VI SEMESTER B.E.

ADVANCED PHYSICS FOR ENGINEERS
(OPEN ELECTIVE)

Subject Code:17PHY661		**CIE Marks: 40**
Number of Lecture Hours/Week: 03		**SEE Marks: 60**
Total Number of Lecture Hours: 40		**Exam Hours: 03**

Credits - 03

Course objectives:

To enable the students to gain the knowledge of

- Quantum mechanics, Raman spectroscopy and its theoretical background with applications
- Quantum computation
- Nuclear and environmental hazards with their implications
- Special theory of relativity and its relevance in latest applications.

MODULE-1 **Raman Spectroscopy**	**Teaching Hours**	**Revised Bloom's Taxonomy Level**
Different energy levels in molecules – Brief explanation of Electronic, Vibrational & Rotational levels with energy level diagram. Rotational energy levels - Derivation of the expression for rotational energy of a diatomic molecule Derivation for Rigid Rotor only and discussion on rotational spectra with selection rule. Short note on non-rigid rotor. Mention of the expression for vibrational energy: Mention of expression for harmonic oscillator, Discussion on zero-point energy, Representation of energy levels in potential energy curve and Discussion on vibrational spectra with selection rule. Short note on anharmonic oscillator. Scattering of light: Coherent and incoherent scattering with examples. Raman effect, Stoke's and antiStoke's lines, Characteristics of Raman spectra Experimental study of Raman effect: Experimental set up, Description and working. Classical theory of Raman effect based on polarisability (Mathematical treatment) Quantum theory of Raman effect based on law of conservation of energy. Rotational Raman spectra (qualitative)- Energy expression, selection rule and spectra Vibrational Raman spectra (qualitative) - Energy expression, selection rule and spectra Resonance Raman effect: Explanation Comparison between Raman effect and Resonance Raman effect Applications of Raman spectroscopy (qualitative): Brief explanation of any five applications. Detailed discussion of role of Raman spectroscopy in Forensic science – Explanation with any two examples Environmental studies: Pollution monitoring. Industrial applications: Semiconductor industry, Manufacturing industry ***Numerical Problems:*** Based on Rotational energy, Vibrational energy and Raman spectra	**08 Hours**	L1, L2, L3

MODULE-2 **Quantum Mechanics**	**Teaching Hours**	**Revised Bloom's Taxonomy Level**
Introduction to Quantum Mechanics – Wave function, properties, normalization, eigen values, eigen functions, time independent Schrodinger wave equation (as a pre-requisite only, no questions to be asked in exam). Operator formalism of Schrodinger equation (time dependent Schrodinger equation- Hamiltonian): Definition of quantum mechanical operators, operators for momentum and kinetic energy. Formulation/Derivation of time dependent Schrodinger wave equation based on operators – Hamiltonian form. Expectation values: Definition with examples (position, momentum, kinetic energy and potential energy) Applications of Schrodinger's equation: 1. Step potential - Determination of reflection and transmission coefficients when the energy of incident particles is (i) greater than the height of step potential (E > Vo) (ii) less than the height of step potential (E<Vo). 2. Rectangular potential barrier - Barrier penetration and quantum mechanical tunneling, Tunneling probability (T) (Determination of Reflection coefficient and transmission coefficients/Tunneling probability) Applications of tunneling: Scanning Tunneling microscope (STM) – Construction, working & applications, Explanation of tunneling in Alpha decay and Tunnel diode. Harmonic oscillator – Energy and wave functions of harmonic oscillator (qualitative). ***Numerical Problems:*** Based on step potential, rectangular potential barrier and harmonic oscillator.	**08 Hours**	L1, L2, L3
MODULE-3 **Quantum Computing**	**Teaching Hours**	**Revised Bloom's Taxonomy Level**
Beginnings of quantum computation: Need for quantum computation and its origin. Classical information and quantum information: Definitions and Differences Moore's law: Statement of law and Explanation Maxwell's demon and Szilard's simplified model: Explanation of model. Landauer's principle: Statement and explanation, Idea of Landauer limit Idea of reversibility: Explanation Superposition in quantum computation with examples (Qualitative): Statement and explanation of principle, Any two examples. Concept of Qubit, Properties of Qubit-vector representations in qubit states Superposed spin states of electron: Explanation of superposed spin states , Quantum amplitudes: Explanation, rotations: Explanation, Hadamord transformation: Definition, Explanation and its application in quantum computing, Toffoli gate: Definition, circuit representation, truth table and permutation matrix form, its usefulness in quantum computation. Examples of quantum computing through NMR system: Difference between classical and quantum computing.	**08 Hours**	L1, L2, L3

