Semester **II**
Name of the Course **: QUANTUM MECHANICS –II (Core – V)**
Subject code **: PP2022**

No. of hours per week	No. of credits	Total No. of hours	Marks
6	5	90	100

Objective

To develop several approximation methods, for bounds states and scattering states and apply them to illustrative problems.

CO	Upon completion of this course, students will be able to:	PSO addressed	CL
CO - 1	enumerate time independent perturbation theory and use approximation methods. (variation principle and WKB method) to solve simple problems (ground state helium, barrier penetration, etc)	PSO-1	K
CO - 2	analyze time dependent perturbation theory to discuss absorption and emission of radiation for harmonic perturbation.	PSO-6	An
CO - 3	interpret quantum theory of atomic and molecular structure.	PSO-4	U
CO -4	formulate Klein-Gordan and Dirac equations and discuss the applications. (particle in a Coulomb field, Spin of electron)	PSO-1	C

Modules

Credit: 5 **Total Hours: 90 (Incl. Seminar & Test)**

Unit	Module	Topics	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
I	**Approximation Methods for Time Independent Problems**					
	1	Time independent perturbation theory: Basic concepts – Non-degenerate energy levels – first and second order	4	To understand the basic concepts of time independent perturbation theory.	PPT, Illustration and theoretical derivation	Evaluation through: Online quiz, Problem solving
	2	Anharmonic oscillator – First-order correction – Ground state of Helium	3	To understand the ground state of Helium.	Illustration, Theoretical formulation Problem Solving	short questions Descriptive

	3	Effect of electric field on the ground state and n=2 of hydrogen	4	To analyze the effect of electric field on hydrogen.	Illustration, Theoretical formulation Problem Solving	answers Formative assessment
	4	Degenerate Energy Levels-Stark effect in hydrogen molecule-Spin-Orbit interaction.	4	To analyze the splitting of energy levels in hydrogen molecule and spin-orbit interaction.	PPT, Theoretical formulation and Problem solving	
II	**Approximation Methods for Time Dependent Perturbation Theory**					
	1	Time dependent perturbation theory: First order perturbation – Harmonic perturbation – Transition to continuum states-Fermi Golden Rule	4	To understand the basic concepts and features related to time dependent perturbation.	PPT Illustration, lecture, and Problem solving	Evaluation through: Online quiz, short questions Descriptive answers Problem solving Formative assessment
	2	Absorption and Emission of radiation – The Electromagnetic field	4	To understand the absorption and emission of electromagneti c radiation.	Descriptive lecture, comparative study	
	3	Hamiltonian operator- Electric dipole approximation- transition probability	4	To formulate the electric dipole approximation.	PPT, Theoretical formulation and Problem solving	
	4	Einstein's A and B coefficients – Selection rules- forbidden transitions.	3	To understand selection rules and forbidden transitions.	Illustration, Theoretical formulation and Problem solving	
III	**Variation and WKB Method**					
	1	Variation method :Variational principle – Ground state of Helium and Deuteron	4	To solve the ground state of Helium and Deuteron.	Illustration, Theoretical formulation and Problem solving	Evaluation through: Online quiz, short questions Descriptive answers
	2	WKB Approximation : WKB method – Connection formula – Solution near a turning point – Validity of the WKB method	4	To analyze the WKB approximation.	PPT, Illustration,The oretical formulationand Problem solving	

	3	Barrier penetration – Alpha emission	4	To understand applications of WKB method.	Illustration, Theoretical formulation and Problem solving	Assignment Formative assessment
	4	Bound states in a potential well	3	To analyze the bound states in a potential well.	Illustration, Theoretical formulation comparative study and Problem solving	
IV	**Quantum Theory of Atomic and Molecular Structure**					
	1	Spin functions – Helium atom-Ground state- First excited state	3	To understand the concept of spin functions of two and three electrons.	Theoretical formulation and Problem solving	Evaluation through: Online quiz, short questions Descriptive answers Problem solving Formative assessment
	2	Central field approximation: -Determination of central field: Thomas Fermi method-Hartree-Fock approximations	5	To compare the central field approximations.	Theoretical formulation and Problem solving	
	3	Molecular Orbital method-Born-Oppenheimer approximation – MO treatment of hydrogen molecule Ion (H_2+)	5	To understand the basic concepts and features of molecular orbital method.	PPT Illustration, lecture, and Problem solving	
	4	Molecular orbital theory of Hydrogen molecule.	2	To analyze the molecular orbital theory of hydrogen molecule.	Descriptive lecture comparative study	
V	**Relativistic Quantum Mechanics & Quantization of the Field**					
	1	Klein – Gordon Equation – Interpretation of the Klein-Gordon equation – Particle in a Coulomb field	4	To understand the basic concepts and features of a particle in a Coulomb field.	PPT Illustration, And Descriptive lecture	Evaluation through: Online quiz, short

