Faculty: Faculty of Science	
Department: Physics department	**Program: M. Sc. of Physics**
Academic year: 2023/2024	**Semester: Second**

Course Plan

First: Course Information

Course No.0302752	***Course Title:* Atom and Molecular Physics**	***Credit Hours: 3***
***Prerequisite:* None**	***Section No.: 1***	***Lecture Time:***
Type Of Course:	***Mandatory Faculty Requirement* ☐ *Optional University Requirement* ☐ *Mandatory University Requirement* ☐ *Faculty Requirement* ☐ *Ancillary Course* ☐ *Optional Specialty Requirement* ■ *Mandatory Specialization requirement* ☐**	
Type of Learning:	■ ***Face-to-Face Learning*** ☐ ***Blended Learning (2 Face-to-Face + 1 Asynchronous)*** ☐ ***Online Learning (2 Synchronous+1 Asynchronous)***	

Second: Instructor's Information

Name: Dr. Saed Jumah Al Atawneh		***Academic Rank:* Assistant Professor**			
Office Number: 341D		***Phone Number:1518***		***Email:* salatawneh@zu.edu.jo**	
Office Hours:	***Sunday*** ***2:00-3:00***	***Monday*** ***11:00-12:00***	***Tuesday*** ***2:00-3:00***	***Wednesday*** ***11:00-12:00***	***Thursday*** ***2:00-3:00***

Third: Course Description

In this course, students will cover topics such as the Hydrogen atom spectrum, including the fine structure, spin-orbit interaction, and relativistic corrections. Additionally, the course will explore many-electron atoms, Hartree-Fock approximation, interaction of atoms with electromagnetic radiation, Fermi golden rule, hyperfine structure, stark effect, Zeeman effect, angular momentum algebra, electron paramagnetic resonance, nuclear magnetic resonance, atom-atom and electron-atom collisions, Born-Oppenheimer approximation, electron states in Hydrogen molecule ion and hydrogen molecule, other diatomic molecules, rotational vibrational spectra of diatomic molecules, polyatomic molecules, symmetry classification of vibrational states, rotational states, and Raman spectroscopy.

Fourth: Course Objectives

This course has several rather broad goals. They include that you:

1. To provide theoretical and practical knowledge on modern atomic and molecular physics.
2. To give basic knowledge about the molecular structure and molecular spectroscopy.
3. To give the basic structure of atoms starting from hydrogen atom to many electron atoms, and beside studying the fine and hyperfine structure of atoms, knowing the behavior of atoms in outer fields.
4. To provide hands-on practice in the calculation of atomic and molecule wave functions and energies.

Fifth: Learning Source

Main Reference:	***1. Physics of Atoms and Molecules.*** ***2. Atomic and Molecular Physics.***	***Publication Year:***
1. Author: B. H. Bransden and C. J. Joachain. ***2. Author: Luciano Colombo.***	***Print: 2rd edition*** ***Print: 2rd edition***	***1. Year: 1983*** ***2. Year: 2023***
Additional Sources & Websites:	• ***Theoretical Atomic Physics, 2nd Edition, Harald Friedrich.*** • ***The Physics of Atoms and Quanta, 6th Edition, H.C. Hermann Haken and Hans Christoph Wolf.***	
Teaching Type:	■ ***Classroom*** ☐ ***Laboratory*** ☐ ***Workshop*** ☐ ***MS Teams*** ☐ ***Moodle***	

Sixth: Learning Outcomes

Number	***Course learning output***	**Associated PILOs Code** Choose one PILO for each CILO*	**Assessment method**** Choose at least two methods	**Scores out of 100** State the total score identified for each CILO	***Minimum acceptable Score/percentage (%)*** *The percentage should not be less than 50%* ***
Knowledge					
K1	To understand the principles of quantum mechanics, including wave-particle duality, Schrödinger's equation, quantum states, operators, observables, and the postulates of quantum mechanics. Understand how these principles apply to atomic and molecular systems.	PK1	Mid-Exam Quiz Final exam	10	5(50%)
K2	Demonstrate the basic knowledge about the molecular structure and	PK2	Mid-Exam Quiz	10	5(50%)

