Textbook Series
for 21st Century

University Physics

Second Edition

Dexin Lu

高等教育出版社
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About the Author

Prof. Lu has long been engaged in the research of theoretical physics in Nanjing University, Northeastern University in Boston, University of Vermont, and The University of New South Wales in Sydney. His field is statistical physics, especially low dimensional many-body systems. During these ten years he also devoted himself enthusiastically to the education initiative. As Dean of Department for Intensive Instruction Nanjing University, he concerns reform of introductory physics course very much. This book is the result of 10 years practice. Besides physics his interests include music, and swimming. He is an amateur photographer and go player.

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Foreword

Physics is developing rapidly, constantly uncovering new phenomena and laws, conquering new fields, infiltrating into adjacent disciplines, and bearing fruits in high-technology. All these require a corresponding reform in university fundamental physics course so as to adapt to the new situations of scientific development. At the turn of century, a challenge confronting researchers and teachers of physics is to write a textbook of university physics oriented to the new century.

Well accomplished in physics, Professor Dexin Lu has long been engaged in the research of theoretical physics and has a wealth of first-hand experiences in scientific research. In recent years, while serving as Dean of the Department for Intensive Instruction, Nanjing University, he has devoted himself to the teaching and reform of introductory physics course. He has given considerable thoughts to the task and formed his own creative opinions. Meanwhile he has strong capacities and willpower to put those ideas into effect. This book is a crystallization of his many years' teaching experiences. Both original and down to earth, it is an excellent textbook for introductory physics course.

The tidal waves of the reform of introductory physics have been worldwide, lasting several decades that have witnessed moments of both success and failure. R. P. Feynman, a master of theoretical physics, offered us an instructive example. He began involved in the reform of introductory university physics in the early 1960s, and taught such courses in the California Institute of Technology, the United States. The well-known three-volume *The Feynman Lecture on Physics* is the record of his attempt. He contributed creatively and significantly to many aspects of physics. To quote a passage from Prof. M. Sands, "To his lectures he has brought the brilliance and clarity of his thought, the originality and vitality of his approach, and the contagious enthusiasm of his delivery. It was a joy to behold". Numerous physical workers and teachers have found inspiration and enlightenment in the book. It has become one of the most frequently cited works of physics. The widespread and profound influence it has brought to the physics community proves that his experiment was a success. But on the other hand, the textbook is often beyond the comprehension of university freshmen. It can be said that it was written for teachers instead of students, for whom it often appears unattainable. As an introductory work, its accessibility is questionable. Despite its shortcomings, the multi-volume *Berkley Physics Course* that appeared later embodies some improvements along the lines of accessibility. Therefore, accessibility has become one of the yardsticks for the measurement of teaching materials. *Physics* by R. Resnick and D. Halliday, while its originality being not as high as Feynman's, goes about things steadily and surely, comes closer to traditional textbooks, and has good accessibility. It has been well received by most teachers and most extensively adopted as a textbook for university physics in the United States. Another problem for innovative textbooks arises from the need for the inclusion of many new contents. Along with the development of science, new progresses in contemporary physics must be integrated into the introductory course of physics. Authors of textbooks generally welcome the new but hate to discard the old, so making textbooks too thick to teach with.

The author of this book strives to change the old face of an introductory textbook of physic by incorporating the developments of contemporary physics into it. In this respect, he has obviously been influenced by Feynman. But he has his own way to do it. For example, while tracing the developments in history, the author introduces the law of universal gravitation in Chap. 4 in an effusive and absorbing way. This is followed by discussions on modern issues of gravitation, such as equivalence of gravitational mass and inertial mass, gravitational redshift, and gravitational collapse, with links to the frontier of physics. Returning then to the discussion of the two-body Kepler problem, it helps the students to achieve a solid understanding of the theories and methods concerned. The whole chapter, which proceeds from history to reality and from concepts to theory, makes pleasant reading. Another example is found in Chap. 27, which begins with the presentation of Bose-Einstein statistics and proceeds with the introduction of the latest experimental results for the discussion of Bose-Einstein condensation. In this way, students are not simply and passively given certain knowledge, but thrown into a dynamic environment of developing physics, thus acquiring a sense of involvement in their learning of physics.

Though concerned with novelty and originality, the author is very conscious of the importance of accessibility. The contents are arranged in the order of Mechanics—Thermal Physics—Electromagnetism—Modern Physics, a reasonable sequence of progression that lends itself easily to teaching. Learners will not feel the presence of any large gaps or disorientation. The author has also paid attention to the areas where students often have misunderstanding or make mistakes. For example, one section gives an enumeration of some illegal expressions for vectors. This detail reflects well that the author is a teacher of experience. Furthermore, the whole book is controlled within 600 pages and suits a two-semester course.

Since 1989 the textbook has been used in a course in the Department for Intensive Instruction, Nanjing University. From 1993 the same course was offered to astronomy majors, and later to students of electronic engineering and other disciplines of science. All these classes have proved to be satisfactory, arousing students' enthusiasm for learning physics and strengthening their ability to explore problems in physics. The students turn out many admirable course thesis and confirm the success of the teaching, though the excellent quality of students of the Department for Intensive Instruction have also helped to pave the way for the successful teaching reform. In a word, as an introductory textbook of physics, it is refreshing, eye opening, and highly suitable for classroom teaching. I would strongly recommend the textbook to teachers of the physics.

