海外优秀理科类系列教材

PEARSON Addison Wesley

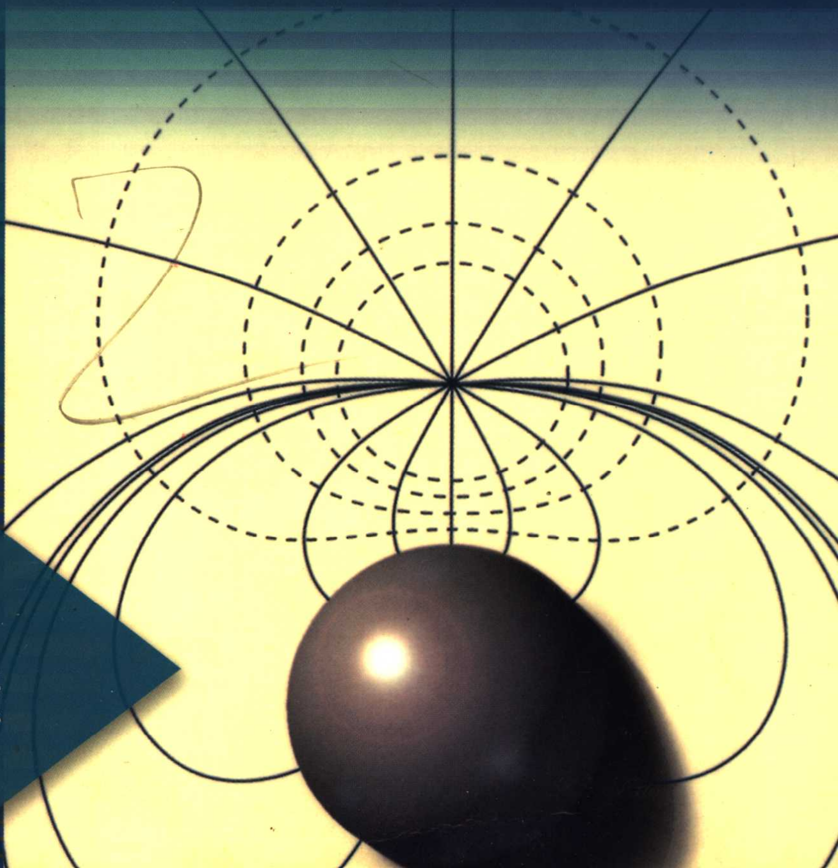
影印版

Electromagnetism

电磁学

Gerald L. Pollack

Daniel R. Stump



高等教育出版社

Higher Education Press

海外优秀理科类系列教材

影印版

电　磁　学

□ Gerald L. Pollack
□ Daniel R. Stump

高等教育出版社

图字:01 - 2005 - 0966
原书 ISBN:0 - 8053 - 8567 - 3

图书在版编目(CIP)数据

电磁学 = Electromagnetism /(美)波拉克(Pollack, G. L.),(美)斯顿普(Stump, D. R.).—影印本.
北京:高等教育出版社,2005.5
ISBN 7 - 04 - 016576 - 7

Ⅰ.电... Ⅱ.①波...②.斯... Ⅲ.电磁学 - 高等学校 - 教材 - 英文 Ⅳ.0441

中国版本图书馆 CIP 数据核字(2005)第 025444 号

策划编辑 庞永江 **责任编辑** 庞永江 **封面设计** 张 楠 **责任印制** 宋克学

出版发行	高等教育出版社	**购书热线**	010 - 58581118
社 址	北京市西城区德外大街 4 号	**免费咨询**	800 - 810 - 0598
邮政编码	100011	**网 址**	http://www.hep.edu.cn
总 机	010 - 58581000		http://www.hep.com.cn
		网上订购	http://www.landraco.com
经 销	北京蓝色畅想图书发行有限公司		http://www.landraco.com.cn
印 刷	北京中科印刷有限公司		
开 本	787 × 1092 1/16	**版 次**	2005 年 5 月第 1 版
印 张	40.5	**印 次**	2005 年 5 月第 1 次印刷
字 数	600 000	**定 价**	60.00 元