	spectroscopic techniques used to study atomic and molecular systems, including absorption spectroscopy, emission spectroscopy, and scattering methods.		Final exam		
K3	To understand the fundamental structure of atoms starting with the hydrogen atom and extends to atoms with multiple electrons. In addition to exploring the fine and hyperfine structures of atoms, it is essential to comprehend how atoms behave in outer fields.	PK3	Mid-Exam Quiz Final exam	12	6(50%)
K4	To understand molecular structure, bonding theories (e.g., molecular orbital theory, valence bond theory), symmetry properties, and spectroscopic methods for characterizing molecules. Explore topics like molecular vibrations, rotations, and electronic transitions.	PK4	Mid-Exam Quiz Final exam	12	6(50%)
Skills					
S1	Applying a mathematical concept such as calculus, differential equations, linear algebra, and complex analysis. These mathematical tools are essential for understanding the theoretical framework of atomic and molecular physics.	PS1	Mid-Exam Quiz Final exam	16	8(50%)
S2	Creating links between the principles and ideas of atomic and molecular physics with observable natural occurrences, such as Molecular Bonding and Chemical Reactions, and Atomic and Molecular Interactions in Biological Systems. This interdisciplinary approach fosters a deeper understanding of the natural world and informs the development of new technologies and applications across various fields.	PS2	Mid-Exam Quiz Final exam	12	6(50%)
S3	Build a strong background in atomic and molecular physics for delving into advanced fields of study like quantum chemistry, spectroscopy, nanotechnology, photonics, and biophysics, among others.	PS3	Mid-Exam Quiz Final exam	12	6(50%)
S4	Develop theoretical models to	PS4	Mid-Exam	16	8(50%)

	describe the atomic or molecular system under investigation. This may involve solving the Schrödinger equation for electronic structure, applying perturbation theory, and/or using advanced quantum mechanical techniques.		Quiz Final exam		
Competences					
C1	Students should accept full responsibility for their own learning.	PC1			
C2	Working a knew problems and identify the suitable way to solve the problem.	PC2			

***Refer to document () and page 2 in document ()**
**** Refer to document ()**
****80% of the students must achieve the minimum acceptable percentage or higher for each CILO**

Seventh: Course Structure

Lecture Date	Teaching Outcomes (ILOs)	Topics	Teaching Procedures*	Teaching Methods***	References***
03/03/2024	PK1 PK2 PK4 PS2 PC1	**Introduction:** **1**. Atomic spectra and the Bohr model of hydrogen. **2**. The Stern-Gerlach experiment - angular momentum and spin. **3**. de Broglie's hypothesis and the genesis of wave mechanics.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book
10/03/2024	PK1 PK2 PS1 PS2 PS4 PC1 PC2	**One-electron atoms:** **1** The Schrodinger equation for one-electron atoms. **2**. Energy levels. **3**. The eigenfunctions of the bound states. **4**. Expectation values. The virial theorem. **5**. One-electron atoms in parabolic coordinates. **6**. Special hydrogenic systems: positronium; muonium; antihydrogen; muonic and hadronic atoms; Rydberg atoms.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book

17/03/2024	PK1 PK2 PS2 PS4 PC1 PC2	**Interaction of one-electron atoms with electromagnetic:** **1.** The electromagnetic field and its interaction with charged particles. **2**. Transition rates.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book
24/03/2024	PK1 PK2 PS2 PC1 PC2	**One-electron atoms: fine structure and hyperfine structure.** **1**. Fine structure of hydrogenic atoms. **2**. The Lamb shift. **3**. Hyperfine structure and isotope shifts.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book
31/03/2024	PK1 PK2 S1 PS2 PC1 PC2	**Interaction of one-electron atoms with external electric and magnetic fields:** **1**. The Stark effect. **2**. The Zeeman effect.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book
07/04/2024	PK1 PK2 PS1 PS2 PS4 PC1 PC2	**Two-electron atoms:** **1**. The Schrodinger equation for two-electron atoms. Para and ortho states. **2**. Spin wave functions and the role of the Pauli exclusion principle. **3**. Level scheme of two-electron atoms. **4**. The independent particle model.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book
14/04/2024	PK1 PK2 PS2 PS4 PC1 PC2	**Two-electron atoms:** **5.** The ground state of two-electron atoms. **6.** Excited states of two-electron atoms. **7.** Doubly excited states of two-electron atoms. Auger effect (autoionisation). Resonances.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book
21/04/2024	PK1 PK2 PS1 PS2 PS4 C1 PC2	**Many-electron atoms:** **1.** The central field approximation. **2.** The periodic system of the elements. **3.**The Thomas-Fermi model of the atom. **4.** The Hartree-Fock method and the self-consistent field. **5.** Corrections to the central	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book

