St. Aloysius College (Autonomous), Jabalpur

Department of Physics

SYLLABUS 2021-22

B. **Sc. III Year**

Paper I: Quantum Mechanics and Spectroscopy

Max. Marks: 40

Pass Marks:13

Course Objectives

The objectives of the course are

	Course Objectives	Cognitive Level
COb-I	To understand the necessity of quantum mechanics. Develop an understanding of Concept of wave packet and wave function	Ap ,C, An, U, R, E
COb -II	Learn the formulation Schrodinger wave equation and its solution under various conditions	U, Ap , An, E
COb -III	Learn the behavior of an atom under electric and magnetic field	R , U , Ap
COb -IV	Basics of Rotational, vibrational and electronic spectra	An
COb -V	Fundamentals of Nuclear physics. Learner will be able to rephrase the properties of nuclei in Nuclear Models, Radioactive decay, Fission and Fusion, Stellar Energy in Stars	U, An, Ap, E

Course Outcome

	Course Outcomes	Cognitive Level
COt-I	Learner will be able to understand aspects of the inadequacies of classical mechanics and historical development of quantum mechanics. Learner will be able to build concepts of Wave packets, Phase and Group Velocities and Uncertainty principle.	U, R, Ap, C, An, E
COt -II	Learner will be able to write the Schrodinger time dependent and time independent equations and Solve them for different cases.	U, An , Ap, E

COt -III	Learner will be able to extend the concept of Quantum Numbers and explanation of Spectra of Alkali/Alkaline Earth metals. Learner will be able to analyze the effect of Electric and Magnetic field on atoms.	R, U, Ap, An
COt -IV	Learner will be able to build, compare & contrast the basic concepts of Rotational, Vibrational and Electronic spectra.	U, An, E
COt -V	Learner will be able to rephrase the properties of nuclei in Nuclear Models, Radioactive decay, Fission and Fusion, Stellar Energy in Stars.	U, Ap, E

COb – Course Objectives; COt – Course Outcome; R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

Unit-I: QUANTUM MECHANICS-1 [Lecture-15]

Particles and Waves: Photoelectric effect. Black body radiation, Planck's radiation law, Stefen- Boltzmann law, Wien's Displacement law and Rayleigh- Jean's law. Compton effect. De Broglie hypothesis. Wave particle duality. Davisson-Germer experiment. Wave packets. Concept of phase and group velocity. Two slit experiment with electrons. Probability. Wave amplitude and wave functions. Heisenberg's uncertainty principle with illustrations. Basic postulates and formalism of Schrodinger's equation. Eigenvalues. Probabilistic interpretation of wave function. Equation of continuity. Probability current density. Boundary conditions on the wave function. Normalization of wave function.

Unit-II: QUANTUM MECHANICS-2 [Lecture-15]

Time independent Schrodinger equation: One dimensional potential well and barrier. Boundary conditions. Bound and unbound states. Reflection and transmission coefficients for a rectangular barrier in one dimension. Explanation of alpha decay. Quantum phenomenon of tunneling. Free particle in one-dimensional box, eigen functions and eigen values of a free particle. One-dimensional simple harmonic oscillator, energy eigenvalues from Hermite differential equation, wave function for ground state. Particle in a spherically symmetric potential. Rigid rotator, Particle in a three dimensional box, Angular Momentum, Properties of Pauli Spin Matrices.

Unit-III: ATOMIC SPECTROSCOPY [Lecture-15]

Atoms in electric and magnetic fields: Quantum numbers, Bohr model and selection rules. Stern-Gerlach experiment. Spin as an intrinsic quantum number. Incompatibility of spin with classical ideas. Orbital angular momentum. Fine structure. Total angular momentum. Pauli exclusion principle. Many particles in one dimensional box. Symmetric and anti-symmetric wave functions. Atomic shell model. Spectral notations for atomic states. Spin-orbit coupling, L-S and J-J coupling. Zeeman effect. Continuous and characteristic X-rays. Mossley's law.

Unit-IV: MOLECULAR SPECTROSCOPY [Lecture-15]

Spectra: Various types of spectra. Rotational spectra. Intensity of spectral lines and determination of bond distance of diatomic molecules. Isotope effect. Vibrational energies of diatomic molecules. Zero point energy. Anharmonicity. Morse potential. Raman effect, Stokes and anti-Stokes lines and their intensity difference. Electronic spectra. Born-Oppenheimer approximation. Frank- Condon principle, singlet and triplet states. Fluorescence and phosphorescence. Introduction to Laser Raman Spectroscopy, Elementry Concept and Application of NMR and EPR.