本书如有缺页、倒页、脱页等质量问题,请到所购图书销售部门联系调换。

物料号 16576 - 00

内 容 简 介

本书是在美国大学使用比较广泛的一本为本科生编写的电磁学教材。虽然在总体上，该教材仍然是一本比较传统的教材，但作者仍然在如何能帮助学生更好的学习电磁学课程做了不少努力。例如，提供不少和实际联系比较紧密的例子，讲解详细的例题以及提供了不少使用计算机解决问题的算例。这些内容对于学生理解电磁学内容，应用所学知识都有很好的帮助。另外，该教材的习题难度适中，并有不少提示，对于巩固学习内容也有很好的帮助。

本书的难度和国内教学要求比较接近，可作为物理类专业电磁学课程的教材，尤其适合开展双语教学的学校，对于有志出国深造的人员也是一本必不可少的参考书。

Preface

This is an intermediate-level textbook on electricity and magnetism. It is intended to be used for a two- or one-semester course for students of physics, engineering, mathematics, and other sciences, who have already had a one-year introductory physics course with calculus.

The book is flexible enough to be used in several ways: (1) The traditional two-semester course would cover electrostatics and magnetostatics in the first semester using Chapters 1-8; and then magnetic materials and time-dependent fields in the second semester using Chapters 9-15. (2) An instructor teaching a one-semester course could cover all the basic principles of electromagnetism by using Chapters 1-3 and 6-11; there might also be time for a few examples from Chapters 4 and 5. (3) An interesting alternative approach in a two-semester course would be to go over the basic principles of Chapters 1-3 and 6-11 in the first semester, and then applications and advanced topics in the second semester based on Chapters 4,5, and 12-15.

The total material in the book is more than could be realistically covered by any instructor, even in two semesters. Instructors are encouraged to pick and choose based on their own judgment of what is important. Electricity and magnetism is a wonderfully interesting subject, but to students at the intermediate level its physical concepts are non-intuitive, and the associated mathematical techniques are new and challenging. Therefore it's important in teaching this subject to avoid the kind of heroic pace which will tire out all but the strongest students and instructors. The general principle that in teaching it's better to uncover a little than to cover a lot, applies to this subject of course.

The order of presentation of subjects is the traditional one: electrostatics first, then magnetism, electrodynamics and Maxwell's equations, relativity, and radiation. Chapter 2 is an introductory treatment of vector calculus, which should help students acquire the necessary mathematical armamentarium. Our experience in teaching this subject is that at the outset of the course most students do not know vector calculus well enough to study electromagnetic field theory, so it's important to help them gain the necessary mastery. Chapter 2 is sophisticated in places, and it is not necessary to comprehend all of it before starting on Chapter 3; the student can return to Chapter 2 when additional mathematical skill is needed. Students might also read a specialized book on vector calculus (e.g., one of the two references at the end of Chapter 2) while studying Chapter 2.

We have given an extensive treatment of electrostatics, in Chapters 3-6. The topics treated later in the book are more interesting than electrostatics to many students and instructors, so there's a tendency to hurry into them. But our experience is that time invested studying electrostatics pays dividends later on, because students acquire in electrostatics mathematical skills and confidence that are needed for other areas of electromagnetism.

Many good textbooks have been written on electromagnetism, and thousands of students have learned the subject from them. The two authors have taught this subject to hundreds of students over several decades, using some of those earlier books. It was from those many interactions with students, as well as with our colleagues and teachers, all remembered with pleasure, that we were led to write this book.

What is special about this book? For the most part it is a traditional, even conventional, exposition of electromagnetism, but we have also done three things we believe are important, and not stressed quite enough in other textbooks. First, we have tried to show how the mathematical principles that students are studying are used in modern technology—i.e., in real applications that students encounter in science and everyday life—applications such as cellular phones, optical fibers, magnetic resonance imaging, and charged particle accelerators and detectors. How is Faraday's Law related to the electricity in a wall socket? How can we calculate the interaction between radio waves and the ionosphere? Although it is necessary to study highly idealized, academic examples in field theory—e.g., the magnetic field of an infinitely long wire carrying a constant current, or the electric field in a spherical capacitor—students should also learn that the theory describes real physical phenomena and devices. The ideal cases are not the whole story.

