**BACHELORS WITH PHYSICS AS MAJOR**
**$8^{th}$ SEMESTER**

**PHY822J2 PHYSICS _ ATOMIC AND MOLECULAR PHYSICS**

**CREDITS: THEORY – 4, PRACTICALS: 2**

**THEORY (4 CREDITS: 60 HOURS)**

*LEARNING OUTCOMES*

***The learning outcomes help a student to gain a deep understanding of advanced quantum mechanics concepts. Develop problem-solving skills for complex quantum systems. Apply theoretical knowledge to analyze and interpret experimental observations in atomic and molecular systems. Enhance mathematical and computational skills relevant to quantum mechanics. Foster an appreciation for the application of quantum mechanics in diverse physical systems.***

1. *Understand the principles of time-independent perturbation theory.*
2. *Apply perturbation theory to calculate energy shifts in quantum systems.*
3. *Analyze the perturbation of the ground state of a linear harmonic oscillator with a perturbation of the type $X^2$.*
4. *Demonstrate proficiency in solving problems involving perturbation theory applications.*
5. *Understand phenomena such as the Lamb shift, hyperfine structure, Zeeman effect (weak and strong fields), Paschen-Back effect, and Stark effect (linear and quadratic).*
6. *Solve the Schrödinger equation for two-electron atoms.*
7. *Comprehend spin wave functions and the role of the Pauli exclusion principle in two-electron systems.*
8. *Apply the independent particle model to analyze the ground state of two-electron atoms.*
9. *Understand the Born-Oppenheimer separation for diatomic molecules.*
10. *Investigate the rotation and vibration of diatomic molecules.*
11. *Analyze rotational spectra of diatomic molecules, including vibrational and vibrational-rotational spectra.*
12. *Develop a quantum mechanical understanding of the Raman Effect in diatomic molecules.*

**UNIT-I (15 HOURS)**

Time-independent perturbation theory, non-degenerate & degenerate cases, Applications such as ground state of linear harmonic oscillator: Perturbation of the type $X^2$.

**UNIT-II (15 HOURS)**

One-electron atoms: Fine structure of hydrogenic atoms. Energy shifts, The Lamb shift, Hyperfine structure, Zeeman effect, weak and strong fields-Paschen-Back effect, Stark effect (linear and quadratic).

**UNIT-III (15 HOURS)**

Two-electron atoms: The Schrodinger equation for two-electron atoms, Spin wave functions and the role of the Pauli exclusion principle, The independent particle model: The ground state of two-electron atoms.

**UNIT IV (15 HOURS)**

Molecular structure: The Born-Oppenheimer separation for diatomic molecules. The rotation and vibration of diatomic molecules, Rotational spectra of diatomic molecules: Vibrational and vibrational-rotational spectra of diatomic molecules, Quantum mechanical theory of Raman Effect.

**PRACTICAL ((2 CREDITS: 60 HOURS)**

1. Study of Hydrogen Spectrum using a constant deviation spectrometer.
2. Study of Sodium spectrum.
3. Determine wave length of D1, D2 lines in sodium spectrum.
4. To study vibrational spectra using an Infra-red Spectrometer.
5. Study of splitting of energy levels of mercury under a strong magnetic field using Fabry-Perot Interferometer.
6. To study Raman effect using a Laser Raman Spectrometer.

**TEXT BOOKS:**


1. Introduction to Quantum Mechanics, by David J. Griffiths and Darrell F. Schroeter, Cambridge University Press.
2. Physics of Atoms & Molecules by B.H. Bransden and C. J. Joachain, Pearson
3. Atoms, Molecules and Photons: An Introduction to Atomic-, Molecular- and Quantum Physics (Graduate Texts in Physics), Wolfgang Demtröder, Springer.
4. The Fundamentals of Atomic and Molecular Physics, Robert Brooks, Springer.
5. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
6. B.Sc. Practical Physics by C.L. Arora
7. A Textbook of Advanced Practical Physics by S. Ghosh: New Central Book Agency.
8. Physics Laboratory Experiments 8th Edition, by Jerry D. Wilson (Author), Cecilia A. Hernández-Hall (Author)