		field approximation. Correlation effects. L-S coupling and j-j coupling.			
28/04/2024	PK1 PK2 PK4 PS2 PC1 PC2	**Molecular structure**: **1.** General nature of molecular structure. **2**.The Bom-Oppenheimer separation for diatomic molecules. **3**. Electronic structure of diatomic molecules. **4**. The rotation and vibration of diatomic molecules. **5**. The electronic spin and Hund's cases. **6**. The structure of polyatomic molecules.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book
05/05/2024	PK1 PK2 PK4 PS2 PS4 PC1	**Molecular spectra**: **1**. Rotational spectra of diatomic molecules. **2**. Vibrational-rotational spectra of diatomic molecules. **3**. Electronic spectra of diatomic molecules. **4**. Spin-dependent interactions and electric dipole transitions. **5**.The nuclear spin.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book
12/05/2024	PK1 PK2 PS2 PC1	**Atomic collisions: basic concepts and potential scattering.** **1.** Types of collisions, channels, thresholds and cross-sections. **2.** Potential scattering. General features. **3.** The method of partial waves. **4.** The integral equation of potential scattering. **5.** The Coulomb potential. **6.** Scattering of two identical particles.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book
19/05/2024	PK1 PK2 PS2 PC1	**Electron-atom collisions and atomic photoionization:** **1.** Electron-atom collisions. General features. **2.** Elastic and inelastic electron-atom collisions at	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book

		low energies. **3.** Elastic and inelastic electron-atom collisions at high energies. **4**. Electron impact ionization of atoms. **5.** Atomic photoionization			
26/05/2024	PK1 PK2 PS2 PC1	**Atom-atom collisions:** **1.** Collisions at very low energies. **2.** Elastic collisions at low velocities. **3.** Non-elastic collisions between atoms. **4.** The impact parameter method. **5.** Atom-atom collisions at high velocities.	Face-to-Face (Direct)	Lecturing, Whiteboard, Data Show	Text book
12/06/2024	**Final Exam**				

* Learning procedures: (Face-to-Face, synchronous, a synchronous). * * Teaching methods: (Lecture, video…..). ** * Reference: (Pages of the book, recorded lecture, video….).

Eighth: Assessment methods

Methods	**Fully Electronic Education**	**Integrated Teaching**	**Direct Teaching**	**Specific Course Output to be measured** *State the score identified for each CILO for each method of assessment out of 100 **If any CILO will not be assessed in the course, mark NA.							
				K1	**K2**	**K3**	**K4**	**S1**	**S2**	**S3**	**S4**
Midterm Exam			**30**	**3**	**3**	**4**	**4**	**4**	**5**		**4**
Quiz (short quizzes, seminar, projects, …)			**30**	**3**	**3**	**3**	**3**	**2**	**3**	**2**	
Final Exam			**40**	**4**	**4**	**5**	**5**	**10**	**4**	**10**	**12**
Total out of 100			**100**	**10**	**10**	**12**	**12**	**16**	**12**	**12**	**16**

Ninth: Course Policies

- Meeting the deadline for the lecture.
- Commitment to interaction and participation.
- Interactive lectures will be given through a platform (MS Teams).
- Duties and tests will be given through a platform (Moodle).
- Commitment to the right appearance in front of the camera with the proper background.
- University regulations for attendance and absence from lectures and examinations are in force.
- Academic Integrity: Fraud or moral impersonation are unacceptable and are punishable according to university regulations and instructions.

Approved by:	Name	Date	Signature
Head of Department	Dr. Riad Masharfe		
Faculty Dean	Dr. Aliaa Burqan		