BOOK REVIEWS

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An Introduction to Magnetohydrodynamics. P. A. Davidson. 431 pp. Cambridge U.P., New York, 2001. Price: $110.00 (cloth) ISBN 0-521-79149-9; $39.95 (paper) ISBN 0-521-79487-0. (Elena V. Belova, Reviewer.)

The field of Magnetohydrodynamics (MHD) covers a variety of very diverse physical objects ranging from liquid metals to space plasmas. Originally, this branch of physics was born in the pioneering works of Swedish physicist Hannes Alfvén in the context of plasma physics applications, most notably, in magnetospheric and space plasma physics. The vast subject of MHD has been receiving much attention ever since because of its broad applicability to solar physics, geophysics, fusion energy research, and industry.

As applications of MHD vary, so does the content of introductory MHD courses. Thus, there are astrophysical and space plasma physics MHD textbooks, fusion plasma MHD texts, and, in this case, an introductory liquid–metal MHD textbook. While there already exist a number of plasma-MHD texts, there have not been many publications similar to P. A. Davidson's *An Introduction to Magnetohydrodynamics*. The purpose of this book is to provide an introduction to MHD which is oriented towards engineering and metallurgical applications. It is this practical aspect (whether applied to metallurgy or to the geo-dynamo theory), as well as a historical perspective, that distinguishes this book from the others.

Intended to serve as an introductory text, the book does not dwell on the set of topics typical for a plasma-MHD course, such as the ideal MHD limit, linear waves and instabilities, etc. Instead, it deals mostly with resistive and turbulent flows, as they occur in nature or in industrial applications, and introduces the MHD theory as the study of the interaction of magnetic fields and conducting fluids (liquid metals).

The book definitely has its strong points: the emphasis on the underlying physics rather than the mathematical description, clear and well written explanations, historical notes, and very enlightening discussions of the MHD applications, from astrophysical to industrial.

An Introduction to Magnetohydrodynamics is intended primarily for advanced undergraduate and graduate students in physics, applied mathematics and engineering. It does not require a background in fluid mechanics or electrodynamics, but it does assume a knowledge of vector calculus.

The first (and larger) part of the book covers the fundamentals of MHD. The author starts by defining what constitutes MHD, and proceeds to a brief history of the subject. He then goes through the relevant basic aspects of both electrodynamics and fluid mechanics, providing the reader with the necessary tools. Next he introduces the governing equations of MHD, using simple examples to illustrate the ideas behind equations and laws. In the four chapters of this part he covers the entire range of coupling between applied magnetic fields and fluid motion, from small to high magnetic Reynolds numbers. Part one presents a wide variety of material, including the basics of incompressible MHD, MHD turbulence, boundary layers, the dynamo effect, and linear stability theorems in the application of geophysics, solar physics and laboratory experiments.

The second part of the book is devoted to engineering applications. It provides an overview of metallurgical applications of MHD, a history of electrometallurgy, as well as a contemporary account of recent developments in metallurgical MHD. The author has extensive research experience in this field, and he has succeeded in making the presentation both lively and informative. This part of the book is intended for a broader audience, and might be of interest to professional researchers in engineering and metallurgy, as well as other researchers in the MHD field.

The book is unique in bringing together a number of diverse MHD topics such as relaxation, turbulence, and dynamo theory, as well as boundary layer physics and vortex dynamics, and presenting it all at a level suitable for an introductory textbook. This task is accomplished with an emphasis on the fundamental physics of MHD phenomena, and includes illuminating physical insights. At the same time, enough mathematical detail and the essential derivations are given, in a way that is both comprehensive and easy to follow. I found the description of basic fluid mechanics, geodynamo theory, and MHD turbulence particularly detailed and interesting. Notes on the history of MHD and its metallurgical applications, describing the evolution of ideas and approaches, also provide for truly exciting reading. The style of the book is generally clear and fluent.

As to the shortcomings, one would hope that even though the book is solely concerned with incompressible flows, the complete set of compressional MHD equations would at least be mentioned, and the incompressibility assumption discussed. Also, the topics of MHD waves and reconnection probably deserve more attention than they are given in this book. A reader with a plasma physics background may find the terminology slightly unconventional. Every chapter is supplemented with exercises; however, some of these will be too difficult for a student to work out independently.

