Form: Course Syllabus	**Form Number**	EXC-01-02-02A
	Issue Number and Date	2/3/24/2022/2963 05/12/2022
	Number and Date of Revision or Modification	
	Deans Council Approval Decision Number	2/3/24/2023
	The Date of the Deans Council Approval Decision	23/01/2023
	Number of Pages	06

1.	**Course Title**	Quantum Mechanics -2
2.	**Course Number**	0302954
3.	**Credit Hours (Theory, Practical)**	(3,0)
	Contact Hours (Theory, Practical)	(3,0)
4.	**Prerequisites/ Corequisites**	None
5.	**Program Title**	PhD in Physics
6.	**Program Code**	9
7.	**School/ Center**	03
8.	**Department**	02
9.	**Course Level**	10
10.	**Year of Study and Semester (s)**	1,2
11.	**Other Department(s) Involved in Teaching the Course**	None
12.	**Main Learning Language**	English
13.	**Learning Types**	☒Face to face learning ☐Blended ☐Fully online
14.	**Online Platforms(s)**	☐Moodle ☒Microsoft Teams
15.	**Issuing Date**	
16.	**Revision Date**	2019

17. Course Coordinator:

Name: Prof. Mahmoud Jaghoub   Contact hours: Sundays, Mondays, Thursdays 10 - 11

Office number: 308   Phone number: 22022

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18. Other Instructors:

Name: None
Office number:
Phone number:
Email:
Contact hours:
Name:
Office number:
Phone number:
Email:
Contact hours:

19. Course Description:

Rotation Operator for Spin-1/2 System; Orthogonal Group and Euler's Rotations, Density Operator and Quantum Statistics; Addition of Angular Momenta; Schwinger's Oscillator Model of Angular Momentum; Spin Correlation Measurements and Bell's Inequality; Time-Dependent Perturbation Theory and Transition Probability; Fermi's Golden Rule; Auger Transition; Harmonic Perturbation; Absorption and Emission of Radiation by a H-Atom; Second-Order Perturbation Theory and Applications; Sudden Approximation; Adiabatic Approximation; Identical Particles.

20. Program Intended Learning Outcomes: (To be used in designing the matrix linking the intended learning outcomes of the course with the intended learning outcomes of the program)

SO1: to be able to demonstrate an advanced and comprehensive understanding of core physics concepts and specialized knowledge in a chosen field of research, contributing to the frontier of physics.

SO2: to be able to develop and execute independent, original research projects that address complex scientific problems, advancing theoretical and experimental physics.

SO3: to be able to apply advanced mathematical and computational techniques to analyze complex physical phenomena and critically evaluate scientific literature and experimental results.

SO4: to be able to effectively communicate complex physics concepts, research findings, and their significance through academic writing, presentations, and public outreach.

SO5: to be able to adhere to high ethical standards and professional responsibility in conducting research, including data integrity, ethical treatment of subjects, and the responsible use of resources.

SO6: to be able to demonstrate leadership and collaborative skills within multidisciplinary teams, contributing to the development of new scientific knowledge and promoting knowledge-sharing across disciplines.

SO7: to be able to cultivate the ability to adapt to new scientific advancements and continuously engage in professional development to contribute to innovation in the field of physics.

SO8: to be able to master experimental and computational techniques relevant to the research field, demonstrating competency in operating and developing specialized physics instrumentation and software.

21. Course Intended Learning Outcomes: (Upon completion of the course, the student will be able to achieve the following intended learning outcomes)

1. Apply rotation operators for spin-1/2 systems and explain their relation to the orthogonal group and Euler's rotations.
2. Demonstrate knowledge of density operators and quantum statistics, including their roles in the description of quantum systems.
3. Analyze the addition of angular momenta in quantum systems, applying relevant mathematical methods to solve problems involving coupled angular momenta.
4. Explain Schwinger's oscillator model of angular momentum and utilize it to understand the quantization of angular momentum in quantum mechanics.
5. Perform spin correlation measurements and analyze experimental setups to test Bell's inequality, understanding its implications for quantum mechanics and quantum entanglement.
6. Apply time-dependent perturbation theory to compute transition probabilities, including the use of Fermi's Golden Rule in evaluating rates of quantum transitions.
7. Explain the mechanisms of Auger transitions and relate them to other perturbative effects in atomic and molecular physics.
8. Analyze harmonic perturbations in quantum systems and apply second-order perturbation theory to solve related problems.
9. Study the absorption and emission of radiation by a hydrogen atom, applying perturbation theory to compute transition probabilities in the context of atomic physics.
10. Apply second-order perturbation theory to solve quantum mechanical problems and discuss its applications to atomic and molecular systems.
11. Utilize the sudden approximation and the adiabatic approximation to understand the behavior of quantum systems under rapid or slow changes in external parameters.

12. Understand the behavior of identical particles in quantum mechanics, applying the principles of indistinguishability and symmetry to describe their states.