Second, we have included in the text many worked-out mathematical examples in each area, including some examples that go beyond the elementary, exactly solvable, ones, and other examples that require multi-step analysis such as the use of the superposition principle. This book is based on a two-semester course that we have taught at Michigan State University. The course is taken by senior undergraduate students, and some first-year graduate students who are not yet enrolled in the graduate-level course. Our experience is that for students to master the intermediate level they must study more than just the simplest cases. Even to "uncover a little" requires that the instructor show a variety of examples. Each chapter starts at an elementary level, with topics the student is likely to know from an introductory physics course. The discussion then leads into the junior/senior-level material which is the heart of the book. At the end of several chapters we've introduced an interesting, more advanced, subject; we hope this will inspire students to future further study of the subject by indicating what lies beyond the horizon.

Third, we have included a number of computer calculations, both in the text and in the end of chapter exercises. Computer software that integrates analysis, numerical calculation, and graphics, e.g., Mathematica, Maple, Mathcad, Matlab, Excel, etc., can be used for these calculations. Students who are comfortable with Fortran or other computer languages can do the exercises by writing their own programs. Much of current physics, both experimental and theoretical, is done with computers, so today's students need this experience. On the other hand, the computer cannot replace the understanding of theoretical principles. We regard the computer exercises as an important, but not dominant, part of the book.

An essential part of this subject is learning how to do problems. There is a tendency (maybe it's even a tradition) for some textbooks on this subject—Smythe's book being the most dramatic example—to give many very difficult problems, on which the student spends uncounted and often frustrating hours. Many practicing physicists, the authors included, have been brought up in this draconian school. We believe however that the principle of "all things in moderation" should be applied to E&M problems. At the end of each chapter we have given a number of exercises of various degrees of difficulty, but mostly of only moderate difficulty, which are intended to help students understand the subject. Hints and answers are given in many of the exercises.

In writing *Electromagnetism* we had in mind the learning needs of present-day students, who are in some ways ready for a deeper understanding of the subject than we, their instructors, were at their age. They have had sophisticated courses in mathematics, even if they are still learning to apply this mathematics; we therefore use advanced mathematics freely, but also give generous explanations, so that students can exercise these valuable, newly acquired, skills. Mastering the subject at the intermediate level is not easy, and we encourage students to discuss what they are learning with other students and with their instructors at every opportunity.[1] Learning and doing physics has a social component. One learns much more from such discussions than by reading a textbook alone.

We believe it is especially important to meet the needs of those students who will go on to further study of electrodynamics, for example in graduate school in physics or electrical engineering, or who will use these principles in industry or engineering. Among these are the men and women who will write the next generation of books on this and related subjects, invent and develop new applications and (who knows?) discover new principles. To this end we try to extend the students' knowledge to a high enough level that they will be adequately prepared for working in J. D. Jackson's *Classical Electrodynamics*, or similar advanced books.

We would like to thank our students for listening to so many of our lectures on electromagnetism. We also owe a great debt to our own teachers of this subject, among them, R. P. Feynman, M. Firebaugh, R. C. Garth, D. L. Huber, F. E. Low, W. Mais, and W. R. Smythe.

[1] "Many will range far and wide and knowledge will increase." *Daniel* 12.4.

Encouragement for the Student

This Section together with Chapter 1 might appropriately be called "Loomings", in the sense that "Loomings" is the title of Chapter 1 of *Moby Dick*[2], because the purpose here, as there, is to give background and indicate an approach to a large subject. In any case, natural *looming*, which is observed in the atmosphere over sea or land, is an optical, *i.e.,* electromagnetic, phenomenon. It is caused by variation of the index of refraction of air with temperature and height. Looming makes objects like ships and lighthouses look larger and more threatening than they really are. There is something like that effect when one first approaches the study of electromagnetism, and is confronted by a very large subject. But, as in optical looming, the size is not really so large. After all, there are only 4 Maxwell equations.

