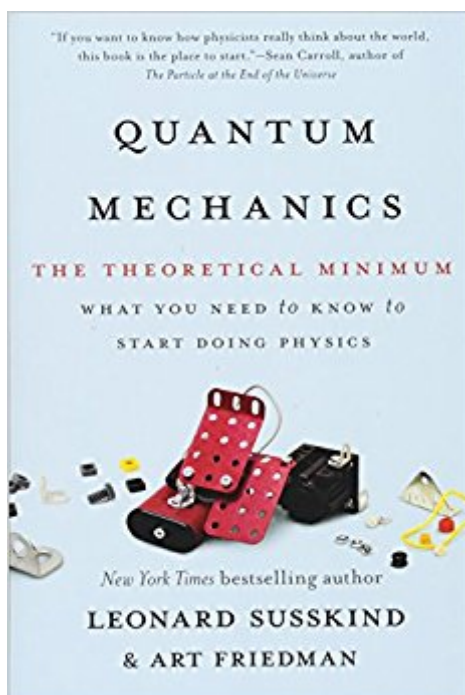


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# Quantum Mechanics: The Theoretical Minimum



## Synopsis

First he taught you classical mechanics. Now, physicist Leonard Susskind has teamed up with data engineer Art Friedman to present the theory and associated mathematics of the strange world of quantum mechanics. In this follow-up to the New York Times best-selling *The Theoretical Minimum*, Susskind and Friedman provide a lively introduction to this famously difficult field, which attempts to understand the behavior of sub-atomic objects through mathematical abstractions. Unlike other popularizations that shy away from quantum mechanics's weirdness, *Quantum Mechanics* embraces the utter strangeness of quantum logic. The authors offer crystal-clear explanations of the principles of quantum states, uncertainty and time dependence, entanglement, and particle and wave states, among other topics, and each chapter includes exercises to ensure mastery of each area. Like *The Theoretical Minimum*, this volume runs parallel to Susskind's eponymous Stanford University-hosted continuing education course. An approachable yet rigorous introduction to a famously difficult topic, *Quantum Mechanics* provides a tool kit for amateur scientists to learn physics at their own pace.

## Book Information

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## Customer Reviews

&#147;The writing is fresh and immediate, with plenty of detail packaged into the smooth narrative.... [O]n their own terms, I found Susskind and Friedman's explanations crisp and satisfying.... I maintain a clear recollection of the bewilderment with which I struggled through my own university quantum-mechanics courses. For students in a similar position, trying to draw

together the fragments of formalism into a clear conceptual whole, Susskind and Friedman's persuasive overview; and their insistence on explaining, with sharp mathematical detail, exactly what it is that is strange about quantum mechanics; may be just what is needed. David Seery, Nature; [T]he book will work well as a companion text for university students studying quantum mechanics or the armchair physicists following Susskind's YouTube lectures. Publishers Weekly; This is quantum mechanics for real. This is the good stuff, the most mysterious aspects of how reality works, set out with crystalline clarity. If you want to know how physicists really think about the world, this book is the place to start. Sean Carroll, physicist, California Institute of Technology, and author of The Particle at the End of the Universe --This text refers to an out of print or unavailable edition of this title.

Leonard Susskind has been the Felix Bloch Professor in Theoretical Physics at Stanford University since 1978. He is the author (with George Hrabovsky) of The Theoretical Minimum, as well as The Black Hole War and The Cosmic Landscape. He lives in Palo Alto, California. Art Friedman is a data consultant who previously spent fifteen years at Hewlett-Packard as a software engineer. A lifelong student of physics, he lives in Mountain View, California.

Physics lectures are of three types according to this anecdote of Niels Bohr: "A young man was sent by his own village to a neighboring town to hear a great Rabbi. He was to bring back a report in which all could share. When he returned he told his eagerly awaiting fellow citizens: "The Rabbi spoke three times. The first was brilliant; clear and simple. I understood every word. The second was even better, deep and subtle. I didn't understand much, but the Rabbi understood it all. The third was by far the finest; a great and unforgettable experience. I understood nothing and the Rabbi himself didn't understand much either." Professor Susskind (1) of Stanford University is far ahead of Bohr's Rabbi "he understands it all. To Susskind "Everything is easy in Quantum mechanics" (2). So easy that he always "destroys his lecture notes to prevent his lectures being the same next time" (3). "Given enough time, with no distractions, you could use [his book (4)] to eventually master Quantum Mechanics" (5). An attractive challenge as the book is only 350 pages. Only 350 pages perhaps, but it assumes you are versed in Classical Mechanics (which you aren't). Realistically, you need Susskind's first book (6) plus a preliminary YouTube series of 9 x 1.5 hour lectures on Quantum Entanglement (7). Plus you will need assistance from 10

