BOOK REVIEWS

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Physical Hydrodynamics. 2nd ed. Etienne Guyon, Jean-Pierre Hulin, Luc Petit, and Catalin D. Mitescu. 536 pp. Oxford U. P., New York, 2015. Price: $74.95 (paper). ISBN 978-0-19-870245-0. (Raymond A. Shaw, Reviewer.)

I wish I could take every one of my physics students for a walk through the halls and rooms at the annual meeting of the APS Division of Fluid Dynamics. Maybe the best time would be right after their first advanced course in classical mechanics. I would exclaim, "Look, you've only just begun, there is so much more!" The meeting is a veritable carnival of physicists (many of them applied mathematicians and applied-physics-types residing in mechanical and chemical engineering departments) reporting on the latest advances and discoveries on topics as varied as the circulation of planetary atmospheres and oceans, quantized vortices in superfluid turbulence, the instability and dynamics of splashing drops, the swimming mechanisms of a jelly fish, and the sloshing of coffee carried in a cup. Fluid mechanics is alive and well in the physics community. But alas, it still suffers in the curriculum of too many physics departments in the U.S.

The extent of fluid mechanics education for physics majors consists of often over-simplified and even misleading treatments of mass continuity and the Bernoulli equation in introductory physics courses. This pedagogical sin of omission has been the subject of several *American Journal of Physics* sermons over the decades [e.g., Vol. **21**, 29 (1953)], but perhaps with the exception of some refreshing emphasis on nonlinear dynamics, most professors have not yet changed their ways. Graduate education is in a better state, reflecting the intensity and diversity of research; a happily large number of physics programs around the country now introduce fluid mechanics, whether through nonlinear dynamics, plasma physics, or the newly amalgamated field of soft-matter physics. One thing is certain: physicists of all stripes would be better off with a more rigorous introduction to the physics of fluids at the undergraduate level. What better way to introduce the mathematics of vector fields, to hone skills in dimensional reasoning and scaling, linear stability analysis, or to introduce Landau's concept of the order parameter? The best part is that many fluid fields can be directly visualized, making vorticity, waves, and wave instabilities intimately accessible to students.

One of the challenges of offering an upper-level undergraduate or entry-level graduate course in fluid mechanics in a physics department is the apparent dearth of suitable texts. At the introductory level, there are Feynman's brilliant chapters on dry and wet water, and at the advanced level is *Fluid Mechanics* by Landau and Lifshitz. But neither is quite right for this level. The texts by Acheson (*Elementary Fluid Dynamics*) and Lighthill (*An Informal Introduction to Theoretical Fluid Mechanics*), and most recently Falkovich (*Fluid Mechanics: A Short Course for Physicists*), are masters of concision and certainly would be options for a course emphasizing applied mathematics. In a 1978 review in this journal [Vol. **46**, 441 (1978)], the late fluid physicist Jerry Gollub described Tritton's *Physical Fluid Dynamics* as "one of those rare books that offers a qualitative advance over what was available previously." And that is still true today: the book is sufficiently formal for instructional use and yet has a decidedly physical approach that avoids becoming too applied and therefore is good for a physics audience. The text by Faber (*Fluid Dynamics for Physicists*) hits the right upper-level undergraduate level, albeit with a rather standard suite of topics; in John Lumley's words from an AJP review [Vol. **64**, 1214 (1996)], "… in fact the choice of subject matter here is very much what we teach our engineering students (and an occasional stray physicist)." I have taught a graduate-level course using Kundu's *Fluid Mechanics* for several years, but after the author's death the book has been revised by several others in a decidedly formal and applied direction and it no longer has the right touch; I won't be using it again.

Now enter the expanded edition of *Physical Hydrodynamics* by Guyon *et al*. I've had the first edition for several years and it's one of those books that I reach for when I want a fresh perspective on a fluids problem new to me. My favorite thing about the book is that, unlike so many other fluid mechanics texts, it is written much more in the style of physicists trying to understand the essence of a problem as opposed to taking a more formal approach such as that of the applied mathematician, or a purely applied approach such as that of the practicing engineer. The new edition is even better. There are several small changes, such as a new section on non-Newtonian fluids, but the biggest additions are a new chapter on quasi-parallel flows and the lubrication approximation (hydrodynamics of wetting, dynamic contact angles, etc.), and a new chapter on turbulence. The former will be of great interest to those in the soft-matter community, and the latter was most definitely a hole in the original edition. Any physicist conducting research involving fluid mechanics should consider having access to a copy of this book.

