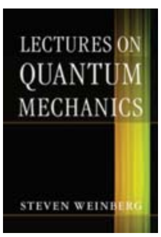
to any expert reader. Baggott says that the quark content of a proton (two ups and a down) violates the fermion statistics embodied in the Pauli exclusion principle, which states that two identical particles cannot inhabit the same quantum state. But if the spins of the two up quarks are opposite, there is no problem; it is baryons like the Δ^{++} with its three up quarks or the Δ^{-} with its three down quarks that inspired Oscar (Wally) Greenberg, Moo-Young Han, and Yoichiro Nambu to propose quark color. And in describing the role of beta decay in helping physicists work out the nature of the weak force, Baggott shows Feynman diagrams that illustrate neutrino scattering instead of beta decay.

Similar mistakes are sprinkled throughout the manuscript. Although they might not be enough to condemn the whole book (some readers will not catch such mistakes in the details), one is left with the unsettling suspicion that comparable errors are to be found in the historical sections as well. Although *Higgs* is more up-to-date, perhaps a safer choice detailing the history of the Higgs boson is Ian Sample's *Massive: The Missing Particle That Sparked the Greatest Hunt in Science* (Basic Books, 2010; reviewed in PHYSICS TODAY, May 2011, page 47).

Lectures on Quantum Mechanics

Steven Weinberg
Cambridge U. Press, New York, 2013.
$75.00 (358 pp.).
ISBN: 978-1-107-02872-2

Steven Weinberg, a Nobel laureate for his contributions to the standard model of elementary particles, has a well-deserved reputation as a writer who draws on great depths of physical insight to produce exceptionally clear prose. Until now, his books have been intended either for a general or advanced audience. For general readers, his books include *The First Three Minutes: A Modern View of the Origin of the Universe* (Basic Books, 1977) and *Lake Views: This World and the Universe* (Harvard University Press, 2010). For advanced readers, he has written *Gravitation and Cosmology* (Wiley, 1972), the three-volume *Quantum Theory of Fields* (Cambridge University Press, 2000), and *Cosmology* (Oxford University Press, 2008).



Weinberg now turns his attention to a core subject in physics with *Lectures on Quantum Mechanics*, a text based on a year-long course he has taught to first-year graduate students. The book begins with a 27-page "Historical Introduction" that concisely and elegantly summarizes the development of quantum physics, including an explication of Werner Heisenberg's matrix mechanics and its equivalence to Erwin Schrödinger's wave mechanics. We also find some little-known historical tidbits, such as who coined the word "photon."

The detailed discussion of quantum mechanics then begins with the Schrödinger equation for a particle in a central potential. Even in such well-worn territory, Weinberg finds interesting twists. For example, he neatly shows how the separability of the wavefunction follows directly from rotational symmetry. He also comments on how the energy levels of different atoms influence the cooling rates of astrophysical gases. This pattern of detailed mathematical exposition enlivened by examples—sometimes surprising ones—of physical phenomena continues throughout the book and is one of its chief merits.

Next, Weinberg introduces the mathematical machinery of state vectors, Hilbert space, observables, and transition amplitudes, with an emphasis on the role of symmetries. Strikingly, though, Paul Dirac's bra–ket notation is eschewed almost entirely, because, as Weinberg explains in the preface, "for some purposes it is awkward." That may be so, but given its ubiquity in the physics literature, it is disappointing that students will get so little exposure to it in this book.

Both students and experts will be particularly interested in the section "Interpretations of Quantum Mechanics," which discusses the Copenhagen, many-worlds, and decoherent-histories interpretations in some detail. Weinberg's striking conclusion, which he admits is "not universally shared," is that "today there is no interpretation of quantum mechanics that does not have serious flaws." That will no doubt provoke further debate, and the section is a good primer for those who would like to follow future developments.

From here, the book moves on to material that is mostly standard for a graduate-level course. But Weinberg presents it with a high level of rigor and clarity and with numerous discussions of related physics not always found in other textbooks: for example, magic numbers in nuclei, how the parity of the pion was determined, and the existence of both left- and right-handed sugars as an example of symmetry breaking. He also gives a complete treatment of the quantization of the electromagnetic field using Dirac's formalism for constrained systems. Calculations of radiative transition rates in atoms then take us back to the phenomena that originally prompted the development of quantum mechanics. The book concludes with a chapter on "Entanglement" that contains derivations of several forms of the Bell inequalities and an all-too-brief discussion of quantum computing.

