" is presented as a classic reference for students, established physicists, as well as dosimetrists or radio-oncologists in radiation therapy. Since March 2023, a third edition of the book, supported by two additional authors, has been available and includes full-colour illustrations and images as well as revised chapters reflecting recent developments in radiation therapy.

Structurally, the book is divided into 14 chapters. Each chapter begins with a brief introduction to the topic, followed by a list of relevant references and a handful of questions. The solutions to these questions are found in the Appendix and can be used to test the comprehension of the learning material. The sections are well-written and easy to follow, containing both practical examples as well as more foundational theoretical passages. The texts are further enhanced through descriptive graphics, images, formulas, and references, significantly improving comprehensibility. For further reading, the references contain both scientific publications and books.

"The Physics of Radiotherapy X-rays and Electrons" introduces the medical linear accelerator in its first chapter as the most frequently used and important radiation treatment machine. The operating principles and components are described and explained, including the modulator, magnetron, waveguide, wedges, and multileaf collimators. As parts of modern machines, image-guiding devices, i.e., onboard kV imaging, CBCT, and portal imaging devices, are also covered. The chapter concludes with innovative treatment devices currently available on the market, such as the Ethos, Unity (MR linac), and CyberKnife.

Over the next three chapters (nos. 2-4), the physics of X-rays and electron beams are covered, as well as their interactions with matter. Important quantities like the absorption coefficient, absorbed dose, and kerma, as well as processes such as mass-energy transfer and photon/electron interactions, are all explained alongside their corresponding formulas. By means of water phantom measurements, the characteristics of X-ray beams, e.g., depth dose curves and penumbra, are clearly explained, as are their dependencies on different factors such as multileaf collimators or wedges. Even an overview of kilovoltage X-ray therapy is given. It has to be highlighted that the clinical implementation and applications are described in detail, especially those of total skin irradiation. Beyond the stated scope of the book, chapter 4 also briefly addresses the basics of proton beam therapy, its challenges, and its opportunities.

Chapter 5 covers multimodal imaging procedures, especially CT imaging used in radiation therapy. Included in these chapters is the necessary background for understanding x-ray CT machines, machine calibration, spectral, and single- as well as dual-energy CT techniques. Furthermore, typical 4D-CT entities are discussed and illustrated with examples. Even if the focus is not on explaining the theoretical background of MRI acquisition, a good overview of the MRI sequences frequently used in radiotherapy can be found in Chapter 5. Unfortunately, there is little information given about recent research in synthetic CT generation on the basis of MRI scans. The typical nuclear medicine scans used in radiotherapy, PET and SPECT, are also briefly reviewed. Importantly, while the fundamentals of registration and fusion of multimodal imaging are covered, the pitfalls of rigid and deformable registrations are missing.

With the fundamentals required for treatment planning introduced, a closer look at different radiation techniques can be found in Chapter 6. An overview of 3D-CRT, IMRT, and VMAT, as well as recommendations for treatment planning quality assurance, are given. However, the dosimetric properties of MLCs are only covered superficially, and although the book is titled "The Physics of Radiotherapy X-rays and Electrons," planning with electrons has been omitted entirely.

Chapter 7, “Image-guided radiation therapy and motion management,” contains several topics, e.g., target definition, patient immobilisation, and different, up-to-date approaches to image- and surface-guidance and motion management. Some of these, like the target definition, might, however, have been better structured as part of Chapter 6.

Chapters 8 and 9 delve into more specialised radiation therapy applications like adaptive and stereotactic radiotherapy. The authors cover the most important aspects and approaches in adaptive radiotherapy and outline the current capabilities of X-ray- and MR-guided devices. Stereotactic treatment approaches are described in detail, including specially developed devices for these treatments – the Gamma Knife and CyberKnife. Additionally, the differences between head frame-based and frame-less treatments, as well as cone-based and MLC-based radiation delivery, are presented. However, the stereotactic body radiotherapy section does not contain any images or graphics to help with understanding the topic.

Chapter 10 deals with the different irradiation models and dose calculation algorithms. Special emphasis is placed on Monte Carlo calculations and the clinical impact of different dose calculation algorithms is discussed. For the first time in the book, brachytherapy is mentioned in the dose calculation segment. However, the core concept of brachytherapy is not discussed in depth in the book. Additionally, it is worth considering if this chapter would not have been better placed as an introduction to radiation planning before Chapter 6.

Chapters 11 and 12 focus on dosimetry and quality assurance. A good overview is given of phantoms important in dosimetry, e.g., water- and anthropomorphic phantoms, as well as of various dosimetric instruments. Included among these instruments are diamonds, films, and TLDs. Background and definitions are not lacking; however, the referred literature should still be perused to deepen the theoretical understanding. In terms of QA, a general roadmap of quality management, assurance, and control is drawn. Due to the authors' national background, references refer to the American guidelines and protocols (from AAPM), which may not be transferred to the regulations in European countries.

In the final chapters, 13 and 14, radiation protection and radiation biology are addressed. Fundamental concepts are presented with the help of graphs and formulas. Of note, the models of tumour and normal tissue response are described in a particularly enlightening manner. The book finally concludes with a brief exploration of the emerging field of flash therapy.

The exercises consist of a mix of comprehension questions and calculations. The corresponding solutions are thorough and supported by pertinent calculations or graphics. However, a larger collection of exercises could enhance this textbook even further.

In summary, “The Physics of Radiotherapy X-rays and Electrons” is an excellent book that can serve as an educational or reference book for both students and professionals in the medical physics of radiotherapy. Surprisingly, more topics than those implied by the book's title are covered, even if a few topics one might expect are missing. In general, the book can be considered a success: the balance of key concepts, illustrations, and theoretical formulas, as well as practical exercises, make it an instructive resource for anyone seeking a basic understanding of this dynamic field.

Dr. Maya Shariff, Department of Radiation Oncology, Universitätsklinikum Erlangen, Germany. Maya Shariff's journey in medical physics began at the University Hospital of Tübingen in 2015. In 2017, she joined the University Hospital of Erlangen as a Medical Physicist Expert and earned her PhD in 2023. Since 2019, she has been chair of the Young Medical Physicists of the DGMP and a co-opted DGMP board member. Her responsibilities within DGMP encompass event certification, expert qualification applications, and oversight of the DGMP Academy. From 2023 onward, she held the positions of postdoctoral fellow and certified Medical Physicist at the University Hospital Erlangen. Maya Shariff's contributions continue to advance the field of medical physics.

Sarah Stefanowicz, M.Sc., Department of Radiation Oncology, Klinikum rechts der Isar of the Technical University of Munich, Germany. She has been working in the field of medical physics in Germany and abroad for more than ten years. She obtained her certification as an MPE for photon and proton beam therapy (in 2015 and 2020) and has been employed as a medical physicist at the Klinikum rechts der Isar of the Technical University of Munich since 2020. Her professional focus is radiosurgery/stereotactic treatment with the Gamma Knife. She is in the process of completing her PhD thesis on proton beam therapy at the OncoRay Center in Dresden, Germany. Sarah is an active member of both the DGMP and the German Society of Radiation Oncology (DEGRO) and is engaged in various working groups. In 2016, she co-founded the young section of the German Society of Medical Physics (DGMP) and was its spokesperson from 2017-2019. Sarah is looking forward to meeting the EFOMP community at the ECMP in Munich in 2024.