

Chem3615 Quantum Mechanics Practice Problems

These problems will not be handed in but are to help you prepare for the midterm

1. Find the results of operating with $\hat{A} = x - \frac{d}{dx}$ and $\hat{B} = x + \frac{d}{dx}$ on the function $f(x) = e^{-\frac{x^2}{2}}$

$$\hat{A}f(x) = \left(x - \frac{d}{dx}\right) e^{-\frac{x^2}{2}} = xe^{-\frac{x^2}{2}} + xe^{-\frac{x^2}{2}} = 2xe^{-\frac{x^2}{2}}$$

$$\hat{B}f(x) = \left(x + \frac{d}{dx}\right) e^{-\frac{x^2}{2}} = xe^{-\frac{x^2}{2}} - xe^{-\frac{x^2}{2}} = 0$$

2. Which of the following functions is an eigenfunction of the operator $\frac{d}{dx}$? Give the eigenvalue where appropriate. k is a constant.

a. k $\frac{d}{dx}(k) = 0 = 0(k)$ \therefore k is an eigenfunction with eigenvalues of 0

b. kx^2 $\frac{d}{dx}(kx^2) = 2kx \neq c(kx^2)$ \therefore kx^2 is not an eigenfunction

c. $\sin(kx)$ $\frac{d}{dx}(\sin(kx)) = k\cos(kx) \neq c(\sin(kx))$ \therefore $\sin(kx)$ is not an eigenfunction

d. e^{kx} $\frac{d}{dx}(e^{kx}) = k(e^{kx})$ \therefore k is an eigenfunction with eigenvalues of k

e. e^{kx^2} $\frac{d}{dx}(e^{kx^2}) = 2kxe^{kx^2} \neq c(e^{kx^2})$ \therefore e^{kx^2} is not an eigenfunction

f. e^{ikx} $\frac{d}{dx}(e^{ikx}) = ik(e^{ikx})$ \therefore k is an eigenfunction with eigenvalues of ik

3. What is the value of the following commutators

a. $[\hat{x}, \hat{p}_x]f = \left[x\left(-i\hbar\frac{\partial}{\partial x}\right) - \left(-i\hbar\frac{\partial}{\partial x}\right)x\right]f = -i\hbar\left[x\frac{\partial f}{\partial x} - \frac{\partial(xf)}{\partial x}\right]$

$$[\hat{x}, \hat{p}_x]f = -i\hbar\left[x\frac{\partial f}{\partial x} - f - x\frac{\partial f}{\partial x}\right] = i\hbar f$$

$$\therefore [\hat{x}, \hat{p}_x] = i\hbar$$

b. $[\hat{x}, \hat{p}_x^2]f = \left[x\left(-\hbar^2\frac{\partial^2}{\partial x^2}\right) - \left(-\hbar^2\frac{\partial^2}{\partial x^2}\right)x\right]f = -\hbar^2\left[x\frac{\partial^2 f}{\partial x^2} - \frac{\partial^2(xf)}{\partial x^2}\right]$

$$[\hat{x}, \hat{p}_x^2]f = -\hbar^2\left[x\frac{\partial^2 f}{\partial x^2} - \frac{\partial}{\partial x}\left(f + x\frac{\partial f}{\partial x}\right)\right] = -\hbar^2\left[x\frac{\partial^2 f}{\partial x^2} - \frac{\partial f}{\partial x} - \frac{\partial f}{\partial x} - x\frac{\partial^2 f}{\partial x^2}\right]$$

$$[\hat{x}, \hat{p}_x^2]f = 2\hbar^2\frac{\partial f}{\partial x}$$

$$\therefore [\hat{x}, \hat{p}_x^2] = 2\hbar^2\frac{\partial}{\partial x}$$

c. $[\hat{x}, \hat{p}_y]f = \left[x\left(-i\hbar\frac{\partial}{\partial y}\right) - \left(-i\hbar\frac{\partial}{\partial y}\right)x\right]f = -i\hbar\left[x\frac{\partial f}{\partial y} - x\frac{\partial f}{\partial y}\right] = 0$

$$\therefore [\hat{x}, \hat{p}_y] = 0$$

4. Angular momentum, L , is given by the cross product $r \times p$. So the angular momentum in the x axis, L_x , is given by $yp_z - zp_y$, what is the operator \hat{L}_x ?

