# FUNDMENTAL MATHEMATICS AND PHYSICS OF MEDICAL IMAGING A BRIEF OVERVIEW

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*Abstract*— **This article reviews Fundamental Mathematics and Physics of Medical Imaging by Jack Lancaster and Bruce Hasegawa.**

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**Fundamental Mathematics and Physics of Medical Imaging (Series in Medical Physics and Biomedical Engineering). CRC Press; Taylor & Francis Group, Boca Raton, FL, 2017. 346 pp. Price: $79.96. ISBN: 978-1-4987-5161-2 (hardcover).**

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## I. Introduction

*Fundamental Mathematics and Physics of Medical Imaging* is a comprehensive outline of the underlying mathematics and physics concepts of radiologic imaging. The textbook provides a structured overview of the mechanisms of image formation and image quality and characterization, in 5 sections and 16 chapters. The book is a thorough re-write based off of the second and last edition of *The Physics of Medical X-Ray Imaging* which was penned by the late Bruce Hasegawa and printed in 1991 by Medical Physics Publishing. It provides engineers and medical physicists in-training with a review of some of the more detailed concepts in medical imaging to help deepen the reader's knowledge and understanding of topics such as contrast, spatial and temporal resolution, and noise. The book serves as a timely addition to the CRC Press *Series in Medical Physics and Biomedical Engineering*, all of whose editors and contributors are accomplished physicists and experts in their respective fields.

## II. Audience

The This book is based on an advanced diagnostic imaging course that has been taught by the author at The Research Imaging Institute at The University of Texas Health Science Center in San Antonio for over 20 years. The course *'Physics of Diagnostic Imaging II'* is aimed at second year graduate students of diagnostic imaging and focuses on the theory and applications of various forms of electronic imaging systems and their analysis, image processing, and display.

While written with medical physics students and residents specifically in mind, this volume can also prove equally beneficial to researchers and clinicians in the imaging sciences who wish to integrate their work or research program into the field as is currently practiced. A basic understanding of physical concepts in imaging such as Bremsstrahlung or photoelectric and Compton interactions is assumed, as are the units, measurement, and principles of radiation protection and nuclear medicine imaging. Although the minimal coverage of background concepts limits the utility of the book to advanced undergraduate or beginning graduate students of medical physics at first glance, the stratifying of the topics into beginner, intermediate, and advanced level sections will enable many readers without the prerequisite training in basic imaging physics to be able to engage and comprehend its material well.

## III. Content and features

The book begins by painting a broad view of basic imaging principles revolving around three central notions namely noise, contrast, and resolution. These are the pillars which the author then spends the subsequent chapters elucidating in detail how each is tied to performance measures such as Wiener Spectra, Signal-to-Noise ratio, Modulation Transfer Functions, and receiver operating characteristic (ROC) analysis. Topics pivotal to the digital era such as sampling requirements and detector technology are interspersed throughout the book.

The text then iterates these three concepts at a more detailed level using Fourier, Bessel, and Hankel transforms, convolution, and various spread functions and probability distributions. Homework problems and more specialized appendices appear at the end of each chapter with online answers. The Rose Model and derivation of Contrast-Detail curves are covered sufficiently well. Many of the problems in the book make use of a java based software package called *Mango*, free for download, which was developed by the author himself, and which provides analysis tools and a user interface to navigate image volumes. The software program comes with several plugins primarily applied to neuroimaging. [1]

The text then covers digital subtraction angiography (DSA) and temporal filtering in separate treatments using the three main concepts discussed in previous chapters, before delving into the final section of the book which examines CT, SPECT, and MRI independently.

## IV. Assessment and comparison

This is a welcome text that many students and researchers should find useful as a follow-up to an upper level introductory physics or engineering course in medical imaging. It is detailed yet concise in its format, and has a lucid but efficient style to its writing. While the utility and clarity imparted therein is never in question, some of the figure diagrams, particularly those from the previous edition can use an upgrade in their presentation.

In short, this book is an indispensable reference for anyone who wishes to specialize in medical imaging physics beyond introductory levels or who intends to enter the field to gain a better understanding of the inner workings of contemporary imaging systems. No doubt, there is considerable need for a resource that is designed to provide additional perspective given the excelling and ongoing advancement of imaging physics in clinical settings.

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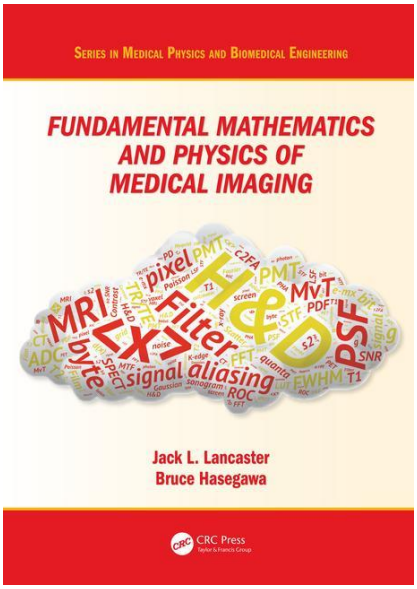


**Fig. 1 Fundamental Mathematics and Physics of Medical Imaging**

## V. Conclusions

The purpose of this book principally is to provide the readers with a more thorough exposition of the mathematical foundations required for the formation of diagnostic images. The textbook will serve as a solid reference for biomedical engineering and medical physics trainees by going beyond the mere description of all ionizing radiation modalities, including MRI and nuclear medicine. The book aims to cover a range of material that is either not available in more introductory books on general medical imaging or is not emphasized well enough in scope or sufficient level of detail.

## References

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