

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

5,800

Open access books available

142,000

International authors and editors

180M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Chapter

Electromagnetic and Acoustic Waves in Bioengineering Applications

Ivo Čáp, Klára Čápková, Milan Smetana and Štefan Borik

Abstract

The textbook deals with the analysis of oscillations, mechanical and electromagnetic waves and their use in medicine. The individual chapters are based on the theoretical foundations of the issue and describe the use of relevant disciplines in medical practice. The chapter on oscillations is a starting point for explaining the basic principles of waves and focuses on explaining the nature of magnetic resonance. The chapter on mechanical waves explains the nature and properties of sound, infrasound, ultrasound, and medical applications, such as lithotripsy or ultrasonography. The chapter on electromagnetic waves discusses their basic principles, origin and properties, and applications of individual frequency bands from long wavelengths to gamma radiation in therapy and diagnostics. The chapter on wave manifestations explains phenomena such as interference and diffraction and their use in applications such as optical imaging systems, holography, virtual reality, etc. The description complements the explanation of the quantum properties of radiation, which are essential for understanding applications such as laser scalpel, fluorescence microscopy, spectroscopy, generation and detection of X-rays and gamma rays. Special attention is paid to the perception of EM waves by the human eye and the perception of sound by the human ear.

Keywords: oscillations, resonance, attenuation, waves, acoustic waves, sound, ultrasound, ultrasonography, lithotripsy, MRI, magnetic resonance, hearing apparatus, audiometry, auscultation, piezoelectric transducers, electromagnetic waves, radiofrequency, microwaves, infrared radiation, visible light, ultraviolet radiation, X-radiation, gamma radiation, quantum properties, radiodiagnostics, ionizing radiation, therapy by radiation, optical methods, photoplethysmography, photometry, colorimetry, human eye, microscopy, endoscopy, fibroskopy, laparoscopy, interference, diffraction, refraction, standing waves, wave resonance, waves transmission, energy of waves, photo-acoustic imaging, waves generators, waves sensors, wave detectors

1. Foreword

In nature, various events take place all the time. From a human point of view, these events can be divided into internal (intracorporeal) and external (extracorporeal). The human organism, as well as its components, is in interaction with its

surroundings. This interaction, on the one hand, affects the state of the organism, on the other hand, reveals everything about the state of the organism. This is the basis of different methods of treatment (therapy), such as targeted action on the body to eliminate the disease, and methods of examination (diagnosis), in which the doctor seeks to detect the disease and its causes.

In addition to the mechanical, thermal, electrical, and magnetic forms of interaction used in diagnostics and therapy, the richest interaction channel are waves - mechanical (sound, infrasound, ultrasound) and electromagnetic (radio waves, microwaves, visible light, infrared, ultraviolet, X-ray, radioactive gamma radiation). Radiation of various kinds is used in medical diagnostics and therapy. Today, highly sophisticated devices such as USG (Ultrasonography), CT (Computed Tomography), MRI (Magnetic Resonance Imaging), PET (Positron Emission Tomography), SPECT (Single Photon Emission Tomography), and many others are used. For a correct and thorough understanding of the principles of such devices, it is necessary to know the properties of mentioned types of waves as well as the methods of their generation and detection.

To understand the laws of generation, propagation, and detection of waves, we first get acquainted with oscillations that are the source of waves. The oscillations take place in one place, while the waves represent the propagation of oscillations into the surrounding space in a given transmission medium. The first part of this textbook, therefore, focuses on an analysis of oscillations. It is followed by an analysis of the waves themselves. We will describe especially mechanical waves in the material substances, and electromagnetic waves, which can also propagate in a vacuum. The wave behavior of waves is followed by a simple explanation of their quantum character, which is important for understanding phenomena such as ionization, spectroscopy, generation of laser radiation, and the like.

The authors of this textbook aim to explain the theoretical fundamentals of phenomena that apply in medical diagnostics and therapy, and which are important for explaining the function of sophisticated devices of medical radiology and nuclear medicine. To master the problems of this textbook, knowledge acquired in the subjects of mathematics, physics, electrical circuits, and electromagnetic phenomena is supposed. The introductory chapters only briefly summarize this basic knowledge without a deeper detailed explanation. For more information on some special topics we recommend, e.g., Bronzino [1], Bronzino [2], Čápková [3], Hall [4], Rubin [5], Street [6], Webb [7], Wise [8].

The textbook is intended mainly for university students in the field of biomedical engineering, but it will also serve others interested in a closer look at the technical means used by modern medicine.

IntechOpen


IntechOpen

Author details

Ivo Čáp*, Klára Čápková, Milan Smetana and Štefan Borik
Faculty of Electrical Engineering and Information Technology, University of Žilina,
Slovakia

*Address all correspondence to: ivo.cap@fel.uniza.sk

IntechOpen

© 2021 The Author(s). Licensee IntechOpen. Distributed under the terms of the Creative Commons Attribution - NonCommercial 4.0 License (<https://creativecommons.org/licenses/by-nc/4.0/>), which permits use, distribution and reproduction for non-commercial purposes, provided the original is properly cited. 

References

[1] Bronzino JD. The Biomedical Engineering Handbook – Medical Devices and Systems. Boca Raton: CRC Press; 2006

[2] Bronzino JD. The Biomedical Engineering Handbook – Biomedical Engineering Fundamentals. Boca Raton: CRC Press; 2006

[3] Čápková K, Čáp I. Sensors in Biomedical Engineering. Žilina: EDIS Press, University of Žilina; 2008

[4] Hall J. Textbook of Medical Physiology. Amsterdam: Elsevier Inc.; 2011

[5] Rubin A. Fundamentals of Biophysics. New Jersey: Wiley-Blackwell; 2014

[6] Street LJ. Introduction to Biomedical Engineering Technology. Boca Raton: CRC Press; 2016

[7] Webb AG. Introduction to Biomedical Imaging. New Jersey: John Wiley & Sons; 2017

[8] Wise DL. Bioinstrumentation and Biosensors. Boca Raton: CRC Press; 1991