Course Specification

(Postgraduate Programs)

Course Title:	**Quantum Mechanics**
Course Code:	**PHY 6111**
Program:	**Master of Science in Physics**
Department:	**Physics**
College:	**Science**
Institution:	**Imam Mohammad Ibn Saud Islamic University**
Version:	**3**
Last Revision Date:	***26/09/2024***

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A. General information about the course:

1. Course Identification:

1. Credit hours: 4				
2. Course type				
A.	☐ University	☐ College	☒ Department	☐ Track
B.	☒ Required		☐ Elective	
3. Level/year at which this course is offered: Level 2 /Year 1				
4. Course General Description:				
This course gives exposure about the various tools employed to analyze the quantum mechanical problems. It introduces Dirac's bra-ket formulation of quantum mechanics and makes students familiar with various approximation methods applied to atomic, nuclear and solid-state physics, as well as adiabatic theorem and Berry's phase and quantum theory of scattering. Finally, relativistic quantum mechanics and Dirac equation will be introduced.				
5. Pre-requirements for this course (if any): None				
6. Pre-requirements for this course (if any): None				
7. Course Main Objective(s):				
At the end of this course, students will be able to: • **Know the advanced concepts and applications of quantum mechanics in the area of symmetries, perturbation theory, scattering theory, many-particle systems.** • **Know basic concepts of field quantization and relativistic quantum mechanics.**				

2. Teaching Mode: (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	75	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**	**0**
3.	**Field**	**0**
4.	**Tutorial**	**30**
5.	**Others (specify)……**	**0**
	Total	**75**

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	**Describe the background and main features of the historical development of quantum mechanics.**	**K1, K2**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Participation ▪ Discussions.
1.2	**State a comprehensive knowledge of the topics covered in the lectures.**	**K1**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Homework. ▪ Quizzes.
1.3	**Outline the advanced topics in quantum mechanics.**	**K1, K3**	• Lectures. • Class discussions. • Tutorials.	▪ Participation. ▪ Exams. ▪ Discussions. ▪ Homework.
2.0	**Skills**			
2.1	**Explain and summarize the basic knowledge gained from Studying quantum mechanics course.**	**S1, S2**	• Lectures. • Class discussions. • Tutorials.	▪ Exams. ▪ Discussions. ▪ Participation.
2.2	**Develop the students ability to solve and analyze problems in physics related the topics covered by the course.**	**S2, S3**	• Problem classes and group tutorial. • Homework assignments as well as problems solutions.	▪ Exams. ▪ Discussions. ▪ Homework.
2.3	**Communicate in a clear and concise manner orally, and**	**S4**	• Lectures. • Class discussions.	▪ Exams.

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
	using IT for acquiring and analyzing information.		• Tutorials. • Encourage students to use electronic mail and internal network for submitting homework and assignments. • Use digital library.	▪ Participation and activities of students in the course community and blackboard. ▪ Homework.
3.0	**Values, autonomy, and responsibility**			
3.1	**Show the collaboration and inter-professionalism in class discussions or team works, as well as solve problems independently.**	**V1, V2, V3**	• Small team tasks • Open discussion at classroom. • Office hours.	▪ Participation ▪ Homework. ▪ Mini-project(s).
3.2				
…				

C. Course Content:

No	List of Topics	Contact Hours
1.	**Fundamental Concepts:** The Stern-Gerlach experiments, Kets, Bras and operators, Base Kets and matrix representations, Measurements, Observables and the uncertainty relations, changes of basis, Position, Momentum, Translation, Wave Functions in Position and momentum Space.	**12**
2.	**Quantum Dynamics**: Time–evolution and the Schrodinger equation, The Schrodinger versus the Heisenberg picture, Simple harmonic Oscillator, The Schrodinger wave equation, Elementary solutions to Schrodinger wave equation, Propagators and Feynmann path integrals, Potentials and gauge transformations.	**12**
3.	**Theory of Angular Momentum**; Rotations and angular–momentum commutation relations, Spin ½, Systems and finite rotations, Euler rotations, Density operator, Spin correlation, Tensor operators.	**10**
4.	**Symmetry in Quantum Mechanics:** Symmetries, Conservation laws and degeneracies, Discrete symmetries, Parity or space inversion.	**8**

5.	**Approximation Methods:** Time independent perturbation theory: Non degenerate and degenerate, Hydrogen like atoms, Time-dependent potentials, Hamiltonian, Time-dependent perturbation theory.	12
6.	**Scattering Theory**: Scattering as a time–dependent perturbation, The scattering amplitude, The Born approximation, Inelastic electron–atom scattering.	8
7.	**Identical Particles**: Perturbation symmetry, Summarization postulate, Quantization of the electromagnetic field.	6
8.	**Relativistic Quantum Mechanics**: Paths to relativistic quantum mechanics, The Dirac equation, Symmetries of the Dirac equation, Relativistic quantum field theory.	7
Total		75

D. Students Assessment Activities:

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Class Activities (class quizzes, homework, solving problems, etc.....)	weekly	20 %
2.	Midterm Exam 1	6th week	20 %
3.	Midterm Exam 2	12th week	20 %
4.	Final Exam	16th week	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	-J. J. Sakurai, J.J. Napolitano, Modern Quantum Mechanics, 2nd Edition, Pearson, 2011.
Supportive References	- R.P. Feynman, R.B. Leighton, M. Sands, The Feynman Lectures on Physics, California, Institute of Technology, 1966. -D. McMahon, Quantum Mechanics Demystified, 2nd Edition, McGraw-Hill, 2013.
Electronic Materials	https://units.imamu.edu.sa/colleges/en/science/Pages/default.aspx
Other Learning Materials	Multimedia associated with the textbook and the relevant websites.

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	**Classrooms**
Technology equipment (Projector, smart board, software)	**Classroom equipped with a whiteboard and a projector.**
Other equipment (Depending on the nature of the specialty)	

F. Assessment of Course Quality:

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	- **Students.** - **Second examiner.**	**Indirect (The student will complete evaluation forms at the end of semester. Final exam is evaluated by the second examiner)**
Effectiveness of students' assessment	- **Instructors.**	**Direct (exams, HW, project, ...)**
Quality of learning resources	- **Faculty.** - **Students.**	**Indirect (surveys)**
The extent to which CLOs have been achieved	- **Instructors.** - **Program Leaders.**	**Direct (excel sheet)**
Other		

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval Data:

COUNCIL /COMMITTEE	**Quality Unit-Physics Department**
REFERENCE NO.	**Department council No. 6**
DATE	**26/09/2024**