Course ILOs	The learning levels to be achieved					
	Remembering	Understanding	Applying	Analysing	evaluating	Creating
1		X	X	X	X	
2				X	X	
3			X	X		X
4			X	X		
5			X	X	X	
6			X			X
7			X	X	X	X
8			X	X		
9		X	X	X		
10			X	X	X	
11			X	X		X
12		X	X		X	

2٢. The matrix linking the intended learning outcomes of the course with the intended learning outcomes of the program:

Program ILOs / Course ILOs	ILO (1)	ILO (2)	ILO (3)	ILO (4)	ILO (5)	ILO (6)	ILO (7)	ILO(8)
1	X		X					
2	X		X	X				
3	X		X					
4	X		X		X			
5		X	X	X				
6	X		X			X		
7	X		X				X	X
8	X		X					X
9	X		X		X		X	
10			X		X		X	
11	X		X			X		
12	X		X			X	X	

2٣. Topic Outline and Schedule:

Week	Lecture	Topic	ILO/s Linked to the Topic	Learning Types (Face to Face/ Blended/ Fully Online)	Platform Used	Synchronous / Asynchronous Lecturing	Evaluation Methods	Learning Resources
1	1.1	Rotations: finite versus infinitesimal rotations	1, 3	Face to Face	MS Teams		Assignments Presentations Exams	
	1.2	Infinitesimal rotations in quantum mechanics	1, 3					
	1.3	Infinitesimal rotations in quantum mechanics	1, 3					
2	2.1	Spin ½ and finite rotations	1, 3					
	2.2	Spin precession	1, 3					
	2.3	Neutron interferometry experiment	1, 3					
3	3.1	Pauli two-component formalism	1, 3					
	3.2	Pauli two-component formalism	1, 3					
	3.3	Unitary Unimodular group	1, 3					
4	4.1	Euler rotations	1, 3					
	4.2	Density operators	2					
	4.3	Polarized versus unpolarized beams	2					
5	5.1	Ensemble averages and the density operator	2					
	5.2	Time evolution of ensembles	2					
	5.3	Continuum generalizations	2					
6	6.1	Matrix elements of angular momentum operators	3, 5					
	6.2	Representation of the rotation operator	3, 5					
	6.3	Orbital angular momentum	3, 5					

7	7.1	Spherical harmonics as rotation matrices	3, 5						
	7.2	Addition of angular momenta	3, 5						
	7.3	Schwinger's oscillator model of angular momentum	3, 5						
8	8.1	Spin correlation measurements and Bell's inequality	3, 5						
	8.2	Time-independent perturbation theory: nondegenerate case	6, 7						
	8.3	Two-state problem	6						
9	9.1	Formal development of perturbation expansion	6, 7						
	9.2	Elementary examples	6, 7						
	9.3	Time-independent perturbation theory: degenerate case	6, 7						
10	10.1	Variational method	7, 8						
	10.2	Time-dependent potentials: the interaction potential	7, 8						
	10.3	Time-dependent two-state problems: nuclear magnetic resonance	7, 8						
11	11.1	Masors	7, 8						
	11.2	Sudden approximation	8, 9						
	11.3	Adiabatic approximation	8, 9						
12	12.1	Dyson series	8, 9						
	12.2	Transition probability	10						
	12.3	Harmonic perturbation	10						
13	13.1	Absorption and stimulated emission	10, 11						
	13.2	electric dipole approximation	11						
	13.3	photoelectric effect	11						
14	14.1	Identical particles: permutation symmetry	12						
	14.2	Symmetrization postulates	12						
	14.3	Two-electron system	12						
15	15.1	The Helium atom	12						
	15.2	Multiparticle states: second quantization	12						
	15.3	Quantization of electromagnetic field	12						

2٤. Evaluation Methods:

Opportunities to demonstrate achievement of the ILOs are provided through the following assessment methods and requirements:

Evaluation Activity	**Mark**	**Topic(s)**	**ILO/s Linked to the Evaluation activity**	**Period (Week)**	**Platform**
Assignments	20	All	All	At the end of each chapter	E-learning, MS Teams, Paper
Presentations	20	Chosen by the student and approved by the instructor	Depends on the chosen topic	Week 14	Face to Face
Mid-term written Exam	20	Material covered in the first 6 weeks	1, 2, 3, 4 and 5	Week 8	Face to Face
Final written Exam	40	All the material	1 to 12	Week 15	Face to Face
Assignments	20	All	All	At the end of each chapter	E-learning, MS Teams, Paper

2٥. Course Requirements:

(e.g.: students should have a computer, internet connection, webcam, account on a specific software/platform…etc.):

Computer with internet connection and installed MS teams.

2٦. Course Policies:

A- Attendance policies: As per University regulations

B- Absences from exams and submitting assignments on time: As per University regulations

C- Health and safety procedures: As per University regulations

D- Honesty policy regarding cheating, plagiarism, misbehavior: As per University regulations

E- Grading policy: Assignments 20, Presentations 20, Mide-term exam 20, Final exam 40.

F- Available university services that support achievement in the course: Library, Computer labs, internet connction.

2٧. References:

A- Required book(s), assigned reading and audio-visuals:

- Modern Quantum Mechanics, J. J. Sakurai, Jim Napolitano, Second Edition, Addison-Wesley, 2011. (The old version by J. J. Sakurai is also acceptable).

B- Recommended books, materials, and media:

- Quantum Mechanics II, A second course in quantum theory, second edition, R. Landau, John Wiley and Sons, Inc.

- Quantum Mechanics, L. I. Schiff, McGraw – Hill Book Company, Inc.
- Quantum Mechanics, E. Merzbacher, John Wiley & Sons, 1970.

2٨. Additional information:

Name of the Instructor or the Course Coordinator: Prof. Mahmoud Jaghoub	Signature: …………..………………	Date: ……..…………
Name of the Head of Quality Assurance Committee/ Department …………………………………………………	Signature: …………..………………	Date: ……..…………
Name of the Head of Department …………………………………………………	Signature: …………..………………	Date: ……..…………
Name of the Head of Quality Assurance Committee/ School or Center …………………………………………………	Signature: …………..………………	Date: ……..…………
Name of the Dean or the Director …………………………………………………	Signature: …………..………………	Date: ……..…………