هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission
اعتماد
NCAA
2024
TPG-153

Course Specification

(Postgraduate Programs)

Course Title: Advanced Quantum Mechanics	
Course Code: PHYS 612	
Program: Master of Science in Physics	
Department: Physics	
College: College of Sciences	
Institution: Majmaah University	
Version: 1	
Last Revision Date 12/2024:	

Table of Contents

A. General information about the course:

1. Course Identification

1. Credit hours: (3)					
2. Course type					
A.	☐University	☐College	☒Department	☐Track	☐Others
B.	☒Required			☐Elective	
3. Level/year at which this course is offered: (1st/1)					
4. Course general Description:					
The course covers the basic principles of Quantum formalism for closed systems and two-slit experiments. Schrödinger equation with spin (Pauli and Dirac equations) - Stern-Gerlach experiment. Quantum statistics, Theory of Angular Momentum and addition of two angular momenta- Approximation Methods, - Time-dependent Hamiltonian, quantum protocol and control; Time-dependent perturbation theory (Dyson method); - Approximations (semi-classical analysis, WKBJ-method, Born-Oppenheimer approximation).- Open systems, dissipative evolutions, decoherence, Caldeira-Leggett model. Weak coupling (Fermi-Golden rule), Lindblad equation, - Quantum nature: superposition, entanglement, tunnelling, nonlocality; Quantum optics. Jaynes-Cummings model, Rabi oscillations, coherent states, squeezing, manipulations of individual atoms - Depending on available time and considering the possible overlap with other courses.					
5. Pre-requirements for this course (if any):					
na					
6. Co-requisites for this course (if any):					
n/a					
7. Course Main Objective(s):					
1. This course expands the knowledge of physics, providing more profound and fundamental insights into the research field you choose to focus on. In addition, there is a strong focus on developing the practical skills you need to successfully conduct experiments. Use perturbation theory (time-					

	independent or time-dependent to resolve approximately the Schrödinger equation: the Stark effect, hyperfine splitting, harmonic oscillator, and Zeeman effect.
2.	Demonstrate an understanding of angular momentum and addition of two momenta in quantum mechanics; Use different approximation methods, understand many-particle Theory, Second Quantization theory, and scattering theory: bosons and fermions

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**	
Total		**45**

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

Code	Course Learning Outcomes	Code of PLOs aligned with program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	Students should be familiar with the Quantum formalism for closed systems and with the two-slit experiment. Schrödinger equation with spin (Pauli and Dirac equations) - Stern-Gerlach	K2	Lectures-Class discussions	Exams-Writing reports

	experiment. Quantum statistics, Theory of Angular Momentum, and addition of two angular momenta.			
1.2	Know Approximation Methods, - Time-dependent Hamiltonian, quantum protocol, and control.	K2	Lectures-Class discussions	Exams Writing reports
1.3	Recognize - Time-dependent perturbation theory (Dyson method) - Approximations (semi-classical analysis, WKBJ-method, Born-Oppenheimer approximation).	K4	Lectures-Class discussions	Exams Writing reports
1.4	Explain Open systems, dissipative evolutions, decoherence, and the Caldeira-Leggett model. Weak coupling (Fermi-Golden rule), Lindblad equation, - Quantum nature: superposition, entanglement, tunneling, nonlocality.	K4	Lectures-Class discussions	Exams Writing reports
2.0	**Skills**			
2.1	Capable of calculating Jaynes-Cummings model, Rabi oscillations, coherent states, squeezing, manipulations of individual atoms, -Depending on available time and considering the possible overlap with other courses.	S1	Solving Problems-Class discussions - Presentations	EXAMS Assignment Quizzes-Observation
2.2	Analysis and calculation path-integrals (example: Aharonov-Bohm effect), - From Einstein-Podolsky-Rosen experiments to Bell inequalities and the Kochen-Specker No-Go Theorems.	S1	Solving Problems-Class Discussions - Presentations	EXAMS Assignment Quizzes-Observation
2.3	Solve various problems related to Schrodinger’s cat and possible solutions to the measurement problem.	S3	Solving Problems-Class discussions -	EXAMS Assignment Quizzes-Observation

			Presentations	
2.4	Capable of calculating the Jaynes-Cummings model, Rabi oscillations, coherent states, squeezing, and manipulations of individual atoms, depending on available time, and considering the possible overlap with other courses.	S3	Solving Problems-Class Discussions - Presentations	EXAMS Assignment Quizzes-Observation
3.0	**Values, autonomy, and responsibility**			
3.1	Work in a group and develop time-management skills.	V1	Presentations-Small group supervisions	Small projects Presentations Survey
3.2	Learn how to search for information through the library and the internet.	V1	Presentations-Small group supervisions	Small projects Presentations Survey
3.3	Present a short report in a written form and orally using appropriate scientific language.	V3	Presentations-Small group supervisions	Small projects Presentations Survey

C. Course Content

No	List of Topics	Contact Hours
1.	Quantum formalism for closed systems, two-slit experiment. Schrödinger equation with spin (Pauli and Dirac equations) - Stern-Gerlach experiment. Quantum statistics, Theory of Angular Momentum and addition of two angular momenta	6
2.	-Approximation Methods, - Time-dependent Hamiltonian, quantum protocol and control.	6
3.	- Time-dependent perturbation theory (Dyson method);, - Approximations (semi-classical analysis, WKBJ-method, Born-Oppenheimer approximation).	6
4.	- Open systems, dissipative evolutions, decoherence, Caldeira-Leggett model. Weak coupling (Fermi-Golden rule), Lindblad equation, - Quantum nature: superposition, entanglement, tunneling, nonlocality;	9

5.	- Quantum optics. Jaynes-Cummings model, Rabi oscillations, coherent states, squeezing, manipulations of individual atoms-Depending on available time and considering the possible overlap with other courses	9
6.	- Introduction to path-integrals (example: Aharonov-Bohm effect)- From Einstein-Podolsky-Rosen experiments to Bell inequalities and the Kochen-Specker No-Go Theorems;	6
7.	- Schoedinger's cat and possible solutions of the measurement problem, Review	3
Total		**45**

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Midterm 1	7	15%
2.	Midterm 2	11	15%
3.	Small Project	13	10%
4.	Quiz	6, 11	10%
5.	Assignment	Each unit	10%
6.	Final Exam	End of the semester	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	1. Advanced quantum mechanics: A practical guide, Nazarov, Yuli V, Cambridge University Press, 2018. 2. Advanced Quantum Mechanics, Franz Schwabl, Springer-Verlag Berlin Heidelberg, 2008
Supportive References	n/a
Electronic Materials	• Saudi Digital Library (SDL) • Web of Knowledge • Physics Today (web version) • MIT Courseware
Other Learning Materials	• Class presentation • Desire to learn (D2L) • Equipment manuals/handout • Software manuals/ user guide

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	• Classroom (must be the same for the same subject) • Seminar room • Computer lab for (e-Quiz)
Technology equipment (projector, smart board, software)	• Blackboard software/login • MS software suite • Origin Graphic software • Smart board that maintains feedback • Whiteboard
Other equipment (depending on the nature of the specialty)	Library, Seminar Room, and Wi-Fi /internet connections.

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students/ internal committee	Direct
Effectiveness of Students assessment	Staff members (Peer Reviewer)	Indirect
Quality of learning resources	Staff members (Peer Reviewer)	Indirect
The extent to which CLOs have been achieved	Staff members (Peer Reviewer)	Direct

Assessors (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	Physics Department
REFERENCE NO.	16
DATE	30/12/2024