$$\hat{L}_x = y\left(-i\hbar\frac{\partial}{\partial z}\right) - z\left(-i\hbar\frac{\partial}{\partial y}\right) = -i\hbar\left(y\frac{\partial}{\partial z} - z\frac{\partial}{\partial y}\right)$$

Quantum Mechanics Problems And Solutions

Lilia M. Woods, Pablo Rodríguez López

Quantum Mechanics Problems And Solutions:

Problems and Solutions on Quantum Mechanics Yung-Kuo Lim, 1998 The material for these volumes has been selected from 20 years of examination questions for graduate students at the University of California at Berkeley Columbia University University of Chicago MIT SUNY at Buffalo Princeton University and the University of Problems & Solutions in Nonrelativistic Quantum Mechanics Anton Z. Capri, 2002 This invaluable book consists of problems in nonrelativistic quantum mechanics together with their solutions Most of the problems have been tested in class The degree of difficulty varies from very simple to research level The problems illustrate certain aspects of quantum mechanics and enable the students to learn new concepts as well as providing practice in problem solving The book may be used as an adjunct to any of the numerous books on quantum mechanics and should provide students with a means of testing themselves on problems of varying degrees of difficulty It will be useful to students in an introductory course if they attempt the simpler problems The more difficult problems should prove challenging to graduate students and may enable them to enjoy problems at the forefront of quantum mechanics

Problems in Classical and Quantum Mechanics J. Daniel Kelley, Jacob J. Leventhal, 2016-11-30 This book is a collection of problems that are intended to aid students in graduate and undergraduate courses in Classical and Quantum Physics It is also intended to be a study aid for students that are preparing for the PhD qualifying exam Many of the included problems are of a type that could be on a qualifying exam Others are meant to elucidate important concepts Unlike other compilations of problems the detailed solutions are often accompanied by discussions that reach beyond the specific problem The solution of the problem is only the beginning of the learning process it is by manipulation of the solution and changing of the parameters that a great deal of insight can be gleaned The authors refer to this technique as massaging the problem and it is an approach that the authors feel increases the pedagogical value of any problem

Problems And Solutions On Quantum Mechanics (Second Edition) Swee Cheng Lim, Choy Heng Lai, Leong-chuan Kwek, 2022-06-02 This volume is a comprehensive compilation of carefully selected questions at the PhD qualifying exam level including many actual questions from Columbia University University of Chicago MIT State University of New York at Buffalo Princeton University University of Wisconsin and the University of California at Berkeley over a twenty year period Topics covered in this book include the basic principles of quantum phenomena particles in potentials motion in electromagnetic fields perturbation theory and scattering theory among many others This latest edition has been updated with more problems and solutions and the original problems have also been modernized excluding outdated questions and emphasizing those that rely on calculations The problems range from fundamental to advanced in a wide range of topics on quantum mechanics easily enhancing the student's knowledge through workable exercises Simple to solve problems play a useful role as a first check of the student's level of knowledge whereas difficult problems will challenge the student's capacity on finding the solutions

Problems in Quantum Mechanics Emilio d'Emilio, Luigi E.

Picasso,2012-02-28 242 solved problems of several degrees of difficulty in nonrelativistic Quantum Mechanics ranging from the themes of the crisis of classical physics through the achievements in the framework of modern atomic physics down to the still alive more intriguing aspects connected e.g. with the EPR paradox the Aharonov Bohm effect quantum teleportation

Exercises in Quantum Mechanics H.A. Mavromatis,2013-06-29 This monograph is written within the framework of the quantum mechanical paradigm It is modest in scope in that it is restricted to some observations and solved illustrative problems not readily available in any of the many standard and several excellent texts or books with solved problems that have been written on this subject Additionally a few more or less standard problems are included for continuity and purposes of comparison The hope is that the points made and problems solved will give the student some additional insights and a better grasp of this fascinating but mathematically somewhat involved branch of physics The hundred and fourteen problems discussed have intentionally been chosen to involve a minimum of technical complexity while still illustrating the consequences of the quantum mechanical formalism Concerning notation useful expressions are displayed in rectangular boxes while calculational details which one may wish to skip are included in square brackets Quantum Mechanics K.

