BOOKS

Special Focus: A Selection of Undergraduate Textbooks

Laser Fundamentals

William T. Silfvast
Cambridge U. P., New York, 1996. 505 pp. $89.95 hc ($39.95 pb) ISBN 0-521-55424-1 hc (0-521-55617-1 pb)

Reviewed by William B. Bridges

Given the great number of books on lasers already in print, one might wonder what new could be said in an introductory text written more than 35 years after the "first light" of the laser. As surprising as it may seem, William T. Silfvast's *Laser Fundamentals* does indeed provide a fresh approach. It may be that Silfvast's three decades of hands-on laboratory experience in lasers at AT&T Bell Laboratories, primarily with gas and metal-vapor lasers, makes the difference. Clearly, this book was written by an experimenter.

The authors of most popular laser texts that spring to mind are life-long academics whose experimental work is done primarily by their students. Silfvast, however, now at the University of Central Florida, is a relative latecomer to the academic world, so his laboratory exploits are first- rather than second-hand. He was the discoverer of many vapor ion lasers, beginning with the helium–cadmium ion laser—which he developed in his graduate years—a laser that is still a commercial product 30 years later. This intimate acquaintance shows through, especially in the problems for the student, which are largely the kind of numerical calculations an experimenter has to make in considering the practicality of an experiment or the details in setting one up. There are none of those usual, long derivations that result in a formula but stop short of plugging in numbers.

Laser Fundamentals is appropriate for an advanced undergraduate or first-year graduate course. There is an extensive background review of radiation physics, properties of materials and quantum mechanics at the beginning of the book, making it particularly useful for students who have had only beginning physics—electrical engineers for example. Indeed, 200 pages go by before the "conditions for producing a laser" appear in chapter 7! Those 200 pages by themselves make a good short course in physics. A particularly nice inclusion is the brief treatment of atomic structure and the origin of spectroscopic names for real energy levels in the LS coupling model. Many texts simply treat energy levels in the abstract and leave it to the student to decode the names of real levels in real lasers from some other book.

The next 100 pages cover gain, saturation, linewidth, threshold, three- and four-level laser alternatives, transient population inversion and pumping techniques. This is followed by 100 pages on Gaussian beams, optical resonators, Q-switching and mode locking. Next are 80 pages covering the characteristics of specific laser types, a much higher ratio of specific lasers to general theory than in any other text. Included are up-to-date descriptions of all commercially available gas lasers (helium–neon, argon ion, helium–cadmium, copper vapor, carbon dioxide, excimer and so on), dye lasers and solid-state lasers (ruby, Nd:YAG/glass, alexandrite, Ti:sapphire, Cr: LiSAF/LiCaF, fiber lasers and semiconductor lasers). The final 20 pages form a brief introduction to frequency conversion by nonlinear optical techniques.

Throughout *Laser Fundamentals,* the emphasis is on conveying a physical understanding of the processes and a sense of the numerical magnitude of the quantities involved. Silfvast is an excellent explainer. Examples set off in boxes are included in each section, giving calculations that demonstrate the numerical magnitude of a result. Other stylistic touches are the "boxing" of important equations and the repetition of the most important of these in the front and back flyleaves, the way a student would summarize before an open-book test. *Laser Fundamentals* is a good read, and I recommend it to students and their teachers alike.

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Vibrations and Waves

William Gough, John P. G. Richards and Rhys P. Williams
Prentice Hall, New York, 1996. 2nd edition. 249 pp. $38.00 pb ISBN 0-13-451113-1

In its second edition, William Gough, John P. G. Richards and Rhys P. Williams's *Vibrations and Waves*, first published in 1983, has been slightly reorganized and includes several new applications to current topics, as well as a companion diskette containing demonstration programs. The book is intended for an introductory course in vibrations, waves and optics, probably at the sophomore level. It has many strengths, but there are some counterbalancing weaknesses.

Some of the book's strong points are: the accompanying demonstration programs; a clearer-than-most generalization to waves in two and three dimensions; a nice introduction to the Dirac δ-function; and up-to-date and interesting applications, including nonlinear oscillations, optical fibers, piezoelectric vibrations, perception of sound, optical coherence and solitons. And the treatment of Fourier analysis is more complete than those of most other texts at this level.

Not all institutions require or even offer a course in vibrations, waves and optics, and among those that do there is far less uniformity of content than in general introductory first-year courses. It so happens that just two years ago my institution added such a course for the fall semester of the sophomore year, and I have been teaching it, so a key component of my assessment of *Vibrations and Waves* is its consonance with the design of the Haverford College course. (In choosing a text for our course I have recently examined the contents of most textbooks available for such a course. Space prevents inclusion of that useful information here, but interested instructors can find a table in my home page on the World Wide Web (http://www.haverford.edu/physics-astro/Roelofs/Roelofs.html).

Vibrations and waves and their applications to mechanical waves, sound and optics are important in their own right in the physics curriculum. However, a course covering these topics can also prepare students for the mathematics they will encounter in upper-level courses, especially the complex exponential function, the eigenvalue problem and Fourier analysis. The study of classical waves also lowers some of the barriers for students when, later, they take their first courses in quantum mechanics. The course at Haverford is built around these general objectives.

