

A user-friendly text with the core ingredients

Physics The First Science

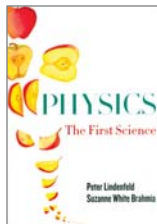
Peter Lindenfeld and
Suzanne White Brahmia
Rutgers U. Press, Piscataway, NJ, 2011.
\$72.00 (416 pp.).
ISBN 978-0-8135-4937-8

Reviewed by Shaukat Goderya

Anyone who is teaching algebra-based physics should consider the textbook *Physics: The First Science*. I am, and I intend to use it in my college physics classes in the spring of 2013.

Armed with their strong teaching experience, Rutgers University professors Peter Lindenfeld and Suzanne White Brahmia have written a highly recommended text that is terse and concise, yet informative and complete. *Physics: The First Science* has an entirely different style and completely different content selection from popular textbooks available on the market. The easy-to-read, double-column format works well to connect the topics within each chapter. The subject progression from chapter to chapter is logical and builds a continuous and well-integrated story. Diagrams and figures are simple, both from the instructor's perspective for use in class lectures and from the student's for assistance in understanding the problem. There are no colored diagrams, which in my opinion are unnecessary for learning physics; after all, students do not often use color when solving problems.

In the first 13 chapters (of 15, plus a quick wrap-up), the authors discuss the fundamental forces of nature and all the core topics in classical mechanics, electricity and magnetism, nuclear physics, and quantum physics. If you are required to assess your algebra-based physics classes, as I must for the Southern Association of Colleges and Schools,



then you will love chapter 14, "Energy in Civilization," and chapter 15, "Atomic Physics Pays Off: Solar Cells, Transistors, and the Silicon Age." They are timely additions that show how physics influences society and our daily life—making such a connection is a criterion for accreditation-agency assessments.

In my many years of teaching physics I have found that a majority of students just don't read bulky textbooks. This roughly 350-page text is structured for a two-semester college physics course and is an easy read. Instructors will have no problem covering half of the text in each semester. Most currently popular textbooks have nearly 1000 pages and 30 chapters to be covered in a two-semester course. Even the most experienced instructors have difficulty covering 15 chapters in 15 weeks. This textbook's compact presentation helps solve that problem; moreover it is structured to allow for flexibility in course design. For example, the essential topics in fluid, heat, and thermodynamics are all covered in chapter 7. Coverage of the second law of thermodynamics and entropy is found in chapter 14, where it could be saved for the second semester or assigned as additional first-semester reading material.

The majority of the text requires only background knowledge of high-school algebra. Derivatives and integrals are used to make connections with slopes and areas where appropriate in the text, but are never required in problem solving.

A unique feature of the book is its guided review questions. Because they are linked to the worked examples, they force the student to concentrate on learning the concepts. Many of those examples and questions require the student to work with the interactive simulations developed by PhET at the University of Colorado, Boulder (<http://phet.colorado.edu>). The PhET simulations are an excellent resource to engage high school and college students in active learning. The website is user friendly, and today's computer-savvy students will have no problem using the simulations. The website is accessible for free, which makes this textbook more economical than some others that charge for access to supplementary Web assignments.

For all its strengths, *Physics: The First Science* has a few drawbacks that instructors should consider. Although there are plenty of problems to choose for homework assignments, the difficulty level of each problem is not stated. And although the solutions to some problems can be found at the book's website (<http://rutgerspress.rutgers.edu/physics.html>), it is not clear whether any ancillary materials—test banks, solution manuals, online problem banks, and so on—are available for the instructor. And unlike other popular algebra-based physics texts, this one does not include helpful discussions on problem-solving techniques and strategies for the concise worked examples. I hope the next edition will offer more symbolic problems, as they are important in illustrating how to develop mathematical relationships between known physical variables and unknown quantities.

Space Chronicles Facing the Ultimate Frontier

Neil deGrasse Tyson
W. W. Norton & Co, New York, 2012.
\$26.95 (368 pp.).
ISBN 978-0-393-08210-4

I love listening to and reading the views of Neil deGrasse Tyson. His comprehensive knowledge of physics, passion for space and science education, sense of humor, and the ease with which he gets to the heart of difficult technical matters make him one of the world's most highly regarded communicators of science and technology. For those reasons, I was eager to read *Space Chronicles: Facing the Ultimate Frontier*—a compilation of his past space-exploration writings, loosely broken into three sections: Why, How, and Why Not.