Overall, the book makes for rewarding reading, and I recommend it to all students of MHD, no matter what their persuasion. It would be an excellent textbook for students with interest in the engineering applications, but also will serve as a perfect complementary text for an introductory plasma MHD course.

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Classical Mechanics, 3rd ed. Herbert Goldstein, Charles Poole, and John Safko. 638 pp. Addison–Wesley, New York, 2002. Price: $105.00 ISBN 0-201-65702-3. (Stephen R. Addison, Reviewer.)

I always open new editions of physics textbooks with some trepidation—you only have to recall the decline of some classics as new editions emerged to understand why. I will leave it to the reader to think of appropriate examples. Of course, there have also been successes: all editions of Kittel's *Introduction to Solid State Physics* are useful—in fact, they are in many ways complementary.

The third edition of Goldstein is neither a disaster nor an outstanding success. The book appears to be well made—it is constructed using sewn signatures. I am sure the book will stand up under heavy use, unlike those produced using the paperback methods that are becoming increasingly common. (For example, I have needed a new copy of the second edition of Boas's *Mathematical Methods in the Physical Sciences* every time I have used it in a course, while my first edition, used daily for more than twenty years, is still holding up well.) Goldstein's third edition is much easier to read than the second, with a font weight comparable to that used in the first edition. The amount of bleed-through from print on the reverse side of the page is similar to the second edition, but the net result is that small symbols (primes for example) stand out much more clearly.

In many ways, this new edition can be considered a minor revision of the second. Most material is presented exactly as it was twenty years ago, and even the new chapter on chaos appears somewhat dated. Thus the book remains a treatment of mechanics primarily for those who are interested in learning the background necessary for quantum mechanics. Goldstein has always fulfilled this role admirably, and I am glad that it will continue to be available to new generations of advanced undergraduates and beginning graduate students.

I expect that many readers will be interested in the new *Suggested References* appearing at the ends of the chapters—this was the first place I looked. Unfortunately, there *aren't* any suggested references in this new edition. The famous capsule reviews of related texts have been replaced by a lightly annotated bibliography at the end, that is barely longer than the one in the second edition. Only the new chapter *Classical Chaos* and the new appendix *Groups and Algebras* have bibliographic references that convey some of the flavor of the original sets of *Selected References*.

The original references are themselves largely absent from the bibliography of the third edition—references provided are mainly from the last ten years. This is a serious omission, since the old references, detailing the sources of the problems, have enabled generations of students to solve the more challenging problems in the text. Of course, many of the solutions can be found on the World Wide Web today, but web availability does not replace the major benefit students derived from the old sets of selected references. Many students first learned literature research skills by tracking down Goldstein's often esoteric sources. And the references are not the only things missing: in the new edition, the number of footnotes has also been reduced. The overall effect is to make the book seem less scholarly—if the first edition was a monograph with problems, the third edition is more clearly a textbook.

Since most readers of this review can be expected to be familiar with earlier editions of the text, I will summarize the differences between the new edition and the second. The third edition contains thirteen chapters and two appendices; the amount of change between editions varies significantly from chapter to chapter.

Chapter One's *Survey of Elementary Principles* has changed little from earlier editions. The number of footnotes has been reduced from six to two. Mathematical references have been entirely eliminated from footnotes. This pattern persists throughout the book. I had always considered the addition of mathematical references to be one of the more significant improvements in the second edition. The first edition assumed mathematical competence, the second provided footnotes for some of the finer points, including references (usually to Kaplan's *Advanced Calculus*); some of the explanations remain, but in later chapters the references are largely omitted. My recent experiences with students' mathematical background suggest that the reform calculus movement has significantly improved computational skills, but familiarity with subtle theoretical issues (such as uniform convergence) and some not-so-subtle points (such as, for instance, how to write the total derivative of a function) is more likely to be lacking. This should have suggested adding *more* footnotes and appropriate references rather than eliminating them.