In that context, *Vibrations and Waves*, despite its several attractive features, is not the choice for me. Gough and his coauthors treat the coupled vibrator problem quantitatively for two particles only, and the treatment is not put into the general context of eigenanalysis. (This failing also precludes the elegant segue from N coupled oscillators to waves on a massive string using the large N limit.) The book also does not support our mathematical course objectives in that it solves the differential equation for the single oscillator—with and without damping—without use of the complex exponential function. Another drawback is that some key applications, especially sound and waves on strings, are not discussed until the penultimate chapter; their integration into the earlier mathematical presentation of wave motion would improve a student's development of intuition. A final important concern is that there are not enough exercises in some of the chapters.

It is becoming more common for textbooks in this field to include demonstration programs. The 1983 edition of *Vibrations and Waves* included programs as lists rather than on diskette. The seven programs on the diskette that comes with the second edition will run only on IBM-compatible platforms. But they do allow user control and are simple in design and use. They are not overly glitzy; students will not confuse them with video games. The authors have made sensible choices of what to demonstrate, although the soliton simulation does not succeed because of numerical instabilities. I would fault the demonstration programs only in that there are no end-of-chapter exercises requiring their use; these are necessary, in my experience, to get students to engage fully with computational demonstrations. (Instructors wishing to incorporate a substantial simulation and demonstration component into a waves course should consider as a supplemental text *Waves and Optics Simulations*, by Wolfgang Christian and others (Wiley, 1995).

Vibrations and Waves is mostly well and clearly written, although American students may find some of the Britishisms puzzling: treacle for molasses, the anachronistic gramophone and pulcatance for angular frequency, to list a few. Although on topical grounds *Vibrations and Waves* is not the choice for my course, its applications and simulations have enriched and informed my teaching.

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Reasoning About Luck: Probability and Its Uses in Physics

Vinay Ambegaokar
Cambridge U. P., New York, 1996. 247 pp. $59.95 hc ($19.95 pb)
ISBN 0-521-44217-6 (0-521-44737-2 pb)

Many physicists bemoan the public's ignorance of physics. Few invest time to consider what the public should know about physics. Vinay Ambegaokar has selected the basics of probability and its physical consequences as the key to public understanding—and as the basis of *Reasoning About Luck*, which he wrote as a text for a one-semester course for liberal-arts students. Beginning with basic statistics and Newton's laws, he relates the molecular model of matter to macroscopic thermodynamics. He then discusses the direction of time and introduces chaos and quantum mechanics, basing the discussion on the fundamental principles of statistics and probability that he introduced at the beginning of the book.

Ambegaokar has correctly identified a major area of public ignorance: No one regularly exposed to television and the other popular media can escape the proliferation of junk physics based on ignorance of the role of statistics in understanding the physical world. Chaos, thermal fluctuations and quantum mechanics are routinely used to justify phenomena ranging from psychic healing to ghosts. If students who are not majoring in science understood no more physics than that presented by Ambegaokar, they would have a solid basis for thinking about physics and the other sciences, as well as practice in constructing logical arguments.

Reasoning About Luck uses no mathematics beyond basic algebra and geometry. It is unusually well written, and the author's dry sense of humor considerably increased my pleasure in reading it. Examples early in the book range from baseball to planning a lobster dinner. At the end, the same basic ideas are used to discuss such ideas as why macroscopic events are not reversible in time even though they are based on physical laws that are completely time-reversible. The solved problems at the ends of the chapters provide a profusion of interesting paper-and-pencil activities. Unsolved problems would also have been helpful.

Although I thoroughly enjoyed reading this slim volume, I do not think that the typical student in a freshman physics course for nonscientists would find it equally appealing. The mathematics is well explained and basically simple, and the physical arguments are elegant and clearly presented. However, most freshmen have never tried to think this way and would need more guidance than is provided here.

While unsuitable for a general liberal-arts physics course, *Reasoning About Luck* would be a superb choice for an upper-division honors seminar aimed at students from all the sciences or as supplementary reading in an undergraduate course in modern physics. Many senior-year physics students become adept at solving problems in thermodynamics without understanding the statistical basis of the subject. Ambegaokar's well-written, mathematically simple treatment would clearly benefit them. It is comparable to Richard Feynman's *The Character of Physical Law* (MIT Press, 1965), also aimed at liberal-arts students but very good reading as well for senior physics majors.

In thinking carefully about the minimum knowledge of physics that an educated citizen should have, Ambegaokar has made a real contribution to the discussion. In addition, he has produced a thoroughly enjoyable physics book.

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Cellular Biophysics

Thomas F. Weiss
Vol. 1: Transport
MIT P., Cambridge, Mass., 1996. 693 pp. $50.00 hc
ISBN 0-262-23183-2

Vol. 2: Electrical Properties
MIT P., Cambridge, Mass., 1996. 557 pp. $45.00 hc
ISBN 0-262-23184-0

Available as a set for $85.00

Physicists are often at a loss to know how to tackle the study of biological systems. If you are interested in learning where physics interfaces with cel-