PHYSICS 陈万绪 徐葆仁 沈一英主编
FOR MEDICINE 刘普和主审
AND BIOLOGY

医学与生物学用物理学〔英文本〕

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FOR MEDICINE AND BIOLOGY

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FOREWORD

Several medical colleges and universities have taught physics in English to a small parts of students for several years. Sorry to say that lessons taught are only parts of the physics required. So there is an urgent need to compile an English physics textbook fulfilling the teaching program laid down by the Ministry of Health. Under the sponsorship of Hunan Medical College, about fifteen key teachers from nine institutes have gathered together to talk over the matter thoroughly and agreed to cooperate closely in compiling such a textbook. Although these teachers have done their best, due to lack of experience, errors are hard to avoid. It seems better to leave the deficiencies of the book to readers, criticism. I think, however, the readers will agree with me to thank them for having filled a blank in compiling this textbook.

Liu Pu-he

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PREFACE

This textbook is intended for students of medical colleges. In compiling this book, we aimed at presenting fundamentals of physics, giving due consideration to the need of medicine. We set about the work in accordance with the teaching program for medical physics laid down by the Ministry of Health. We had to leave out the materials which the students had already learned in middle schools. Therefore. this book differs in several ways from conventional physics textbooks designed for science majors.

Firstly, the choice of basic physics topics to be included or emphasized has been determined by the needs of medicine majors. This has necessitated the inclusion of some topics no longer of great current interest to physicists, such as mechanics of fluids, phenomena on liquid surface. acoustics, ultrasound, geometric optics and X-rays. It has also resulted in minimizing historical materials and areas of contemporary physics. which are not indispensable to the study of medicine and biology.

The second major difference is that some examples have been chosen from medical systems, or"life science" books. This contrast to the common use of examples with an engineering flavor.

The third difference is the contents of the text devoted to the application of physics to medical systems. These discussions motivate the students to learn physics by demons-

trating its relevance to medicine. as well as measuring student's understanding of the physical principles involved.

In short, we have tried to provide a textbook in English which is comparable in content to the chinese textbook on physics normally used in medical colleges. Also, this book can be referred to biology and agriculture major and medical personnel. There are eighteen chapters contained in this book and 80—100 class hours will be needed for lecture.

The level of mathematics used in this book assumes that the students have had a minimal introduction to calculus. All physical calculations must be carried out using a consistency of units. In this book the SI system is used. It is the system that is used in all major scientific publications.

Owing to the lack of experience in compiling such a textbook on the part of the compilers. There may be lots of shortcomings and even mistakes in this book. We sincerely welcome criticisms and suggestions from teachers and students who use it.

Finally, we must express our gratitude to the comrades of The Hunan Science and Technology Publishing House. Their assistance and suggestion have made the publication of this textbook possible.

Editors

INTRODUCTION

"Why should we study physics?" This is one of the questions most frequently asked by medical students. It seems appropriate therefore to begin this book with an attempt to answer it.

The word 'physics' comes from a Greek term meaning 'nature', and therefore, physics should be a science dedicated to the study of all natural phenomena. There is no clear definition of what physics is, or which topics belong to physics and which do not. A typical short dictionary says that physics is the branch of science that deals with matter, energy, and their interactions. This is vague and general enough to include what is usually considered to be chemistry, in any case, it doesn't give any real feeling for what is involved. Longer dictionary entries usually expand the definition by noting that physics includes subfields as mechanics, heat, electricity, magnetism, optics, and so forth. They give no clues as to why some subfields of science are included and others are not.

A better approach to defining physics is to ask what physicists are concerned about. Physicists attempt to understand the basic rules or laws that govern the operation of the nature world in which we live. Since their activities and interests evolve with time, the basic science called physics also changes with time. Many of the most active contemporary subfields of physics were undreamed of a generation or two ago. On the other hand, some parts of what are now considered to be che-

mistry or engineering were once considered to be physics. This is because physicists sometimes gradually abandon a field once the basic principles are known, leaving further developments and practical applications to others.

Concretely, we may say that physics deals with the mechanical phenomena, and the phenomena relevant to the structure and state of real objects, the nature of the fields, the interaction between fields and real objects, etc,

Since we have written this book primarily for students majoring in medicine, we have not stressed the historical or philosophical aspects of physics. Rather, we have tried to make clear in every chapter the connection between physics and medicine.