Chapter Two, *Variational Principles and Lagrange's Equations*, while not extensively revised, includes more changes than Chapter One, and in this respect is typical of the later chapters. The sections on minimum surface of revolution and the brachistochrone problem have been expanded. The discussions of nonholonomic systems and symmetry have been revised and clarified. Conservation of energy has been moved from its former place (in the section on conservation properties and symmetries) to a separate section. The references to Lanczos's *The Variational Principles of Mechanics* are missed. The absence of any reference to a rigorous text on variational methods is a serious problem—Gelfand and Fomin's *Calculus of Variations* and Rund's *The Hamilton-Jacobi Theory in the Calculus of Variations* should have been listed in the bibliography, along with Lanczos.

Chapter Three, *The Central Force Problem*, has a revised title. The publisher describes this chapter as updated; I found that most of the changes occur in the second half. Section 3-5 has been shortened and omits the material on elliptic integrals. Section 3-7 adds material on Keplerian orbits. In section 3-9 a diagram has been added to clarify the Laplace–Runge–Lenz vector. The treatment of scattering is largely as it was in the previous editions. A section on the three-body problem, based on Hestenes's *New Foundations for Classical Mechanics*, has been added.

Chapter Four, *The Kinematics of Rigid Body Motion*, is largely unchanged. The equations have been renumbered, and some notational changes have increased the clarity of discussions. The labeling of some diagrams has been improved. The (frequently omitted) treatment of Cayley–Klein parameters has been reduced from ten pages to one (however, some of this material is presented in Appendix B of the present edition). Matrices are denoted by brackets [ ] rather than parentheses ( ). Unfortunately, this notation is inconsistently applied, and later chapters often revert to parentheses.

Chapter Five, *The Rigid Body Equations of Motion*, actually includes a new footnote—a reference to the *American Journal of Physics*. Section 5-2, in which tensors and dyadics were formerly treated, is now limited to tensors. In practice the treatment of dyadics was omitted by many instructors; nevertheless, specific reference to Milne's *Vectorial Mechanics* or Symon's *Mechanics* would have been appreciated—students should be aware of the power of dyadic methods in complicated calculations of moments of inertia. The balance of the chapter is largely unchanged, though there is some rewording in places.

Chapter Six, *Oscillations*, includes more detail in its examples. The major change is the addition of a section on the damped driven pendulum and the Josephson junction.

Chapter Seven now bears the unwieldy title *The Classical Mechanics of the Special Theory of Relativity*. This chapter, perhaps the most heavily revised in the second edition, has been revised again. Complex Minkowski space has been abandoned in favor of a real metric with signature -2. Other modern notation, including 1-forms, mapping, and the wedge product, is also introduced. Some widely used relativistic terminology (''boost,'' ''Poincaré transformation'') is also introduced, though I found myself wishing for some material on manifolds and affine transformations. A brief introduction to general relativity has been added; this four page section includes the contraction of tensors in curved spaces, and discusses the cosmological constant. The chapter will be considerably more useful to those students going on to study general relativity than the equivalent chapter in either of the earlier editions.

Chapter Eight, *The Hamilton Equations of Motion*, is largely unchanged. Sympletic notation is now illustrated by an example. The section on Routh's procedure has been shortened.

Chapter Nine, *Canonical Transformation*, is also largely unchanged. Some footnotes have been omitted. A table summarizing the useful properties of the four basic canonical transformations has been added. The examples of canonical transformations include more calculational detail than in the earlier editions.

Chapter Ten, *Hamilton-Jacobi Theory and Action-Angle Variables*, is unchanged in its basic content, although some sections have been expanded and a few have been dropped. In particular, the harmonic oscillator as an example of the Hamilton-Jacobi method is now worked out in detail, ignorable coordinates and the Kepler problem are treated in a separate section, with more calculational details provided, and diagrams for Lissajous figures are added in the section on action-angle variables for completely separable systems; the section on the relationship of action-angle variables to Bohr quantum theory, and the section on Hamilton-Jacobi theory, geometrical optics and wave mechanics, have been dropped.