x 1.5 hour YouTube lectures (8) in parallel with the book. Still a realistic challenge given the results (9). According to Susskind, Quantum Mechanics is much more fundamental than classical physics. As far as we know quantum mechanics provides an exact description of every physical system (10). Moreover, the logic of classical mechanics of Newton is incorrect, the underlying structure is inadequate (11). Not only should we logically learn quantum mechanics first, it is technically much easier than classical mechanics (12). Susskind lives in a Quantum Mechanical world, the real world, deploring our choice of units that makes Avogadro's Number (13) and the speed of light (14) ridiculously large and Planck's Constant (15) ridiculously small. He blames historical chemists who measured things by comparison to the size of their hands. Choosing units appropriate to the sub-atomic scale, such as making Planck's constant = 1, would make his world feel normal. For those who enjoyed science and mathematics to a reasonable level (16) but who had to follow a career to survive in the world, this is more an opportunity than a challenge. Not that it is not a challenge! It is a mind tingling challenge. A way of familiarizing with the real subject with the actual equations - not a popularization. The fascinating history of Archimedes, Johannes Kepler and Isaac Newton fitting an ellipse to the Mars orbit and concluding with the Law of Gravity is only the half of it. Understand how the mathematics of vectors and matrices are fitted to the real world being Quantum Mechanics. Like Archimedes the French mathematicians Joseph-Louis Lagrange, Simon Poisson, and the Irish mathematician William Rowan Hamilton were nice enough to magically or inadvertently provide the mathematics a long time prior to make it possible. Why this mathematical physics works no one knows, neither Susskind nor the Rabbi. One moment you feel like Niels Bohr's student in his third lecture then you are stunned when Professor Susskind commences a short summing-up by saying, in a matter-of-fact way, that an equation derived in the lecture is called Schrödinger's equation (17)! Or that the postulates he has been talking about are Dirac's postulates of Quantum Mechanics formulated in the 1930's which have never needed to be replaced (18). Or, early on, describes a vector and says that it is Dirac's notation (19). Finally, Susskind is to be applauded. If this can be done with Quantum Mechanics, it can be done in any subject of Physics or Mathematics or any other area of study. There must be a value in doing this (other than ex-auto workers retraining themselves for jobs at CERN) as the work will inevitably not continue to be publically funded unless tax-payers have some idea what it is. PS: The advantage of a career outside Physics is to know you always write the minutes before the meeting. Bohr's student may finally have understood so little that he was not game to return to his village. As a precaution I have written this travelogue well before completing

the trip.(1) Leonard Susskind is the Professor of Theoretical Physics at Stanford University, and director of the Stanford Institute for Theoretical Physics. His Wikipedia entry is a good read in itself.(2) Lecture 9, Quantum Entanglements(3) Lecture 9, Quantum Entanglements(4) Quantum Mechanics “The Theoretical Minimum by Leonard Susskind & Art Friedman. The “minimum” means just what you need to know to proceed to the next level.(5) Science News: quote from back cover of Susskind’s book.(6) The Theoretical Minimum “What you Need to Know to start doing Physics Leonard Susskind and George Hrabovsky.(7) Quantum Entanglements, Susskind, Stanford University, YouTube. It seems that the old unadorned lecture format has stood the test of time with only the whiteboard and marker (when it works) replacing the blackboard and chalk.(8) Modern Physics, Quantum Mechanics, Susskind, Stanford University, YouTube.(9) Well, you did not expect to read 350 pages straight cover to cover and then know Quantum Mechanics, did you? This is a 6 to 12 month project “reading, watching YouTube lectures, frantic note taking hoping you might understand it later (the iPad pause button being a luxury unavailable in university lectures), revision, pushing forward, retreating, then finally with your newfound knowledge applying for a job at CERN.(10) Page xix.(11) Lecture 1, Quantum Mechanics(12) Page xx.(13) Avogadro’s number, number of units in one mole of any substance (being its molecular weight in grams)  $\sim 6.02 \times 10^{23}$ .(14) Speed of Light:  $c \sim 3 \times 10^8$  m/s.(15) Planck’s Constant: The energy contained in a photon, the smallest possible “packet” of energy in an electromagnetic wave  $\sim 6.6 \times 10^{-34}$  joule-seconds.(16) Realistically, for those who think they know classical Newtonian Physics and remember studying vectors and matrices, exponentials such as  $e^{i\vec{A} \cdot \vec{A}_j} = \cos \vec{A} \cdot \vec{A}_j + i \sin \vec{A} \cdot \vec{A}_j$  and who once knew the expansion of  $\sin(\vec{A} \cdot \vec{A}_j + \vec{A} \cdot \vec{A}_k)$ .(17) Lecture 9, Quantum Entanglements(18) Lecture 4, Quantum Mechanics(19) Page 11, Quantum Mechanics “The Theoretical Minimum” Malcolm Cameron 8 May 2016

If you have the mathematical chops to absorb the material, this is a very good introduction to quantum mechanics. Unlike a lot of popular treatments, this one does not shy away from using mathematics to describe its subject. Technically, you do not need much more than high school algebra since the author does a good job of explaining the math he does use, but it would not hurt to have some college or AP level math courses (linear algebra and calculus especially) under your belt. Ironically, this approach seems to make the material more understandable. Most of the popular treatments gloss over the math, which leaves some pretty substantial holes in their explanations (Feynman’s QED is a notable exception). A comment about the Kindle edition: Most Kindle books

with math are horrendously formatted. This book is an exception. The equations are not microscopic (which is usually the case), nor are they enormous (which also happens rather frequently). I have noted that depending on the particular Kindle device you use, there is still some variation in the quality, so your mileage may vary. Just so you are not confused, this comment only refers to the Quantum Mechanics volume of The Theoretical Minimum. The first volume, surprisingly, is not so well formatted.

This book is not a popular physics narrative meant to inspire people about concepts. It is something far more useful. It is a real down to Earth look at the mathematical basis one must have in order to actually work with systems that are effected by quantum mechanical phenomenon. This book doesn't pretend that quantum physics is immediately attainable and that anyone who can read a book can go and accurately explain things like the quantum limitations on the size of silicon transistors. I liked this book because it is up front about the work you must put in to understand the mathematical language and established physical theories which describes how things interact in our Universe, so that we aren't all just adding to the confusion.

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