A Student's Guide to the Schrödinger Equation

by Daniel. A. Fleisch

Publisher: Cambridge University Press, 2020

AUTHOR(S) OF THIS REVIEW: Alexander Bilsland,
Simon Langton Grammar School for Boys.

Accepted for publication: July 27th 2020

Address correspondence to: Sixth Form. Simon Langton Grammar School for Boys, Canterbury, Kent. CT4 7NS.

Chief Editor: Claire L Parkin[PhD]. Current affiliation is: Kent and Medway Medical School and Centre for Professional Practice, University of Kent, Canterbury, Kent. ME44AG.

C.L.Parkin@kent.ac.uk | Claire.parkin@kmms.ac.uk
AJPP@kent.ac.uk
https://journals.kent.ac.uk/index.php/ajpp/index

AJPP (ISSN Number: Online, 2059-3198). Copyright © 2015 by the Centre for Professional Practice.

STATEMENT ABOUT THE BOOK'S PURPOSE

A Student's Guide to the Schrödinger Equation is a supplementary guide to be read alongside a more wide-reaching text on introductory quantum mechanics, and to a lesser extent, an introduction to the Schrödinger equation for beginners, covering its uses, origins and the problems it is used to solve.

Introduction: A Student's Guide to the Schrödinger Equation is a book from the Student's Guide series, published by Cambridge University Press and written by Daniel Fleisch, who has authored several books in this series. It is written as a guide for students who are studying physics, to deepen their understanding of parts of their course, and is targeted mostly towards those on pre-existing courses as a supplementary resource.

Dotted throughout the chapters are small subheadings entitled, 'Main ideas of this section' and 'Relevance to quantum mechanics'. These are exceptionally useful summaries and serve to distil the most important points of a chapter in the reader's memory. They also provide an understanding as to why the book is covering such ideas in the first place.

Each chapter in the book ends with a set of ten questions for the reader to complete, which increase in difficulty. The answers to these questions, along with sets of hints and worked solutions, can be found on the book's complementary website; the link to which is provided on the back cover. It would be useful if the solutions were also available at the back of the book for offline use, however, the online bank is very detailed, and offers far more than just a list of answers.

Context: The structure of this book comprises five chapters, each with a set of questions at the end. The chapters all cover slightly different topics but are best read in order, as mathematical apparatus used in later chapters are explained in earlier ones.

The first two chapters are dedicated to a succinct explanation of the mathematical description of a quantum state, with Chapter 1 being focused largely on abstract vectors and spaces, whilst Chapter 2 focuses more on operators and matrix representations of operators. The first chapter lends itself to relatively simple explanations, and anyone with a basic knowledge of vectors and some simple calculus should not have trouble following the reasoning, nor answering the questions at the end. However, those encountering these concepts for the first time may have trouble grasping the concept of an abstract space, or make the mistake of trying to picture a vector state space as a representation of real space.

Chapter 2 provides a summary of matrix mechanics, Hermitian conjugation, and how operators act on quantum states to produce an eigenstate. While this is a useful chapter for teaching how operators pertain to quantum mechanics, it does not suitably equip someone unversed in matrices, as it requires at least a basic understanding of matrices and how a matrix representation can change from one basis set to another. It is however, a fairly good introduction to Hermitian conjugation for those unfamiliar to this concept. Notably, it takes time to introduce the reader to the idea of projection operators which, despite being useful, is not actually required to understand the rest of the book, inferring that it may have been better placed at the end of the chapter.

Chapter 3 focuses on obtaining an understanding of the Schrödinger equation itself. The author's choice to approach the equation using the general expression of a wave was novel, and helped to show how the equation usually produces solutions in the form of weighted combinations of sinusoids. The reader might find the pace of this chapter quite fast, requiring multiple readings to understand the content, but the questions at the end are particularly helpful to tie the content together and reinforce it, thus making the questions an essential part of this chapter.

Chapter 4 deals with solutions to the equation, and the first half consolidates all that has come before in a way that is fairly easy to understand how the results shown at this point have been obtained. The section on understanding the shape and curvature of the wavefunction, depending on the energy term of the time independent equation, is in particular a very intuitive and well-explained section, with the results of the mathematics being easily understood through the diagrams shown. The second half of the chapter is much more challenging and deals with Fourier transforms and how position and momentum wavefunctions are related to them. The book assumes that the reader is already quite familiar with Fourier transformations and how functions of position and wavenumber are connected, and so further reading might be required before tackling this chapter. There is a prior book in the Student's Guide Series that explicitly deals with Fourier transformations, and so the expectation could be that the reader would tackle this first, however, the two books are written by different authors, and do not seem to share a connection.

Chapter 5 is split into three separate sections concerning three different problems: the infinite potential well, the finite potential well, and the quantum harmonic oscillator. All three of these problems are hard to grasp and require multiple readings to understand, but they serve to consolidate the mostly abstract work of the prior chapters, showing how the Schrödinger equation is actually used in context to solve problems. The end-of-chapter questions in this section are particularly hard, but as these are the final in the entire book, this makes sense as they serve to test the reader's accumulative knowledge, gained throughout the preceding chapters

Evaluation: Overall, I would say that this book is very successful at its stated goal of serving as supplementary material to a course, but as a complete guide for beginners it is lacking in some areas. The book explains several topics extremely well, but leaves others largely untouched, hence, one cannot recommend it to a complete beginner. For instance, the time independent equation is introduced largely independent of context, and those unfamiliar with the concept of a Hamiltonian may be confused by this. The last chapter is an excellent consolidation exercise, with almost every piece of information covered in the prior chapters being necessary to understand the solutions to the problems given.

Summary: This is a very useful text for those on a course covering these topics who wishes to deepen their understanding, as well as for anyone with at least a passing familiarity with the mathematics involved. It is not overly well-suited as an introductory text, but it does not aim to be one. Overall, the book paces itself well and introduces the reader to new mathematical concepts at a steady enough pace to not be overwhelming, and the questions and additional resources provided help tie it all together. It is very easy to read and informative, and I will be seeking out the other books by the author as a result, in the hope that they are just as illuminating and well written.

REFERENCE

Fleisch, D.A. (2020) *A Student's Guide to the Schrödinger Equation*. Cambridge: Cambridge University Press.