Chapter Eleven, *Classical Chaos*, is the only new chapter in this edition. Topics include periodic motion, the Kolmogorov–Arnold–Moser theorem, attractors, chaotic trajectories and Liapunov exponents, Poincaré maps, the Hénon–Heiles Hamiltonian, bifurcations and driven-damped motion, the logistic equation, Feigenbaum diagrams, and fractals. The level of presentation is slightly more advanced than Baker and Gollub's *Chaotic Dynamics: An Introduction*. Many of the diagrams are adapted from Hénon's *Numerical Exploration of Hamiltonian Systems*, Gollub and Baker, and other texts. The chapter is a worthy addition, presenting a clear survey of classical chaos.

Chapter Twelve, *Canonical Perturbation Theory*, introduced for the first time in the second edition, has been revised. The first three sections (through time-dependent perturbation theory) are largely unchanged. The calculational detail is somewhat increased in the discussion of time-independent perturbation theory. The discussion of specialized perturbation techniques in celestial mechanics has been eliminated.

Chapter Thirteen, *Introduction to the Lagrangian and Hamiltonian Formulations for Continuous Systems and Fields*, probably the weakest chapter in the first edition, was improved by a discussion of Noether's theorem and the addition of a section on relativistic field theories in the second edition. It is essentially unchanged in the new edition. The section on the Hamiltonian formulation has been shortened. The section on Noether's theorem has been rewritten and clarified. I anticipate continuing to refer students to Slater and Frank's *Mechanics* for a lucid introduction to continuous systems and to Jackson's *Classical Electrodynamics* for field theories.

Appendix A, *Euler Angles in Alternative Conventions and Cayley-Klein Parameters*, contains some of the material presented in Chapter Four in earlier editions.

Appendix B, *Groups and Algebras*, introduces the properties of groups, representation theory, Lie groups and algebras, Clifford algebras, and the group theoretic classification of elementary particles—all in twelve pages. The material will be useful to advanced students who want something to jog their memories, but the treatments are too terse for the uninitiated. The space would have been better occupied by a good annotated bibliography.

While I have been critical of certain points, and consider this revision less scholarly than its predecessors, it remains a classic. As a survey of theoretical mechanics for the physics of the nineteenth and twentieth centuries it is unsurpassed, and it should be on the shelf of every serious physics student. Those who are interested in modern theoretical mechanics, framed in the language of differential geometry and Lie groups, will have to remain content with Arnold's *Mathematical Methods of Classical Mechanics*, or consider new works such as the recent estimable *Symmetry in Mechanics: A Gentle Modern Introduction* by Stephanie Frank Singer.

In conclusion, I will still refer students to Goldstein. However, I will likely supply them with annotated reference lists, in the spirit of the first two editions. Readers interested in complete bibliographic details for the texts mentioned in this review will find them in the first two editions of Goldstein.

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BOOKS RECEIVED

Applied Complex Variables for Scientists and Engineers. Yue Kuen Kwok. 392 pp. Cambridge U.P., New York, 2002. Price: $90.00 (cloth) ISBN 0-521-80302-0; $34.95 (paper) ISBN 0-521-00462-4.

Barron's How to Prepare for the AP Physics C Advanced Placement Examination. Robert A. Pelcovits and Joshua Farkas. 749 pp. Barron's, Hauppauge, NY, 2002. Price: $16.95 ISBN 0-7641-1802-1.

Closure Strategies for Turbulent and Transitional Flows. Edited by Brian Launder and Neil Sandham. 754 pp. Cambridge U.P., New York, 2002. Price: $120.00 ISBN 0-521-79208-8.

Collisional Transport in Magnetized Plasmas. Per Helander and Dieter J. Sigmar. 292 pp. Cambridge U.P., New York, 2002. Price: $110.00 ISBN 0-521-80798-0.

Computational Fluid Dynamics. T. J. Chung. 1012 pp. Cambridge U.P., New York, 2002. Price: $95.00 ISBN 0-521-59416-2.

Data Analysis with Excel: An Introduction for Physical Scientists. Les Kirkup. 446 pp. Cambridge U.P., New York, 2002. Price: $110.00 (cloth) ISBN 0-521-79337-8; $40.00 (paper) ISBN 0-521-79737-3.