For the physics instructor, fluid mechanics can be a bit like the junior-level course in thermal physics, a potpourri of loosely related topics chosen to illustrate various aspects of thermodynamics and statistical mechanics. The field is vast and not all of the canonical examples of engineering texts will inspire physics students. This is exactly where *Physical Hydrodynamics* stands out. Nearly every section is evidence that the authors are physicists. The treatment is suitably rigorous but is always focused on fundamental physical understanding. It is filled with figures and sections describing physical phenomena, experimental methods, and results. In this regard, it reflects the French tradition in fluid mechanics and soft-matter physics, which is known to many through the work of de Gennes and is alive and well today. It is a book that allows individual sections to be savored. The sections on the frictional force on an object of arbitrary shape, Rayleigh-Bénard convection, and the physics of flames stand out as examples of creativity. There are several nicely written sections on rotating flows and their relevance to geophysical fluid dynamics. There are tables outlining dimensionless ratios so useful in fluid mechanics, and the parallel nature of convection and Taylor–Couette flow. The one major flaw in the book, by no means the fault of the authors, is the appallingly tiny font. For any reader over the age of 45, like this one, this will be a real barrier. The publisher must have set up the page layout on a large monitor and forgotten to look at the printed page.

If I were teaching an upper-level undergraduate or first graduate physics course in fluid mechanics, I might select some topics from chapter 1 that are not covered elsewhere in the curriculum, but would quickly move to the brilliant phenomenology of chapter 2. Table 2.1 is a highlight, introducing the dimensionless parameters that capture the relative importance of convective versus diffusive transport of mass and energy. There's really very little like this in the formalized, sanitized teaching of physics, often so distanced from the wandering of the experimentalist relying on scale analysis and dimensional reasoning. Chapter 3 is a rigorous yet concise coverage of kinematics, and ends with a refreshing section on flow visualization, once again paying homage to the experimental aspects of hydrodynamics that are part of the present-day revolutions in research. Dynamics of viscous fluids and conservation equations covered in chapters 4 and 5 would form the core of any course. My sense is that physics students, especially those interested in soft-matter problems, will appreciate the attention given to non-Newtonian fluids, usually considered only as an afterthought in most introductory texts.

Fundamentals having been covered, the challenge next is to decide what topics to draw from chapters 6 through 12. The particular choice can reflect the focus of the course. Certainly vorticity and rotation (chapter 7) should be covered at some level, and my own personal interests cause me to appreciate the introduction of rotating fluid phenomena such as geostrophic flow and Rossby waves. The Appendix on quantum fluids could be an excellent choice for physicists too. A course with a soft-matter focus can draw heavily from the insightful treatment of lubrication, wetting, and capillarity in chapter 8. Instability theory is so central to the education of physicists that some topics from chapter 11 would need to be covered, and this text provides so many great possibilities to choose from. Once again, my attention is drawn to the tables: Table 11.1 is an insightful synthesis of common and contrasting elements of three fluid instabilities, including their driving and viscous-damping forces, relaxation time-constants, and characteristic parameters. One weakness of the text for classroom use is the somewhat limited set of exercises. Those that are included are thoughtful and solutions are outlined at the end of the text, but instructors will likely want to supplement with their own problems or from other texts.

The passion of the authors is captured by this gem of an anecdote from one of my own graduate school professors: "[Guyon] gave the most memorable physics colloquium in my career as a graduate student ... His talk was on nonlinear chemical oscillations (the Belousov–Zhabotinsky reaction). The subject was interesting in itself but what was even more interesting was what he did halfway through the talk. He suddenly stopped speaking, his face turned red, he shook a bit, and then he screamed PHYSICISTS! THEY LEARN SECOND QUANTIZATION BEFORE THEY LEARN THE REYNOLDS NUMBER. After ridding himself of this burden, he recovered his calm and finished his talk in a normal tone." So, physicists, I invite you to pick up this delightful, spirited book and come to a deeper appreciation of the physical meaning and consequences of the Reynolds number. Better yet, use the book to take your students on a one-semester stroll through the growing, bustling carnival of fluid mechanics.