Tyson had me at the dedication: "To all those who have not forgotten how to dream about tomorrow." Indeed, space advocates, the physics community, and the public will find much to like about this book.



Shaukat Goderya is an associate professor of engineering and physics and director of the program for astronomy education and research at Tarleton State University in Stephenville, Texas. He has taught algebra-based physics for more than two decades.

I particularly enjoyed his description of why space exploration is important to society and why the US must continue to explore. His thought-provoking discussion of the economic and national security benefits of the nation's space program is enlightening, and his use of historical analogues is vivid and compelling. I found myself agreeing with him on the importance of seeking breakthrough innovations: developing new space technologies and industries to provide lasting societal benefit and to serve as a catalyst to the US high-tech economy. I believe his thesis that reaching for grand technological challenges is the best way to move our society forward and inspire the next generation into science and technology fields.

In chapter 32, "Perchance to Dream," Tyson poses an interesting question. We've improved on the brick-sized cell phone, the eight-track tape, the car with a mechanical crank starter, and the airplane that looked like a cloth-wrapped insect. So why do we stare with awe and reverence at the Saturn V rocket? Why have we not yet surpassed this legendary first-of-a-kind system? Why does the space community try over and over again to repeat the Apollo program?

Space Chronicles is an excellent read, but I believe Tyson's text misses the mark in two areas: In its farsighted focus on the future, it misses the excitement of the present, and its recommendations for NASA funding are oversimplified.

The book offers surprisingly little discussion of the space advancements actually being made today, many of which are revolutionary. I had hoped Tyson would enlighten me, in his own unique way, on the search for Earth-like planets by NASA's *Kepler* spacecraft, discoveries anticipated from the Mars *Curiosity* rover, missions planned to the outer planets, and the way we will view the universe and ourselves when first data from the *James Webb Space Telescope* are analyzed.

Tyson fails to adequately recognize the dramatic and revolutionary commercial competition for cargo and crew transport services to low Earth orbit. Indeed, the SpaceX *Dragon's* successful berthing at and return from the International Space Station in May was one for the history books. He also fails to cover the advances NASA is making to enable humans to live and work in deep space and the scientific and technological benefits the research being conducted on the ISS is having to life on Earth.

The book provides compelling, easy-to-understand views of the NASA budget and advocates for greatly increasing—even doubling or quadrupling—the current budget. Unfortunately, Tyson's perspective ignores the fact that NASA funding must be balanced among other science and technology agencies and across the federal government as a whole. It also contradicts Tyson's own statements, backed by history, that only war, greed, or the celebration of power can motivate sustained federal funding of large science and technology programs.

Rather than discuss such a dramatic and, frankly, unrealistic increase in the NASA budget, I would have hoped Tyson would discuss more thoroughly what NASA can do with its approximately \$18-billion budget. That amount, according to Appendix H in *Space Chronicles*, is 50% higher than the cumulative amount spent by the rest of the world. Tyson's stated motive for dramatically increasing NASA's space-exploration spending is to spur more students into science and technology careers. That goal is certainly worthy of federal action and investment, but it may be best

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accomplished by focusing NASA on innovation, technology, and discovery to obtain the most “dream advancement” per dollar from the agency’s far-reaching programs. As Tyson points out, a NASA that is focused on exploring deep space is much more inspiring than one going round and round in low Earth orbit.

By winning the 1960s race to the Moon, NASA made a lasting imprint on the economic, national security, and geopolitical landscape of the time. Told in a style that is a joy to read, *Space Chronicles* captures the challenges faced by our space program then as well as today and reminds the reader why NASA matters as much now as ever.

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100 Years of Superconductivity

Edited by Horst Rogalla and Peter H. Kes
CRC Press, Boca Raton, FL, 2012.
\$99.95 (830 pp.).
ISBN 978-1-4398-4946-0

Last year more than 1300 scientists gathered in The Hague for the Superconductivity Centennial Conference honoring Heike Kamerlingh Onnes’s landmark discovery. Out of that celebration came *100 Years of Superconductivity* edited by conference chairmen Horst Rogalla and Peter Kes. Contributors were asked to detail the historical roots and phenomenal growth of the science and technology of superconductivity over its first century. Far from being a conference proceeding, the book is a retrospective chronicling 100 years of serendipitous discoveries and intellectual triumphs—and technological breakthroughs that Onnes could not have imagined in 1911.