Unit-V: NUCLEAR PHYSICS [Lecture-15]

Basic properties of nucleus: Shape, Size, Mass and Charge of the nucleus. Stability of the nucleus and Binding energy. Alpha particle spectra – velocity and energy of alpha particles. Geiger-Nuttal law. Nature of beta ray spectra. The neutrino and its Physics. Energy levels and decay schemes. Positron emission and electron capture. Selection rules. Beta absorption and range of beta particles. Kurie plot. Nuclear reactions, pair production. Q-values and threshold of nuclear reactions. Nuclear reaction cross-sections. Examples of different types of reactions and their characteristics. Compound nucleus, Bohr's postulate of compound nuclear reaction, Semi empirical mass formula, Shell model, Liquid drop model, Nuclear fission and fusion (concepts).Classification of elementary particles and their interactions; Conservation laws; Quick Structure of hadrons; Elementary ideas about unification of forces.

References:

1. Quantum Mechanics: V.Devanathan, Narosa Publishing House, New Delhi, 2005
2. Quantum Mechanics: B.H. Bransden, Pearson Education, Singapore, 2005
3. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, John Wiley and Sons. Ltd, 2009
4. Physics of Atoms and Molecules: B.H. Bransden and C.J.Joachaim, Pearson Education, Singapore, 2003
5. Fundamental of Molecular Spectroscopy: C.M.Banwell and M. McCash, McGraw Hill.
6. Introduction to Atomic Physics: H.E.White
7. Quantum Mechanics: Schaums Outlines, Y.Peleg, R.Pnini, E.Zaarur, E.Hecht.

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Mode of Evaluation: Digital Assignments, Quiz, Quarterly Exam, Half Yearly Exam, Final examination

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SYLLABUS 2021-22

B. **Sc. III Year**

Paper II: Solid State Physics and Devices

Max. Marks: 40

Pass Marks: 13

Course Objectives

The objectives of the course are :

	Course Objectives	Cognitive Level
COb-I	To get an idea about crystal structure and bonding in solids. To understand lattice vibration and its consequences.	U,Ap , An, E
COb -II	Develop an understanding about magnetism in solids.	U,C, An, E
COb -III	To understand semiconductor physics and idea about two & three terminal electronic devices eg diode transistor etc.	R , U , Ap ,An
COb -IV	To applications of transistor as amplifier and oscillator.To get an idea about modulation and demodulation.	An,C
COb -V	To learn about application of nanotechnology. To learn about Synthesis and classification of nanomaterials.	U, An, Ap

Course Outcome

	Course Outcomes	Cognitive Level
CO-I	Learner will be able to outline the idea about crystalline and amorphous solids, and diffraction of X-rays by Crystalline materials.	U, R, Ap, E
CO-II	Learner will be able to illustrate Lattice vibrations, phonons, theories of specific heat of solids and different types of magnetism.	U, Ap , An, R

CO-III	Learner will be able to formulate Band Theory of Solids, originate the idea of two terminal devices & their applications.	R , U , Ap , C, E
CO-IV	Learner will be able make-up the concept of three terminal devices (BJT, FET) and their applications.	U, C
CO-V	Learner will be able to outline the 3D, 2D, 1D, 0D nanostructure materials and their synthesis.	U

CO – Course Outcome; R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

Unit-I: SOLID STATE PHYSICS-1 [Lecture-15]

Crystal Structure and bonding: Crystalline and amorphous solids. Translational symmetry. Lattice and basis. Unit cell. Reciprocal lattice. Fundamental types of lattices (Bravias Lattice). Miller indices Lattice planes. Simple cubic. Face centered cubic. Body centered cubic lattices. Laue and Bragg's equations. Determination of crystal structure with X-rays, X-ray spectrometer. Ionic, covalent, metallic, van der Waals and hydrogen bonding. Band theory of solids. Periodic potential and Bloch theorem. Kronig-Penny model (Qualitative).

Unit-II: SOLID STATE PHYSICS-2 [Lecture-15]

Lattice structure and properties: Dulong Petit, Einstein and Debye theories of specific heats of solids. Elastic and atomic force constants. Dynamics of a chain of similar atoms and chain of two types of atoms. Optical and acoustic modes. Electrical resistivity. Specific heat of electron. Wiedemann-Franz law. Hall effect. Response of substances in magnetic field, dia-, para- and ferromagnetic materials. Classical Langevin theory of dia and paramagnetic domains. Curie's law. Weiss' theory of ferromagnetism and ferromagnetic domains. Discussion of BH hysteresis. Super Conductivity, Meissner's effect, Josephson junction effect and high temperature superconductivity