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Experiments and Demonstrations in Physics Bar-Ilan Physics Laboratory, 2nd ed. Yaakov Kraftmakher. 796 pp. World Scientific, Singapore, 2015. Price: $95 (paper). ISBN 978-981-4434-89-8. (Andrew J. Hachtel and Samir Bali, Reviewers.)

This is a 784-page compendium of 144 experiments and demonstrations catering to physics instructors and students primarily at the high school level and university introductory physics level, although certain topics in each chapter could be included as part of a more advanced undergraduate lab activity. The book covers an impressively wide range of topics in physics, neatly classified under Chapter headings such as

- Introductory Experiments: 30 experiments, primarily at the high school level, to familiarize readers with data-acquisition software and instrumentation developed by PASCO Scientific, which are heavily used throughout the book.
- Mechanics: 11 experiments on oscillations and waves, including nonlinear and chaotic pendulum motion.
- Molecular Physics: 11 experiments on calorimetry, thermodynamics, and thermoelectric phenomena, which would have sat more comfortably under the title "Thermal Physics."
- Electricity and Magnetism: 13 experiments covering not just traditional topics such as Fourier's theorem, Maxwell's laws, and LCR circuits, but also useful concepts in electrical signal processing, lock-in detection, and correlation analysis.
- Optics and Atomic Physics: 12 experiments on interference and diffraction including a brief exposition of the Poisson spot, optical activity and Faraday rotation, atomic

spectra and spectrophotometry, and electron-atom collisions in gases.
- Condensed Matter Physics: 11 experiments on measuring the speed of sound in solids and liquids, magnetism in materials and alloys, and optical response of liquid crystals.
- Semiconductors: 10 experiments on the Hall effect and conductivity in semiconductors, diodes and LED's, bandgap measurement, and spectral analysis of various types of noise in semiconductors.
- Applied Physics: 11 experiments on miscellaneous applied topics, mostly "classics" such as dc motor, transformer, transmission line and coaxial cable, magnetic levitation, oscillations with loudspeakers, fluorescent lamp spectra and cathode-ray devices, the dipole antenna, and piezoelectricity with a quartz resonator.
- Nobel Prize Experiments: 10 Nobel Prize winning experiments demonstrating the principles for which the award was given, but using modern equipment.
- Student Projects: 25 experimental proposals for projects intended to stimulate mainly high school students.

This is the 2nd edition, providing significant enhancement to the already admirable 1st edition published in 2008 (see review in *Physics Today*, March 2008, p. 55), which had just 88 experiments. The chapter organization has been improved, featuring entirely new chapters "Applied Physics" and "Semiconductors," while adding several new experiments to each of the older chapters. The result is a remarkable body of work that offers something for everyone at the high school and freshman/sophomore university levels. In that sense, this book perfectly complements another excellent pedagogical text *Experiments in Modern Physics*, by Melissinos and Napolitano, also in its 2nd edition, which is aimed at the junior/senior university level. Modern day introductory physics instruction at the freshman/sophomore university level aims to integrate the lab with the lecture (e.g., through "inverted classroom" models such as SCALE-UP), and a vast majority of the experiments described in the book are amenable to such integration.

The author, Professor Yaakov Kraftmakher, is in the Department of Physics at Bar-Ilan University, Israel. Many experiments presented in this book stem from his published work over a pedagogical career spanning nearly 60 years: more than 100 refereed articles in journals such as *American Journal of Physics, European Journal of Physics,* and *The Physics Teacher,* to name a few. The firsthand knowledge of the author shows in useful tidbits offered to prospective instructors interested in setting up a lab, such as the advice to use just one lens to demonstrate Newton's rings instead of the classic arrangement with a glass plate and planoconvex lens (p. 288), or the reminder that birefringent polarizers may have up to a 40° tolerance in the angle of incidence (p. 309). The data that are presented are often taken by the author himself, and appropriately referenced.

