هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

اعتماد
NCAAA

2024
TP-153

Course Specification
(Bachelor)

Course Title:	Quantum Mechanics 2
Course Code:	PHYS 0444
Program:	BSc in Physics
Department:	Physics
College:	Science
Institution:	Majmaah University
Version:	1
Last Revision Date:	30/12/2024

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A. General information about the course:

1. Course Identification

1. Credit hours: (3=3+0+0)					
2. Course type					
A.	☐University	☐College	☒ Department	☐Track	☐Others
B.	☒ Required		☐ Elective		
3. Level/year at which this course is offered: (Year 4 / Level 7)					

4. Course General Description:

The course introduces the formalism needed by QM and presents some applications such as orbital momentum, spin, and the addition of momenta. The theory of perturbation is also introduced.

5. Pre-requirements for this course (if any)**:**

PHYS 0342

6. Co-requisites for this course (if any)**:**

none

7. Course Main Objective(s):

At the end of the course, the students should be able to:

1. Understanding the Dirac formalism related to bras, kets, and Hermitian operators
2. Apply the quantum mechanics postulates in various situations
3. Grasp the importance of the orbital angular momentum and the spin in quantum mechanics
4. Demonstrate an understanding of the addition of two angular momenta in quantum mechanics and evaluate the energy shift due to spin-orbit coupling
5. Use perturbation theory to solve approximately Schrödinger equation especially to study the Stark effect, Zeeman effect, Hyperfine splitting, anharmonic oscillator, …
6. Study and use variational principle and its applications as well as the WKB approximation.

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	45	100%
2	E-learning		
3	Hybrid • Traditional classroom • E-learning		
4	Distance learning		

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	45
2.	**Laboratory/Studio**	
3.	**Field**	
4.	**Tutorial**	
5.	**Others (specify)**	
Total		45

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	Remember and re-introduce Quantum Mechanics Postulates using Dirac notation	**K1**	Interactive lectures Problem-Solving Sessions Case Studies Presentations Group Projects	Quiz Midterm Exams Homework Assignments Presentation Final Exam
1.2	Describe orbital angular momentum and intrinsic angular momentum			

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.3	Recognize the general theory of angular momentum	**K2**		
2.0	**Skills**			
2.1	Understand Hilbert space and the concepts of ket, bra, and Hermitian operators	**S1**	Interactive lectures Problem-Solving Sessions Case Studies Presentations Group Projects	Quiz Midterm Exams Homework Assignments Presentation Final Exam
2.2	Use Dirac notation and application of the Quantum Mechanics Postulates	**S2**		
2.3	Analysis and manipulation of several operators related to angular momentum	**S2**		
2.4	Apply perturbation theory to compute the energy shifts in specific systems	**S4**		
3.0	**Values, autonomy, and responsibility**			
3.1	Demonstrate the ability to explain quantum concepts to both technical and non-technical audiences	**V2**	Interactive lectures Problem-Solving Sessions Case Studies Presentations Group Projects	Quiz Midterm Exams Homework Assignments Presentation Final Exam
3.2	Animate a presentation on a topic related to the course.			

C. Course Content

No	List of Topics	Contact Hours
1.	Mathematical tools of Quantum Mechanics (Hilbert Space and Dirac Notations, Operators, Commutator, Hermitian Adjoint, Eigenvalues and Eigenvectors of an Operator, Representation in Discrete Bases)	9
2.	Postulates of Quantum Mechanics	6
3.	Angular Momentum (Orbital Angular Momentum, Commutation relations, General Formalism of Angular Momentum, Eigenvalues and Eigenvectors of the Angular Momentum Operator, Matrix Representation of Angular Momentum, Spin, Spherical Harmonics)	9
4.	Addition of Angular Momenta	9
5.	Approximation Methods for stationary States (Time-Independent Perturbation Theory, Nondegenerate Perturbation theory, Degenerate Perturbation theory, Application to Hydrogen Atom, Stark Effect, Zeemann Effect, Harmonic Oscillator, Variational Method, WKB Method)	9
6.	Time-Dependent Perturbation Theory	3
Total		**45**

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Quiz	4	10
2.	Midterm Exam 1	6-7	15
3.	Midterm Exam 2	10-12	15
4.	Homework assignments	continue	10
5.	Presentation	12-15	10
6.	Final Exam	end	40

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

E. Learning Resources and Facilities

1. References and Learning Resources

Essential References	Quantum Mechanics: Concepts and Applications, Nouredine Zettili, Wiley, 2009
Supportive References	Introduction to Quantum Mechanics David J. Griffiths, Darrell F. Schroeter, Cambridge University Press, 2018 Introduction to Quantum Mechanics A.C. Phillips, Wiley, 2003 Quantum Mechanics Claude Cohen-Tannoudgi, Bernard Diu, Frank Laloe, Wiley, 1991
Electronic Materials	Quantum simulation software (e.g., QuTiP, Quantum Composer)

	Quantum Country (https://quantum.country/) MIT OpenCourseWare - Quantum Mechanics I (https://ocw.mit.edu) Quantum Atlas (https://quantumatlas.org)
Other Learning Materials	Research papers and case studies

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Classroom
Technology equipment (projector, smart board, software)	Projector, smart board
Other equipment (depending on the nature of the specialty)	Internet. Library

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	**Internal Reviewer committee**	**Direct**
Effectiveness of Students assessment	**Faculty, Students**	**Direct (Exams, Rubrics), Indirect (Surveys)**
Quality of learning resources	**Students, Peer Reviewers**	**Indirect (Surveys)**
The extent to which CLOs have been achieved	**Faculty, Program Leaders**	**Direct (Exams, Rubrics)**
Other	**Students, Faculty, Alumni**	**Indirect (Questionnaires, Feedback Forms)**

Assessors (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify)
Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	DEPARTMENT COUNCIL
REFERENCE NO.	**16**
DATE	**30/12/2024**