Foreword

In 2009, the University of Pavia launched the first Italian medical course taught in English, with the aim of creating an international school that would attract students from abroad as well as from Italy. We had the honor and the pleasure of teaching Medical Physics to the students of this course in the years between 2009 and 2014 (Prof. D. Scannicchio), and after 2015 (Prof. A. Bacchetta).

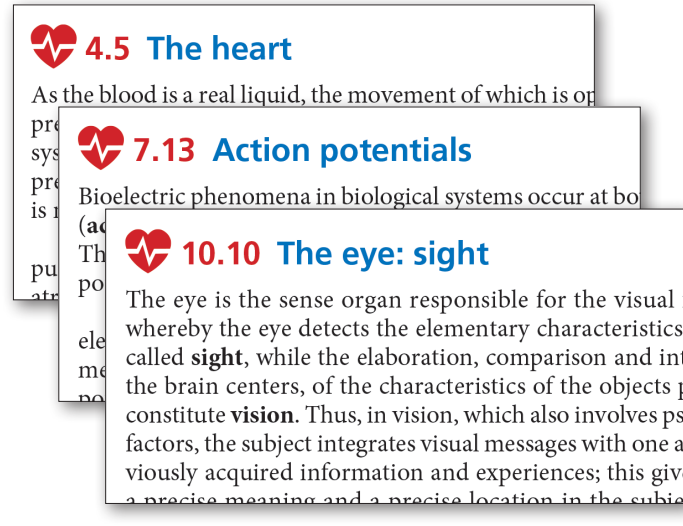
Many other international courses have been set up in Italy and in other European countries in recent years. However, we have noticed that there is a lack of suitable textbooks, i.e., texts that cover the topics usually dealt with in European courses with the appropriate level of sophistication. There are excellent textbooks in Italian, but they do not fit our context. There are also excellent textbooks in English, but they cover different topics and have a different approach (most of them are entirely algebra-based). So we decided to write our own book, taking advantage of the long-established teaching methods developed at our university, which was founded in 1361 and has one of the most prestigious medical faculties in Italy.

Writing this book in a language that is not our own has been a challenge. We apologize if our style does not sound very natural and elegant to English-speaking readers. However, our limitations have led us to focus more on content than on style. For this reason, we hope that the book will be a simple and concise resource for students who use English as a second language.

Similarly, we are physicists, not doctors. We are aware that our knowledge may be incomplete or outdated when discussing medically oriented concepts and applications. However, the aim of the book is not to be exhaustive and flawless, but rather to convey the idea that the concepts of Physics are essential in Medicine and that the hard science approach, whenever applicable, is the best means we have to solve problems, even in Medicine.

We have organized the book with the following goals in mind:

- to show how Physics can be used to explain some phenomena that occur in the human body, from the microscopic to the macroscopic level;
- to describe the physical principles that underlie modern medical instrumentation for diagnostic and therapeutic purposes;
- to provide a useful reference for students of other biomedical courses.

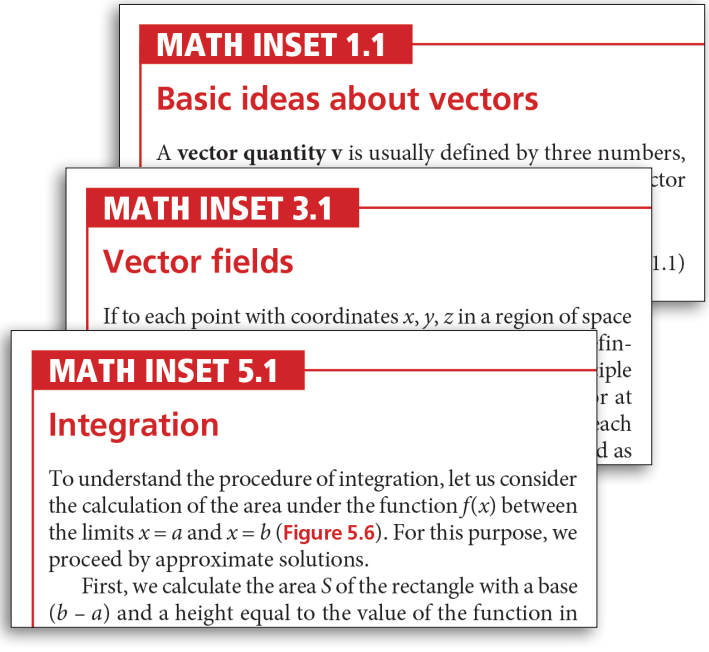


In each chapter, the sections devoted to biomedical applications are indicated by a heart-shaped icon; more than a third of the sections in the book are of this type.

As can be seen from the Table of Contents, we start with mechanics (Chapter 1) and its applications

to the muscular and skeletal systems (Chapter 2). We devote Chapter 3 and 4 to fluid dynamics, as applied to the cardiovascular system. We then discuss gases and thermodynamics in relation to the respiratory system, human physiology and thermoregulation (Chapter 5). Chapter 6 is devoted to an analysis of the phenomenon of diffusion, in particular through membranes; although this topic is not usually included in introductory Physics courses, it is of great importance to Medicine. In Chapter 7, we review electrical phenomena and emphasize their role in cellular activity. Chapter 8 deals with the physics of wave phenomena, from sound waves to the perception of sound. Chapter 9 briefly reviews the concepts of magnetism that give rise to electromagnetic waves, which are now widely utilized in medical diagnostics and therapy. Chapter 10 considers the specific example of visible electromagnetic waves, i.e., light, and discusses optics and vision. Chapter 11 describes the structure of atoms and nuclei, in order to explain the nature of radiations, which are commonly exploited in diagnostic and therapeutic applications, and their interaction with biological systems. The last chapter (Chapter 12) deals with some important examples of biomedical instruments and recalls some of the notions discussed in the previous chapters.

As mathematics is the language of Physics, the book displays a certain level of mathematical sophistication. The students attending our courses are at the highest level: they deserve to be informed about the existence of certain mathematical tools and of how powerful and versatile they can be. These are described in several **MATH INSETS**. For instance, we have introduced derivatives and integrals, in simplified terms. However, the book can be read without any prior knowledge of Calculus.



In each chapter, we provide many examples and present problems, together with their solutions and numerical results. These not only show that Physics is useful in Medicine when it provides quantitative predictions, but also give the reader an indication of the orders of magnitude of the physical quantities encountered in biomedical problems.

We are aware that a standard, one-semester course in Physics for Medicine cannot cover all the subjects included in our textbook. Nevertheless, we hope that the book can be used as a flexible tool, both by teachers, who can select the topics and applications they consider most appropriate, and by students, who can also use the text as a reference manual for other courses, for specialist Master's Degrees, and for their future careers.

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