In the 24 October 2002 *New York Review of Books*, Weinberg wrote of the tension between "cultures of the image and cultures of the word." He declared, "I am an unreconstructed believer in the importance of the word, or its mathematical analogue, the equation." This book clearly reflects that belief, as it contains not a single figure: There are no pictures, diagrams, plots, or graphs of any kind. Furthermore, Weinberg is completely comfortable with dense notation and expects that his readers will be as well: In the chapter "General Scattering Theory," we encounter an *S*-matrix element labeled with 14 subscripts. These aspects of the book, along with a relatively modest set of end-of-chapter problems, may temper its appeal as a primary textbook, especially for students with limited preparation.

Overall, *Lectures on Quantum Mechanics* must be considered among the very best books on the subject for those who have had a good undergraduate introduction. The integration of clearly explained formalism with cogent physical examples is masterful, and the depth of knowledge and insight that Weinberg shares with readers is compelling.

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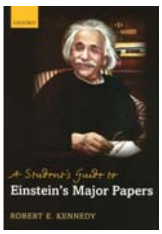
A Student's Guide to Einstein's Major Papers

Robert E. Kennedy
Oxford U. Press, New York, 2012.
$45.00 (296 pp.).
ISBN 978-0-19-969403-7

Physics professors often refer to Albert Einstein's work when teaching relativity, quantum mechanics, or statistical mechanics. I have never given his original papers to my students to supplement their learning, but that will change. I appreciate the importance of having undergraduates read classic and original physics literature, and I have tried to inspire my experimental physics students by assigning Albert Michelson's 1880 description of his measurement of the speed of light or Robert Millikan's 1911 oil-drop paper. I have egged the students on to try and do better than Michelson or Millikan using modern technology.



Some of Einstein's classic papers could also motivate undergraduates, if the physics were fully explained. For instructors who choose to expose their students to Einstein's scientific articles, Robert E. Kennedy's *A Student's Guide to Einstein's Major Papers* will be a welcome supplement. Kennedy focuses on Einstein's four classic papers published in the annus mirabilis of 1905, his doctoral thesis (published in 1906), and his 1916 general relativity paper.

The original papers, unfortunately, do not appear in the book, though free versions can be found on the internet. With great care, Kennedy explains the papers' physics and equations and fills in the gaps in Einstein's derivations. When necessary, he translates Einstein's equations into modern notation. Kennedy also corrects some misconceptions; he observes, for example, that Einstein presented the equivalence of mass and energy, but did not write it as $E = mc^2$.

The book provides a brief history of Einstein's life before 1905 and a backdrop of physics history leading up to that remarkable year in physics. It also presents historical background on each paper before commencing with the explanations. The text's conclusion summarizes Einstein's contributions to the development of quantum mechanics; however, absent any related Einstein article to work through, that chapter feels out of place.

I know from personal interactions that Kennedy, an emeritus professor at Creighton University in Nebraska, has a deep dedication to physics education. He obviously spent a significant amount of time preparing his book so that readers could fully understand the important physics Einstein introduced. But does Kennedy's book contribute anything that has not already been covered by Abraham Pais in *"Subtle Is the Lord . . .": The Science and the Life of Albert Einstein* (Oxford University Press, 1982)? Kennedy makes a point of working through practically every equation that appears in the six papers—to some extent, he has created a workbook that will help readers unravel those papers. Pais distills the most important points associated with the important papers, and is far more detailed on Einstein's history.

The perfect audience for Kennedy's guide would be physics professors on sabbatical. Most physicists would enjoy it, but working through the physics is time consuming and nontrivial, even if ultimately rewarding. I would be hesitant to give Kennedy's book to undergraduates, except perhaps in the context of a senior thesis project. A motivated teacher could certainly use it as a tool to help guide students through a reading of a particular paper. However, in my view, only four of the six original papers are appropriate for undergraduates: "On a heuristic point of view concerning the production and transformation of light," "On the electrodynamics of