Superconductivity manifests quantum mechanics on a macroscopic scale. That single fact explains the century of excitement that has followed its discovery. On the theoretical side, superconductivity became a challenge to the brightest minds of the time, and a satisfactory microscopic theory of even the simplest materials had to await the development of a quantum many-body formalism. Experimentalists were challenged to discern subtle quantum effects in complex materials at cryo-

genic temperatures, and engineers struggled to exploit the advantages of superconductivity. In the end, science has triumphed. Over the past century, nine physicists have received the Nobel Prize for their contributions to superconductivity, and there has been much to celebrate.

The midpoint of superconductivity’s first century roughly divides scientific exploration from technological development. Although the bulk of *100 Years of Superconductivity* is devoted to technology, the exciting first half-century receives due attention. It was during those early years that physicists revealed the fantastic nature of the phenomenon. Experimentally, Onnes showed that the superconducting state exhibits zero resistance, and Walther Meissner revealed its perfect diamagnetism. Those observations were explained by the phenomenological theory of brothers Fritz and Heinz London, who assumed that electrons flow without scattering.

As quantum mechanics matured, it became apparent that scattering is suppressed when electrons condense into a single macroscopic quantum state. Applying that idea, Fritz London noted that the magnetic flux through a superconducting loop will be quantized. Then Vitaly Ginzburg and Lev Landau developed a phenomenological equation for the macroscopic wavefunction itself. Finally, the puzzle of the condensate was solved by John Bardeen, Leon Cooper, and Robert Schrieffer, who developed the amazingly complex microscopic BCS theory, based on an attractive force mediated by phonons, that binds a pair of electrons of opposite spin into a so-called Cooper pair (see the review by Malcolm Beasley of *BCS: 50 Years* in *PHYSICS TODAY*, July 2011, page 53).

The book details the long struggle to discover materials and engineer conductors that carry large currents in the presence of high magnetic fields. The path to superconductive applications began with Onnes’s vision of an electromagnet maintaining a persistent field without input power. To his great disappointment, Onnes discovered that magnetic fields above a modest value completely penetrated the materials of his day and destroyed their superconductivity. Large-scale applications, such as magnets and electric-power distribution, had to wait until Alexei Abrikosov saw the possibility of a second type of superconductor for which the field penetration is gradual and

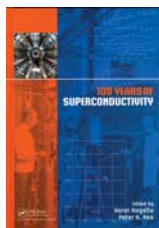
takes the form of individual flux quanta or vortices that leave the surrounding material superconducting. The practical conductors developed from such materials are now used in myriad applications, including magnets for magnetic resonance imaging and the bending and focusing magnets essential to CERN’s Large Hadron Collider.

Small-scale electronic applications largely rely on superconductive tunneling effects predicted by Brian Josephson. Motivated by the possibility of revealing the phase of the macroscopic wavefunction, Josephson applied BCS theory to solve the tunneling Hamiltonian for Cooper pairs and demonstrated that pair tunneling is sensitive to the difference in phase between two superconductors. Based on that effect, the superconducting quantum interference device is highly sensitive and capable of resolving a small fraction of a flux quantum. Its many applications at the frontiers of research include magnetoencephalography, quantum computing, and the search for dark matter.

From start to finish, the book includes historical vignettes, provides a comprehensive introduction to the science and technology behind a wide range of applications, and presents authoritative and often personal accounts of specialists in the field. The insights and anecdotes captured in *100 Years of Superconductivity* will be a delight to those engaged in the field and a significant resource to historians.

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The Theory That Would Not Die

How Bayes’ Rule Cracked the Enigma Code, Hunted Down Russian Submarines, and Emerged Triumphant from Two Centuries of Controversy

Sharon Bertsch McGrayne
Yale U. Press, New Haven, CT, 2011.
\$27.50 (320 pp.).
ISBN 978-0-300-16969-0

For more than 200 years, a controversy has persisted over the incontrovertible theorem developed by 18th-century British amateur mathematician Reverend Thomas Bayes. The story is captured by Sharon McGrayne in *The The-*