هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

Course Specifications

Course Title:	**Quantum Mechanics (3)**
Course Code:	**PHY4508**
Program:	**Physics**
Department:	**Physics**
College:	**Applied Sciences**
Institution:	**Umm Al-Qura University**

Table of Contents

A. Course Identification

1. Credit hours: 4 hrs
2. Course type **a.** University ☐ College ☐ Department ☑ Others ☐ **b.** Required ☑ Elective ☐
3. Level/year at which this course is offered: 10 Level /4th Year
4. Pre-requisites for this course (if any): **Quantum Mechanics (2)**
5. Co-requisites for this course (if any):

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	40	100%
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Contact Hours
1	Lecture	40
2	Laboratory/Studio	-
3	Tutorial	-
4	Others (specify) Exams/ Quizzes	-
	Total	40

B. Course Objectives and Learning Outcomes

1. Course Description

This course builds upon quantum mechanics (1) and quantum mechanics (2) in the previous levels, and it covers a variety of interesting theoretical developments, including the WKB approximation, Time–dependent perturbation theory, Adiabatic Approximation and scattering theory.

2. Course Main Objective

This course together with quantum mechanics (1) and quantum mechanics (2) offer a systematic introduction and fundamental background to non-relativistic quantum mechanics.

3. Course Learning Outcomes

	CLOs	Aligned PLOs
1	**Knowledge and understanding**	
1.1	Describe the approximate solutions to the time independent Schrödinger equation by the WKB approximation.	K1(I), K2(I)

CLOs		Aligned PLOs
1.2	Differentiate between Stationary and time-dependent perturbations.	K1(I)
1.3	Recognize the adiabatic criteria for the evolution of a given quantum mechanical system.	K1(I)
1.4	Differentiate between Elastic and Inelastic Scattering processes.	K1(I)
2	**Skills:**	
2.1	Connect classical and quantum equations of motion, using either the WKB approximation or a path-integral approach.	S1(I), S2(I)
2.2	Justify the necessary conditions to apply the Adiabatic Approximation for a given quantum mechanical system.	S2(I)
2.3	Apply the time-dependent perturbation theory on a given system to calculate a transition amplitude.	S1(I), S2(I)
2.4	Compute a cross section in terms of an amplitude using partial wave analysis.	S1(I)
2.5		
3	**Values:**	
3.1	Participate effectively in multidisciplinary and/or interdisciplinary teams.	V2(I)
3.2		V1(I), V2(I)
3.3		V1(I)
3.4		V1(I)

C. Course Content

No	List of Topics	Contact Hours
1	**Time–Independent Perturbation Theory:** Non-Degenerate perturbation theory (First and Second Order Corrections), Degenerate perturbation theory, The fine structure of hydrogen, Zeeman Effect, Hyperfine Splitting.	12
2	**Time-Dependent Perturbation Theory:** Pictures of Quantum Mechanics (Schrödinger, Heisenberg, and Interaction Pictures), Two-level systems, Time-Dependent Perturbation Theory, Transition Probability, Constant Perturbation, Harmonic Perturbation, Interaction of Atoms with Radiation, Transition Rates for Absorption and Emission of Radiation, Transition Rates within the Dipole Approximation, Electric Dipole Selection Rules, Spontaneous Emission.	12
3	**The variational principle:** Methodology of the variational principle, accuracy, Ground state energy vs ground state wavefunctions, the trial wave function, One-dimensional harmonic oscillator, Delta-function potential, Helium Atom, Hydrogen molecule ion.	8
1	**The Wentzel–Kramers–Brillouin (WBK) Approximation Method:** General Formalism, Bound States for Potential Wells with No Rigid Walls, Bound States for Potential Wells with One Rigid Wall, Bound States for Potential Wells with Two Rigid Walls, Tunneling through a Potential Barrier.	8
4		10
Total		40

D. Teaching and Assessment

1. Alignment of Course Learning Outcomes with Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**		
1.1	Describe the approximate solutions to the time independent Schrodinger equation by the WKB approximation.	1. Lectures. 2. Discussions 3. Slides and computer simulation software may be used by the teachers to clarify concepts. 4. Problems solving 5. Students may be asked to solve some problems using MATLAB language	1- Homework assignments. 2- Group Project assignment. 3- Question –answer session in class. 4- Exams: quizzes, Mid-term, and final exams
1.2	Differentiate between Stationary and time-dependent perturbations.		
1.3	Recognize the adiabatic criteria for the evolution of a given quantum mechanical system.		
1.4	Differentiate between Elastic and Inelastic Scattering processes.		
2.0	**Skills**		
2.1	Connecting classical and quantum equations of motion, using either the WKB approximation or a path-integral approach.	1. Lectures. 2. Discussions. 3. Problem solving. 4. Encourage the student to look for the information in different references. 5. Define duties for each chapter	**1**- Homework assignments. **2**- Group Project assignment. **3**- Question –answer session in class. **4**- Exams: quizzes, Midterm and final exams.
2.2	Justify the necessary conditions to apply the Adiabatic Approximation for a given quantum mechanical system.		
2.3	Apply the time-dependent perturbation theory on a given system to calculate a transition amplitude.		
2.4	Compute a cross section in terms of an amplitude using partial wave analysis.		
3.0	**Values**		
3.1	Participate effectively in multidisciplinary and/or interdisciplinary teams	**1.** Groupe assignments **2.** Clarify deadlines for delivery of assignments, reports, and exams.	**1.** Evaluate the efforts of each student in preparing the report. **2.** Evaluate the work in teams. Evaluation of student's presentations.
3.2	Accepting different ideas and respecting other opinions.		
3.3	Manage a project (modelling or simulation) with due attention to time and resource management		
3.4	Take responsibility and take the course instructions seriously.		

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Exercises and HomeWorks	All weeks	10%
2	Participation in activities	All weeks	10%
3	Mid-term exam	6th week	30%
4	Final exam	End of the term	50%

*Assessment task (i.e., written test, oral test, oral presentation, group project, essay, etc.)

E. Student Academic Counseling and Support

Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice:

Students are supervised by academic advisers in the physics Department and the timetables for academic advice were given to the student each semester. (8hrs per week).

F. Learning Resources and Facilities

1.Learning Resources

Required Textbooks	Introduction to Quantum Mechanics 2nd Edition, by David J. Griffiths, Pearson Education Limited (2014).
Essential References Materials	**1.** Quantum Mechanics: Concepts and Applications 2nd Edition, by Noureddine Zettili, John Wiley & Sons, Ltd, (2009). **2.** Quantum Physics, 3rd Edition, by Stephen Gasiorowicz, John Wiley & Sons, Inc, (2003).
Electronic Materials	https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2013/lecture-videos/
Other Learning Materials	

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.).	Lecture room Labs
Technology Resources (AV, data show, Smart Board, software, etc.).	data show
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list).	None

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Student Feedback on Effectiveness of Teaching	Students	Direct
Evaluation of Teaching	Department	Indirect
Improvement of Teaching	Program leaders	Direct
Quality of learning resources	Faculty	Direct
Extent of achievement of course learning outcomes	Program leaders	Direct

Evaluation areas (e.g., Effectiveness of teaching and assessment, Extent of achievement of course learning outcomes, Quality of learning resources, etc.)
Evaluators (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)
Assessment Methods (Direct, Indirect)

H. Specification Approval Data

Council / Committee	Dr. Atif Ismail, Dr Walid Belhadj and Prof. Khaled Abdel-Waged
Reference No.	
Date	