Duan Feng

October 1996

Preface to the Second Edition

The excellent critique and fairly positive response to the first edition of this book have encouraged me to prepare this second edition. I was greatly helped by suggestions from colleagues and students. Meanwhile we have profited from our experience in teaching the course. In particular I would like to mention my colleague Professor Wang Xu who has taught the course with me for years and contributed a lot to the improvement of the book and the teaching.

In this edition I have tried to make improvement whatever possible. We have corrected all mistakes and typos ever discovered. Many paragraphs have been rewritten to make them more accurate, understandable and neat. Following a widespread request, I have put the answers to the odd-numbered problems at the end of the book. Appendix A, Commonly Used Physical Constants, has been renewed to '1998 recommended values'. Throughout this edition those constants are all tuned to new values. Users may find that this is an introductory textbook for pedagogical purpose, yet it provides reliable references. Some recent progress in research of frontier topics has been mentioned. Several new references are added.

Most figures are treated again to make them clearer, better, and more helpful.

I would like to express my sincere appreciation to Editor Kaifei Hu who did an impossibly careful job of proofreading, making my preparation of the manuscript a pleasant task.

Preface to the First Edition

This book is based on the lecture notes for a course *University Physics* given in the Department for Intensive Instruction, Nanjing University since 1989. As the academic disciplines of the Department include not only physics, but also biophysics, astronomy, chemistry, biology, biochemistry, etc., a textbook of physics suitable for all majors is needed. Moreover, the basic contents of many introductory physics textbooks are somewhat out of date, and obviously inappropriate for university physics education at the turn of the century. Furthermore, the shortened period of schooling requires courses to be more compact. This book has been written with intent to take contemporary physics as the core component to be used in a two-semester introductory course of physics for students from different academic disciplines.

Nowadays the tendency of overlap, synthesis, and infiltration across different disciplines is getting more and more obvious. Therefore, it is necessary to introduce this new tendency and to emphasize the correlation between the various branches within disciplines, though I am fully aware that the revelation of the "entanglement" between physics and other disciplines and among the branches of physics is a difficult task. Besides, I believe that most frontier topics should have their "roots" in the fundamentals. Arduous as it may be to search these "roots" , as soon as I find any contents in frontier topics that suit the teaching of fundamental concepts, I never hesitate to include them in the textbook. It is hoped that such an effort of root digging can make the textbook richer and more substantial. On the other hand, the ideas and methodologies adopted by researchers in their acquisition and processing of data, in handling the relationship between mathematics and physics, in constantly adjusting their research procedure, in deepening their understanding of the research results and in expanding research achievements are valuable assets for beginners of physics. These valuable assets, which are often inaccessible to the students, will also be introduced in the textbook through the exposition of practical problems.

Traditional introductory courses emphasize the teaching of basic knowledge, theory, and skill. Practice shows that more can be achieved through such courses: e.g. developing students' creativity and explorative spirits, building their morality, and sharpening their sense of scientific research. For undergraduate education this is a demanding goal. But indeed it is my true intention. We may show students historical and modern models of scientific discoveries. We can also make room for students to proceed towards the depths and widths of the learning contents. For this purpose, instruction should not be confined to one book. In this textbook, references are cited from journal articles and books and problems still unsettled by research are presented. Classical and specialized references are provided mainly for teachers' use. The sections or paragraphs marked with asterisk are optional reading materials. The accompanying software program that provides supporting materials of the textbook contains the author's opinions on such aspects as answers to exercises, literature reading, and course paper writing. It also has a list of additional reference materials. For the sake of focus, I have left out the discussion of optics and electric circuits, but proposed some new opinions and methods concerning the solution to certain research problems. Furthermore, attempts are

made to discuss the aesthetic value of physical laws etc.

It has been eight years since the first draft of the textbook was written. During the period, it has been adjusted and revised. The blame for any remaining inaccuracies or misstatements rests with the author.

I would like to express my sincere appreciation to Zufu Chen, Duan Feng, Zhiguang Feng, Yuansheng Jiang, Aoao Xu, and Congguang Deng for their support and encouragement. The book has benefited from suggestions and comments from many friends and colleagues: Yuansheng Jiang, Kunmiao Liang, Tingyang Chen, Tianyi Huang, Jian Shen, Qichang Zhao, and Daqian Pan. I am particularly indebted to Prof. Duan Feng, Member of the Chinese Academy of Sciences, who has read the manuscript, written the foreword, and made many valuable and insightful suggestions about the adjustment and supplement of the contents. I would also like to thank my teaching assistants who have helped to improve the book, and my students who used the early typescript of the textbook and served as the medium through which the book grew. I hope this book can evoke pleasant memories in them.

Dexin Lu

CONTENTS

Part Two Thermal Physics

Part Three Electromagnetism

Part Four Fundamental Modern Physics

Appendix