جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Applied Quantum Mechanics - MSE 227

Division	Physical Science and Engineering Division
Course Number	MSE 227
Course Title	Applied Quantum Mechanics
Academic Semester	Fall
Academic Year	2019/2020
Semester Start Date	08/25/2019
Semester End Date	12/10/2019
Class Schedule (Days & Time)	04:00 PM - 05:30 PM | Sun Wed

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Stefaan De Wolf	stefaan.dewolf@kaust.edu.sa	+966128084849	3237, 5, Al-Kindi (bldg. 5)	Upon appointment

Teaching Assistant(s)

Name	Email

Course Information

Comprehensive Course Description	This course starts with a very brief overview of Newtonian Mechanics, electromagnetism and special relativity theory. Next, we dive into the wave-particle duality, the wave function and the Schrodinger wave equation to calculate it. This is followed by discussions of the statistical interpretation of the wave function, probability, normalization, momentum and Heisenberg's uncertainty principle. We then discuss stationary states, and study the infinite square potential well to understand their properties. A following section discusses the quantum-mechanical harmonic oscillator, its physical relevance, and two different methods to solve this problem, namely the algebraic method, using operators, and the analytical method. We then focus on the quantum-mechanical description of the free particle, and its scattering and tunneling properties when interacting with potential walls and barriers. We also discuss the properties and evolution of wave packets. Next, we study the case of the Dirac delfta-function potential, and discuss in broader context bound and scattering states, with specific attention to the finite square potential well. So far we mainly dealt with one dimensional cases. A next section discusses the important case of spherically symmetric potentials in three dimensions. With this knowledge, we are ready to fully solve the hydrogen atom problem, and briefly discuss corrections to our results. With the understanding of the quantum numbers for this atom, we will then discuss the properties of other atoms and seek to understand the periodic table. A final section will discuss the formation of energy bands in periodic potential systems such as crystals.
Course Description from Program Guide	Introduction to non-relativistic quantum mechanics. Summary of classical mechanics and electrodynamics. Postulates of quantum mechanics, wave functions, operator formalism and Dirac notation. Stationary state problems, including quantum wells and tunneling. Harmonic oscillator. Time evolution. Approximation methods for time-independent as well as time-dependent interactions.
Goals and Objectives	-Objective 1: The student will be able to formulate and explain the fundamental concepts of Quantum Mechanics. -Objective 2: The student will learn to solve Schrodinger equation fo obtain eigenvectors and energies. -Objective 3: The student will learn to calculate and describe the propagation of a particle in a simple, 1 dimensional potential. -Objecrive 4: The student will gain fundamental insight in the properties of atoms.

Required Knowledge	The student should know about Fourier transforms, Taylor series expansion, basic matrix manipulation, 1st and 2nd order differential equations, as well as standard classical mechanics and electrostatics.
Reference Texts	-David J. Griffiths and Darrell F. Schroeter, Introduction to Quantum Mechanics, Third Edition, Cambridge University Press, 2018, ISBN-13: 978-1-107-189638 -Herbert Kroemer, Quantum Mechanics for Engineering, Materials Science and Applied Physics, Prentice Hall, 1994. ISBN 0-13-747098-3
Method of evaluation	**15.00**% - Quiz(zes) **20.00**% - Presentation **25.00**% - Homework /Assignments **20.00**% - Exam 2 **20.00**% - Exam 1
Nature of the assignments	-There will be regularly a short (written) Quiz on Sunday, covering last weeks material: 15% of total grade -There will be 5 times a homework assignment, each 5 % of total grade. Each homework consists of sets of problems. Students are usually given two weeks to solve these problems and hand over a written report. -There will be 1 presentation project (12 min talk): 20% of total grade
Course Policies	The students are expected to attend all classes and to hand in all homework on time. No deadline extension will be granted.
Additional Information	

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Sun 08/25/2019	Introduction - Newton - Maxwell - Einstein
1	Wed 08/28/2019	Wave-particle duality – Schrodinger wave equation [Presentation assignment]
2	Sun 09/01/2019	Statistical interpretation – Probability – Normalization
2	Wed 09/04/2019	Momentum – Uncertainty Principle [HW1]
3	Sun 09/08/2019	Stationary states
3	Wed 09/11/2019	Infinite square well
4	Sun 09/15/2019	Harmonic oscillator
4	Wed 09/18/2019	Harmonic oscillator – Algebraic method [HW2]
5	Sun 09/22/2019	University holiday
5	Wed 09/25/2019	Harmonic oscillator – Analytical method
6	Sun 09/29/2019	Free particle
6	Wed 10/02/2019	Free particle: Scattering and Tunneling [HW3]
7	Sun 10/06/2019	Free particle: Wave packet
7	Wed 10/09/2019	Repetition material for Midterm Exam
8	Sun 10/13/2019	Midterm Exam
8	Wed 10/16/2019	Delta-function potential [HW4]
9	Sun 10/20/2019	Fall Enrichment
9	Wed 10/23/2019	Fall Enrichment
10	Sun 10/27/2019	Bound and scattering states
10	Wed 10/30/2019	Bound and scattering states
11	Sun 11/03/2019	Presentation projects
11	Wed 11/06/2019	Spherically symmetric potentials [HW5]
12	Sun 11/10/2019	Spherically symmetric potentials - Spherical Harmonics
12	Wed 11/13/2019	Spherically symmetric potentials - Angular Momentum
13	Sun 11/17/2019	Hydrogen Atom
13	Wed 11/20/2019	Hydrogen Atom - Ground State and Energy Eigenvalues
14	Sun 11/24/2019	Hydrogen Atom - Corrections
14	Wed 11/27/2019	Atoms - Periodic table
15	Sun 12/01/2019	Atoms - Periodic table
15	Wed 12/04/2019	Repetition for final exam
16	Sun 12/08/2019	Final Exam

Note

The instructor reserves the right to make changes to this syllabus as necessary.