Although learning electromagnetism is a great intellectual challenge – mastering any subject is difficult of course – there's nothing in it that should deter serious students. On the contrary, in our study of the subject we will encounter many interesting ideas, physical phenomena, and mathematical techniques; and many of these things have great beauty! It's a challenge less dangerous than the voyage of the *Pequod.* A good thing about the electromagnetism voyage is that it won't end.

In this Section the authors offer some suggestions to smooth the way of learning.

How to study this book. In learning a new subject, especially one with a lot of mathematical content, it's a good idea to take it in small increments. In this book we've tried to limit the ideas/page, *i.e.,* the idea density, to a value for which 3-5 pages per learning session is about right. It is good practice to read the material before going to class. This first reading can be casual, without paper and pencil. Then the instructor's presentation will be more understandable. But then it is necessary to reread the material, this time slowly and carefully with paper and pencil at hand. Try to fill in the intermediate steps in the calculations. When you get mired down, which is inevitable in theoretical physics, don't spend an inordinate amount of time struggling with a particular step. Pick up the argument wherever you can and go on.

Worked-out examples. The Examples in the text illustrate application of the principles to classic problems. They range from elementary to sophisticated. The

[2] Herman Melville, *Moby Dick*, 1851.

latter introduce new ideas. We suggest that you read each example line by line, so that you are able to repeat the calculation on your own and apply the ideas to other problems.

Formal language. Informal language plays an essential role in learning and exchanging information. We all use it most of the time. But more formal language, which is used in this and similar books for proofs, derivations, and statements of problems, is also necessary. It is important not to be intimidated by the formalism, whose purpose is to avoid confusion or ambiguity. You'll get used to it, and after reading a few chapters you'll feel comfortable with it.

Exercises. In the end, most of what you learn will have come from doing exercises yourself.[3] Because so much time and effort must go into this process, the experience should be as pleasant as possible. Therefore, exercises are provided at the end of each chapter. Ideally, you should try to understand and solve all the end-of-chapter exercises.

A common student difficulty in using textbooks is "to understand the material" but not be able to do the problems. There's a gap between what is learned from the text and what is needed to do the exercises. There is no easy fix for this difficulty, but we have tried some things to help bridge the gap: Some exercises are footnoted in the text where they are related to the text. Some exercises are grouped together by the appropriate section of the chapter. Of course the *best* exercises require material from many sections, and a wider perspective. Those exercises are more like the problems that arise in research in science and engineering.

The end-of-chapter exercises include a range of difficulty, but we have tried to omit the very difficult kind that only a few students can solve, and then only after a Herculean effort.[4] Although it is crucial to work on the exercises yourself, it is also useful to discuss them with classmates, instructors, or interested bystanders. There is a social aspect of science, and you will learn a lot by interactions with other scientists. Please eschew the "method of multiple books" – looking for the solution of an exercise in another book. That takes more time than just figuring it out yourself.

If you get stuck on some problems, console yourself with the thought that this happens to everyone. The knowledge you are seeking has taken hundreds of years to accrue, developed by thousands of people who made the same mistakes and false starts as you. So, if you feel hopelessly stuck, then close the book, contemplate the problem at leisure, talk it over with some other people, and try again tomorrow.[5]

[3] Most physicists will say: "Everything I know I taught myself!" What they mean is that they worked out a lot of problems, by the sweat of their own brows, and that's how they learned the subject.

[4] If you want to try some really difficult problems, they can be found in more advanced books like *Smythe* or *Jackson*.

[5] You can take encouragement from the Midrash Rabba (Fifth century) which says: "There isn't a blade of grass in the world below which doesn't have a star and an angel above that strike it and tell it, 'Grow! Grow!' "

Introductory textbooks. This book is intended for students who have already taken an introductory college-level course on physics. All introductory textbooks cover electricity and magnetism, in quite a lot of detail, including the mathematical theory. The textbook used in your introductory course should be used as a reference book when you encounter a difficult topic in this intermediate-level book. (In the same way, when you study electromagnetism in a graduate course, you will refer back to this book when you encounter a difficult topic in the advanced-level graduate text.) Reading over the material at a slightly lower level of sophistication can be very helpful in understanding the new ideas.

A list of good introductory textbooks is given at the end of Chapter 1.

Contents