Kong Wan,2020-11-01 This is a companion volume to K Kong Wan's textbook Quantum Mechanics A Fundamental Approach published in 2019 by Jenny Stanford Publishing The book contains more than 240 exercises and problems listed at the end of most chapters This essential manual presents full solutions to all the exercises and problems that are designed to help the reader master the material in the textbook Mastery of the material in the book would contribute greatly to the understanding of the concepts and formalism of quantum mechanics *Problems And Solutions In Nonrelativistic Quantum Mechanics*

Anton Z Capri,2002-12-13 This invaluable book consists of problems in nonrelativistic quantum mechanics together with their solutions Most of the problems have been tested in class The degree of difficulty varies from very simple to research level The problems illustrate certain aspects of quantum mechanics and enable the students to learn new concepts as well as providing practice in problem solving The book may be used as an adjunct to any of the numerous books on quantum mechanics and should provide students with a means of testing themselves on problems of varying degrees of difficulty It will be useful to students in an introductory course if they attempt the simpler problems The more difficult problems should prove challenging to graduate students and may enable them to enjoy problems at the forefront of quantum mechanics

Problems and Solutions in Quantum Mechanics Kyriakos Tamvakis,2005-08-11 This collection of solved problems corresponds to the standard topics covered in established undergraduate and graduate courses in Quantum Mechanics Problems are also included on topics of interest which are often absent in the existing literature Solutions are presented in considerable detail to enable students to follow each step The emphasis is on stressing the principles and methods used allowing students to master new ways of thinking and problem solving techniques The problems themselves are longer than those usually encountered in textbooks and consist of a number of questions based around a central theme highlighting

properties and concepts of interest For undergraduate and graduate students as well as those involved in teaching Quantum Mechanics the book can be used as a supplementary text or as an independent self study tool Exploring Quantum Mechanics Victor Galitski,Boris Karnakov,Vladimir Kogan,2013-03-01 A series of seminal technological revolutions has led to a new generation of electronic devices miniaturized to such tiny scales where the strange laws of quantum physics come into play There is no doubt that unlike scientists and engineers of the past technology leaders of the future will have to rely on quantum mechanics in their everyday work This makes teaching and learning the subject of paramount importance for further progress Mastering quantum physics is a very non trivial task and its deep understanding can only be achieved through working out real life problems and examples It is notoriously difficult to come up with new quantum mechanical problems that would be solvable with a pencil and paper and within a finite amount of time This book remarkably presents some 700 original problems in quantum mechanics together with detailed solutions covering nearly 1000 pages on all aspects of quantum science The material is largely new to the English speaking audience The problems have been collected over about 60 years first by the lead author the late Prof Victor Galitski Sr Over the years new problems were added and the material polished by Prof Boris Karnakov Finally Prof Victor Galitski Jr has extended the material with new problems particularly relevant to modern science *Problems and Solutions in Quantum Chemistry and Physics* Charles Sidney Johnson,Lee G. Pedersen,1986-01-01 Two hundred and eighty problems with detailed solutions plus 139 exercises all covering quantum mechanics wave mechanics angular momentum molecular spectroscopy scattering theory and related subjects An excellent problem book I would highly recommend it as a required supplement to students taking their first quantum chemistry course Journal of the American Chemical Society Quantum Mechanics Lanbrecht Piet Kok,J. Visser,1987 **Quantum Mechanics: Problems with Solutions, Volume 6: Problems with Solutions** Konstantin K. Likharev,2019-05-22 Quantum Mechanics Problems with Solutions contains detailed model solutions to the exercise problems formulated in the companion Lecture Notes volume In many cases the solutions include result discussions that enhance the lecture material For readers convenience the problem assignments are reproduced in this volume