Hardly can any activities of research including medicine and biology advance without the use of modern physical principles and techniques. The physical laws governing the behavior of molecules, atoms, and atomic nuclei are the basis for chemistry and biochemistry. physiology offers many examples of physical processes and principles; diffusion within cells. the regulation of body temperature. the motion of fluids in the circulatory system, and electrical signals in nerve fibers are just a few. Perhaps the most obvious impact of physics on biology and medicine is at the level of instrumentation. The modern hospital is squipped with laboratories in which the most sophisticated physical techniques are used. A knowledge of physics helps in the intelligent use of everything from light microscopes and centrifuges to electron microscopes, computers, lasers, Computed Tomography, ultrasound scanners, electronic techniques, and elaborate radiation detection systems used in nuclear medicine. Therefore it may be con-

cluded that physics is related to medicine and biological science mainly in two respects:

1. The knowledge of physics is indispensable to the understanding of life phenomena.

2. The means and techniques provided by physics have opened up many new approaches to the research of medicine and medical practice.

A few remarks about how one studies physics may be helpful. More than any other science, physics is a logical and deductive discipline. In any subfield of physics, there are just a few fundamental concepts or laws derived from experimental measurements. Once one has mastered these basic ideas, the applications are usually straightforward conceptually, even though the details may sometimes become complicated. Consequently, it is important to focus one's attention on the basic principles and to avoid memorizing a mass of facts and formulas.

In summary, we believe students of medicine and biology will benefit in two major ways from studing physics. They will gain an understanding of the basic laws govern everything in our world from the subatomic to the cosmic scale and will also learn much that will be important in their work in medicine and biology. The study of physics as a basic science is not particularly easy, but we believe it is rewarding, particularly for students planning further training in related to life science. We hope that all who use this book will agree.

CHAPTER 1 THE ROTATION OF RIGID BODIES

Mechanics is the foundation on which the rest of physics is built. So we ought to be study that some of mechanics. In this chapter, we shall give a brief introduction for the rotation of rigid body, which consists vectors (scalar product and vector product), torque, angular variables, Newton's Law for rotational motion, angular momentum and angular impulse, and conservation of angular momentum.

1.1 Vectors—Scalar Product and Vector Product

We have assumed in the high school discussion that the vectors being added together are of like kind; that is, displacement vectors are added to displacement vectors, or velocity vectors are added to velocity vectors. Just as it would be meaningless to add together scalar quantities of different kinds, such as mass and temperature, so it would be meaningless to add together vector quantities of different kinds, such as displacement and electric field.

However, like scalars, vectors of different kinds can be multiplied by one another to generate quantities of new physical dimensions. Because vectors have direction as well as magnitude, vector multiplication cannot follow exactly the same rules as the algebraic rules of scalar multiplication. We

must estabish new rules of multiplication for vectors.

We find it useful to define three kinds of multiplication operations for vectors: (1) multiplication of a vector by a scalar, (2) multiplication of two vectors in such a way as to yield a scalar, and (3) multiplication of two vectors in such a way as to yield another vector. There are still other possibilities, but we shall not consider them here.

The multiplication of a vector by a scalar has a simple meaning. The product of a scalar k and a vector $\boldsymbol{a}$, written $k\boldsymbol{a}$, is defined to be a new vector whose magnitude is k times the magnitude of $\boldsymbol{a}$. The new vector has the same direction as $\boldsymbol{a}$ if k is positive and the opposite direction if k is negative. To divide a vector by a scalar we simply multiply the vector by the reciprocal of the scalar.

When we multiply a vector quantity by another vector quantity, we must distinguish between the scalar (or dot) product and the vector (or cross) product. The scalar product of two vectors $\boldsymbol{a}$ and $\boldsymbol{b}$, written as $\boldsymbol{a}\cdot\boldsymbol{b}$, is defined to be

$$\boldsymbol{a}\cdot\boldsymbol{b} = ab\cos\phi, \tag{1.1}$$

Where a is the magnitude of vector $\boldsymbol{a}$, b is the magnitude of vector $\boldsymbol{b}$, and $\cos\phi$ is the cosine of the (smaller) angle ϕ between the two vectors (see Fig.1.1)

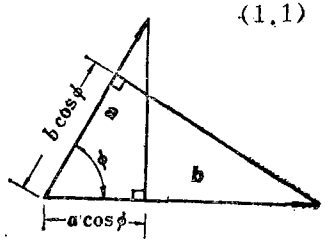

Fig.1.1

Since a and b are scalars and $\cos\phi$ is a pure number, the scalar product of two vectors is a scalar. The scalar product of two vectors can be regarded as the product of the magnitude of one vector and the component of the other vector in the direction of the first. Because of the notation, $\boldsymbol{a}\cdot\boldsymbol{b}$ is also