MODULE-4 **Environmental Hazards**	**Teaching Hours**	**Revised Bloom's Taxonomy Level**
Regions of atmosphere based on vertical temperature profile: Explanation of regions Tropospheric greenhouse gases- O3, NO, NO2, CO, CO2, CH4 and non CH4: Short note on each gas. Atmospheric aerosol particles: Definition, Examples, Size distribution, Generation by aerosol spray and electronic cigarette, and mention of applications. Role of trace gases and aerosols in atmospheric energy balance: Explanation Effect of anthropogenic activities on (a) trace gases and aerosols (b) Surface warming (c) climate change and (d) stratospheric ozone: Explanation Effect of CFC's on stratospheric ozone: Explanation, Ozone hole : Explanation. Nuclear Hazards: Radiation: Explanation of Ionising and non-ionising radiation, Ionizing radiation and its effects: Explanation *Mutation:* Genetic load, mutation rates, Background radiation (Brief explanation of terms) Units of radiation: Roentgen and rad. (Definitions and their relationship) Relative biological effectiveness (RBE): Definition and Explanation Roentgen equivalent man (REM): Definition and Explanation *Man-made radiation:* X-Rays: Production, Characrestics and its biological effects. Nuclear radiation: Definition, types and their biological effects Radiation sickness: Definition, Causes and effects. Absorption of radiation by biological beings: Explanation of absorption of radiation.	**08 Hours**	L1, L2,
MODULE-5 **Special Theory of Relativity**	**Teaching Hours**	**Revised Bloom's Taxonomy Level**
Frames of reference: Definition and types of frames of reference. Galilean transformations: Derivation of transformation equations. Michelson and Morley experiment-significance of negative result of the experiment.: Experimental set up, Derivation of path difference expression, Calculation of fringe shift, significance of negative result. Postulates of Einstein's theory of relativity: Statement and explanation of postulates. Lorentz transformation equation -space and time: Derivation of transformation equations for x and t. Length contraction and time dilation: Derivation of expressions. (l & l', t & t' relations). Velocity addition theorem: Statement and Proof. Relativistic expression for variation of mass with velocity: Derivation, Relativistic expression for energy of a particle in terms of momentum - Derivation. Equivalence of mass and energy: Derivation of $E=mc^2$ Relevance of special theory of relativity in GPS: Explanation *Numerical Problems: Based on all derived equations.*	**08 Hours**	L1,L2, L3, L4

Revised Bloom's Taxonomy Level	L1 – Remembering, L2 – Understanding, L3 – Applying. L_4 - Analyze

Course outcomes:

1. Differentiate relativistic and non-relativistic motion and its relevance to terrestrial communication.
2. Apply the concept of quantum mechanics to tunneling problems.
3. Familiarize with the developments in modern computing.
4. Understand the basic environmental and nuclear hazards.
5. Apply the concept of Raman spectroscopy to various fields including engineering and medicine.

Question paper pattern:

Note:- The SEE question paper will be set for 100 marks and the marks will be proportionately reduced to 60

- The question paper will have ten questions.
- Each full Question consisting of 20 marks. There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. Concepts of Modern physics by Arthur Beiser, Tata McGraw-Hill Publishing Company Limited, New Delhi.
2. Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash, Tata McGraw-Hill Publishing Company Limited, New Delhi.
3. Spectroscopy by H. Kaur, Pragati Prakashan, Meerut.

Reference books:

1. Quantum computation and quantum information by M.A. Nielsen and I.L. Chuang, Cambridge University Press.
2. Quantum computing – A Gentle Introduction by Eleanor G. Rieffel, Wolfgang H. Polak, MIT press.
3. Chemistry and Physics of Air pollution and climate change by John. H. Seinfield.