The encyclopedic nature of the book is both a strength and a weakness. It is extremely useful to have such a vast and well-organized collection of experiments and projects all in one place. But, this also forces some of the explanations to be terse. The ideal reader would treat the book as a starting point and use the exhaustive list of 1200 citations, each of which is referenced appropriately in-text, to research further as needed. The citation list often includes multiple interesting published variations of the same experiment.

The typical format of presentation for each experiment includes a brief introduction to the relevant physics, an equipment list, a description of the experimental apparatus, a brief summary of the experiment, and the data. More advanced topics, such as nonlinear and forced oscillations, Fourier analysis, lock-in detection, high-temperature superconductivity, and some others, include a few pages devoted to background and basic physics, followed by a set of two to three experiments.

While there is much to like about this comprehensive work, a few negative aspects are inevitably present and deserve mention, though they do not significantly diminish the overall utility of this fine book.

- The book heavily relies on PASCO software and instrumentation, which is an understandable path to take, since PASCO equipment is widely used in undergraduate lab instruction. The recently added experiments use the newer generation PASCO 850 Universal Interface (conveniently notated in-text with a large flag inscribed with 850). Some significant improvements over the relatively dated 750 Universal Interface are: a higher-sample-rate oscilloscope (10 MHz), two powerful independent function generators, and integration with the new Capstone software. These improvements simplify data-taking and reduce the need for accessories (e.g., external power supplies and function generators).
- For several experiments, interference and diffraction being one example, the brief introduction contains copious references that, while useful, are presented in a manner that is not convenient for ready reference. A table, with complete reference titles, primary author and year of publication, reference to the citation list at the back of the book, and a brief comment, would be a more desirable method of presentation.
- Some tighter editing would catch typographical errors such as the formula for elastic potential energy on page 14, and the fact that some of the references at the back of the book (about 18, less than 2% of the total citations) are in a language completely different from English. Thus, translation is required in order to decipher the journal in which the article has appeared. Similarly, a translation of the German phrase for the speed of light measurement apparatus on page 667 is advisable.
- User-friendliness of the text would be enhanced if in-line equations were written in TeX, and if some color was used.

Finally, we remark that most experiments described in this book are readily adaptable to alternative modern forms of data-gathering such as Arduino or National Instruments MyRio devices interfaced with LabVIEW, which may lead to exciting new possibilities in introductory and advanced physics lab instruction.

Andrew J. Hachtel is an instructor and Samir Bali is a professor in the physics department at Miami University. They teach undergraduate introductory-level physics courses in an inverted classroom structure. They have developed experiments in optical and atomic physics for the advanced

undergraduate laboratory and published their results in American Journal of Physics. Samir also teaches graduate-level courses and an advanced lab on lasers and optics for seniors and graduate students. His research interests lie in the area of laser cooling and atom trapping, and optical sensing in highly turbid media.

BOOK RECEIVED

Quantum Phase Transitions in Transverse Field Spin Models: From Statistical Physics to Quantum Information. Amit Dutta, Gabriel Aeppli, Bikas K. Chakrabarti, Uma Divakaran, Thomas F. Rosenbaum, and Diptiman Sen. 346 pp. Cambridge U. P., New York, 2015. Price: $140 (hardcover) ISBN 978-1-107-06879-7.

The Quotable Feynman. Michelle Feynman (Ed.). 429 pp. Princeton, U. P., Princeton, NJ, 2015. Price: $24.95 (hardcover) ISBN 978-0-691-15303-2.

Einstein. A Hundred Years of Relativity. Andrew Robinson. 256 pp. Princeton, U. P., Princeton, NJ, 2015. Price: $24.95 (paper) ISBN 978-0-691-16989-7.

Biophysics of DNA. Alexander Vologodskii. 260 pp. Cambridge U. P., New York, 2015. Price: $120 (hardcover) ISBN 978-1-107-03493-3.

Feynman's Operational Calculus and Beyond: Noncommutativity and Time-Ordering. Gerald W. Johnson, Michael L. Lapidus, and Lance Nielsen. 384 pp. Oxford U. P., New York, 2015. Price: $84.95 (hardcover) ISBN 978-0-19-870249-8.

Atomic and Molecular Spectroscopy: Basic Concepts and Applications. Rita Kakkar. 430 pp. Cambridge U. P., New York, 2015. Price: $75 (hardcover) ISBN 978-1-107-06388-3.