The Dawn of Human Culture: A Bold New Theory on What Sparked the "Big Bang" of Human Consciousness. Richard G. Klein with Blake Edgar. 288 pp. Wiley, New York, 2002. Price: $27.95 ISBN 0-471-25252-2.

Defects and Geometry in Condensed Matter Physics. David R. Nelson. 377 pp. Cambridge U.P., New York, 2002. Price: $110.00 (cloth) ISBN 0-521-80159-1; $40.00 (paper) ISBN 0-521-00400-4.

Electricity, Magnetism, and Light. Wayne Saslow. 735 pp. Academic, San Diego, CA, 2002. Price not given; ISBN 0-12-619455-6.

Floer Homology Groups in Yang-Mills Theory. S. K. Donaldson. 236 pp. Cambridge U.P., New York, 2002. Price: $75.00 ISBN 0-521-80803-0.

The God of Hope and the End of the World. John Polkinghorne. 154 pp. Yale U.P., New Haven, CT, 2002. Price: $19.95 ISBN 0-300-09211-3.

How the Universe Got Its Spots: Diary of a Finite Time in a Finite Space. Janna Levin. 208 pp. Princeton U.P., Princeton, NJ, 2002. Price: $22.95 ISBN 0-691-09657-0.

Instability Rules: The Ten Most Amazing Ideas of Modern Science. Charles Flowers. 228 pp. Wiley, New York, 2002. Price: $24.95 ISBN 0-471-38042-3.

An Introduction to Cosmology, 3rd ed. Jayant Vishnu Narlikar. 541 pp. Cambridge U.P., New York, 1983, 2002. Price: $100.00 (cloth) ISBN 0-521-79028-X; $50.00 (paper) ISBN 0-521-79376-9.

An Introduction to Quantum Theory. F. S. Levin. 793 pp. Cambridge U.P., New York, 2002. Price: $170.00 ISBN 0-521-59161-9.

Modern Instrumentation for Scientists and Engineers. James A. Blackburn. 319 pp. Springer, New York, 2001. Price not given; ISBN 0-387-95056-7.

Neutron Scattering with a Triple-Axis Spectrometer: Basic Techniques. Gen Shirane *et al.* 273 pp. Cambridge U.P., New York, 2002. Price: $95.00 ISBN 0-521-41126-2.

Physics of Ice (paperback edition). Victor F. Petrenko and Robert W. Whitworth. 373 pp. Oxford U.P., New York, 1999, 2002. Price: $65.00 (paper) ISBN 0-19-851894-3.

Project Orion: The True Story of the Atomic Spaceship. George Dyson. 345 pp. Henry Holt, New York, 2002. Price: $26.00 ISBN 0-8050-5985-7.

Pushing Gravity: New Perspectives on Le Sage's Theory of Gravitation. Edited by Matthew R. Edwards. 316 pp. Apeiron, Montreal, Canada, 2002. Price: $25.00 (paper) ISBN 0-9683689-7-2.

A Quantum Approach to Condensed Matter Physics. Philip L. Taylor and Olle Heinonen. 414 pp. Cambridge U.P., New York, 2002. Price: $120.00 (cloth) ISBN 0-521-77103-X; $45.00 (paper) ISBN 0-521-77827-1.

Quantum Evolution: How Physics' Weirdest Theory Explains Life's Biggest Mystery (paperback edition). Johnjoe McFadden. 338 pp. Norton, New York, 2000, 2002. Price: $16.95 (paper) ISBN 0-393-32310-2.

Quantum Groups and Lie Theory. Edited by Andrew Pressley. 234 pp. Cambridge U.P., New York, 2001. Price: $39.95 (paper) ISBN 0-521-01040-3.

Radiation: At Home, Outdoors, and in the Workplace. Edited by Dag Brune *et al.* 547 pp. Scandinavian Science Publisher, Oslo, Norway, 2001. Price: $95.00 ISBN 82-91833-02-8.

The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900–1933. Emily Thompson. 500 pp. MIT, Cambridge, MA, 2002. Price: $44.95 ISBN 0-262-20138-0.