Unit-III: SEMICONDUCTOR DEVICES-1 [Lecture-15]

Electronic devices: Types of Semiconductors (p and n). Formation of Energy Bands, Energy level diagram. Conductivity and mobility. Junction formation, Barrier formation in p-n junction diode. Current flow mechanism in forward and reverse biased diode (recombination), drift and saturation of drift velocity. Derivation of mathematical equations for barrier potential, barrier width. Single p-n junction device (physical explanation, current voltage characteristics and one or two applications). Two terminal devices. Rectification. Zener diode. Photo diode. Light emitting diode. Solar cell. Three terminal devices. Junction field effect transistor (JFET). Two junction devices. Transistors as **p-n-p** and **n-p-n**. Physical mechanism of current flow and characteristics of transistor.

Unit-IV: SEMICONDUCTOR DEVICES-2 [Lecture-15]

Amplifiers (only bipolar junction transistor). CB, CE and CC configurations. Single stage CE amplifier (biasing and stabilization circuits), Q-point, equivalent circuit, input impedance, output impedance, voltage and current gain. Class A, B, C amplifiers (definitions). RC coupled amplifiers (frequency response). Class B push-pull amplifier. Feedback amplifiers. Voltage feedback and current feedback. Effect of negative voltage series feedback on input impedance. Output impedance and gain. Stability, distortion and noise. Principle of an Oscillator, Barkhausen criterion, Colpitts, RC phase shift oscillators. Basic concepts of amplitude, frequency and phase modulations and demodulation.

Digital Electronics : Boolean Identities, De- Morgan's law, Logic gate and tables, Simple logic circuits; Thermistors, Solar cells, Concepts of Microprocessors and digital Computer.

Unit-V: NANO MATERIALS **[Lecture-15]**

Nanostructures: Introduction to nanotechnology, structure and size dependent properties. 3D, 2D, 1D, 0D nanostructure materials and their density of states, Surface and Interface effects. Modelling of quantum size effect. Synthesis of nanoparticles - Bottom Up and top Down approach, Wet Chemical Method. Nanolithography. Metal and Semiconducting nanomaterials. Essential differences in structural and properties of bulk and nano materials (qualitative description). Naturally occurring nano crystals. Applications of nanomaterials.

References:

1. Introduction to Solid State Physics: C.Kittel, VIII Edition, John Wiley and Sons, New York, 2005.
2. Intermediate Quantum Theory of Crystalline Solids: A.O.E. Animalu, Prentic-Hall of India Pvt. Ltd., New Delhi, 1977
3. Solid State Electronic Devices: B.G.Streetman, II Edition , Prentic-Hall of India Pvt. Ltd., New Delhi
4. Microelectronics: J.Millman and A. Grabel, McGraw Hill, NewYork
5. The Physics and Chemistry of Nanosolides: Frank J. Owens and Charles P. Pooles Jr., Wiley Inter Science, 2008
6. Physics of Low Dimensional Semiconductors: An introduction, J.H. Davies, Cambridge University Press, UK, 1998
7. Electronic Fundamental and applications, J.D. Ryder, Prentic Hall, India

Mode of Evaluation: Digital Assignments, Quiz, Quarterly Exam, Half Yearly Exam, Final examination

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List of Physics Practical

Student need to perform at least 16 practicals.

1. To determine the value of Planck's constant "h" by solar cell.
2. To determine the energy band gap of a semiconductor by Regnault's apparatus.
3. To plot the characteristic curve of PN Junction Diode in Forward bias condition.
4. To plot the characteristic curve of a Zener Diode in forward and reverse bias condition.
5. To plot the characteristic curve of a Tunnel Diode.
6. To plot the characteristic curve of different colour LEDs.
7. To study the characteristic curve of JFET.
8. To study the characteristic curves of a transistor in CE mode.
9. To study the characteristic curves of a transistor in CB mode.
10. To study the half wave, full wave and bridge rectifier and the effect of different filter circuits on ac-ripple factor.
11. To study the frequency response curve of single stage RC-coupled amplifier and to calculate the band width.
12. To determine energy band gap of germanium crystal using four probe method.
13. To study Hartley oscillator/ Colpitts oscillator.
14. To study RC phase shift oscillator.
15. To study Hall Effect.
16. To study B-H curve and calculate Hysteresis Loss of Ferromagnetic material.
17. To study modulation /demodulation.
18. To determine the capacitance by Schering Bridge.
19. To determine the unknown frequency by Lissajous Figures.
20. To study Zeeman Effect.
21. To study Faraday Effect.

****** Any other experiments related to theory can be added.