Contemporary Quantum Mechanics in Practice Lilia M. Woods,Pablo Rodríguez López,2024-04-30 This helpful and pedagogical book offers problems and solutions in quantum mechanics from areas of current research rarely addressed in introductory courses or textbooks It is based on the authors own experience of teaching undergraduate and graduate courses in quantum mechanics and adapts problems from contemporary research publications to be accessible to students Each section introduces key quantum mechanical concepts which are followed by exercises that grow progressively more challenging throughout the chapter The step by step solutions provide detailed mathematical derivations and explore their application to wider research topics This is an indispensable resource for undergraduate and graduate students alike expanding the range of topics usually covered in the classroom as well as for instructors and early career researchers in

quantum mechanics quantum computation and communication and quantum information Princeton Problems in Physics, with Solutions Nathan Newbury, 1991-02-21 Aimed at helping the physics student to develop a solid grasp of basic graduate level material this book presents worked solutions to a wide range of informative problems These problems have been culled from the preliminary and general examinations created by the physics department at Princeton University for its graduate program The authors all students who have successfully completed the examinations selected these problems on the basis of usefulness interest and originality and have provided highly detailed solutions to each one Their book will be a valuable resource not only to other students but to college physics teachers as well The first four chapters pose problems in the areas of mechanics electricity and magnetism quantum mechanics and thermodynamics and statistical mechanics thereby serving as a review of material typically covered in undergraduate courses Later chapters deal with material new to most first year graduate students challenging them on such topics as condensed matter relativity and astrophysics nuclear physics elementary particles and atomic and general physics

Quantum Mechanics Konstantin Konstantinovich Likharev, 2018 1 Introduction 2 1D wave mechanics 3 Higher dimensionality effects 4 Bra ket formalism 5 Some exactly solvable problems 6 Perturbative approaches 7 Open quantum systems 8 Multiparticle systems 9 Elements of relativistic quantum mechanics Appendices A Selected mathematical formulas B Selected physical constants

Quantum Mechanics K. Kong Wan, 2020-11-01 This is a companion volume to K Kong Wan's textbook Quantum Mechanics A Fundamental Approach published in 2019 by Jenny Stanford Publishing The book contains more than 240 exercises and problems listed at the end of most chapters This essential manual presents full solutions to all the exercises and problems that are designed to help the reader master the material in the textbook Mastery of the material in the book would contribute greatly to the understanding of the concepts and formalism of quantum mechanics

Quantum Mechanics :Through Problems V. K. Thankappan, 2003 The Importance Of Problem Solving In Understanding The Principles And Applications Of Quantum Mechanics Cannot Be Over Emphasized As Such The Book Will Be A Valuable Tool For The Students Of Quantum Mechanics The Book Is Divided Into Two Parts The First Part Is Composed Of 8 Chapters Entitled Linear Vector Spaces Quantum Dynamics Theory Of Angular Momentum Symmetry And Conservation Laws Scattering Theory Approximation Methods Identical Particles And Relativistic Wave Equations Each Chapter Consists Of A List Of Problems Preceded By A Brief Write Up On The Topic Of The Chapter The Detailed Solutions To The Problems Are Given In The Second Part Chapter 9 Which Is Divided Into Sections Each Section Corresponding To A Chapter Of The Same Title Such A Physical Separation Of The Solutions From The Problems Is Intended To Encourage Students To Attempt Their Own Solutions Before Looking Up The Solutions Given In The Book

Solution Manual to Accompany Volume I of Quantum Mechanics by Cohen-Tannoudji, Diu and Laloë Guillaume Merle, Oliver J. Harper, Philippe Ribiere, 2023-07-19 Solution Manual to Accompany Volume I of Quantum Mechanics by Cohen Tannoudji Diu and Lalo Grasp the fundamentals of quantum mechanics with this essential set of solutions Quantum

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Solution Manual For Quantum Mechanics (2nd Edition) Ishtiaq Ahmed, Fayyazuddin, Riazuddin, 2014-03-11. This is the solution manual for Riazuddin's and Fayyazuddin's Quantum Mechanics 2nd edition. The questions in the original book were selected with a view to illustrate the physical concepts and use of mathematical techniques which show their universality in tackling various problems of different physical origins. This solution manual contains the text and complete solution of every problem in the original book. This book will be a useful reference for students looking to master the concepts introduced in Quantum Mechanics 2nd edition.

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