	2	Dirac's equation for a free particle – Dirac matrices – Plane wave solution –Negative energy states – Spin of the Dirac particle	4	To understand the concept of Dirac particle.	Descriptive lecture and Theoretical formulation	questions Descriptive answers Problem Solving
	3	Magnetic moment of the electron – Spin-orbit interaction.	2	To apply the concept of magnetic moment of electron.	Descriptive lecture and Theoretical formulation	
	4	Quantization of the Field - Lagrangian equation- Hamiltonian equation- Schrodinger equation- Quantization of Electromagnetic fields	5	To understand the quantization of the field.	Descriptive lecture and Theoretical formulation	Formative assessment

PO- Program outcome; LO – Learning outcome; Cognitive Level : K- Knowledge; Analyze- An; U – Understand; Create – C.

Course Instructor: Dr. M.Priya Dharshini & Dr.S.Sonia

Semester II
Major Core –VI
Name of the Course : Condensed Matter Physics-I
Subject code : PP2023

No of hours per week	No of credits	Total no of hours	Marks
6	4	90	100

Objective

To give strong foundation in the conceptual understanding of the development of solid state physics with appropriate theoreticalbackground.

CO	Upon completion of this course the students will be able to :	PSO addressed	CL
CO- 1	differentiate between different lattice types and explain the concepts of reciprocal lattice and crystal diffraction	PSO-4	Ap
CO- 2	analyze various crystal imperfections and ordered phases of crystal	PSO-2	An
CO- 3	explain the theory of lattice vibrations and analyze the thermal properties of solids	PSO-2	An
CO -4	formulate the problem of electrons in a periodic potential	PSO-1	U

Modules

Credits: 4 Total contact hours: 90 (Including assignments and tests)

Unit	Section	Topics	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
	Crystal Physics:CrystalStructure					
		Lattice representation, Simple symmetry operations, Bravais Lattices, Unit cell, Wigner - Seitz cell		To acquire knowledge on space lattice and symmetry operations	Lecture Discussion with PPT illustration	Evaluation through Online quiz Class test Formative assessment I
		Miller planes and spacing, Characteristics of cubic cells, Structural features of NaCl, CsCl, Diamond, ZnS, Closepacking.		To be able to identify the crystal structure of materials	Lecture discussion with illustration, SLO	
		Crystal Binding: Interactions in inert gas crystals and cohesive energy, Lennard - Jones potential, Interactions in ionic crystals and Madelung energy		To understand the different kinds of bonding	Lecture discussion	
		valent bonding , Heitler - London Theory Hydrog en bonding , metallic bonding .		To acquire knowledge on hydrogen, metallic and mixed bonding	Lecture discussion, PPT	
	Diffraction of Waves and Particlesby Crystals					
		X-rays and their generation,		To know the principles	Lecture Discussion	Short test

Semester IV
Course Name: Nuclear and Elementary Particle Physics
Course Code: PP2041

Hours/Week	Credits	Total Hours	Marks
6	**5**	**90**	**100**

Learning Objectives

1. To know about the fundamental principles and concepts governing nuclear and particle physics and their social, economic and environmental implications.
2. To understand the concept of elementary particles.

Course Outcome

COs	Upon completion of this course, students will be able to:	PSO addressed	CL
CO-1	Understand the properties of Nuclear forces and outline their behavioral formulation.	**PSO - 1**	**U**
CO-2	Analyze the different nuclear models of the nucleus and examine the application of the shell model of nucleus.	**PSO - 4**	**E**
CO-3	Explain the characteristics and effect of radioactive decay phenomena. (alpha,beta,gamma)	**PSO - 1**	**U**
CO-4	Discuss the outcome of various types of nuclear reactions.	**PSO - 4**	**C**
CO-5	Examine the Particle Physics phenomena and their basic theoretical description.	**PSO - 3**	**An**

Module

Total contact hours: 90 (Including lectures, assignment and tests)

Unit	Section	Topics	Lecture Hours	Learning outcomes	Pedagogy	Assessment/Evaluation
I	**Nuclear Forces**					
	1	Characteristics of Nuclear Forces – Exchange forces and tensor forces – charge independence	**4**	Define the basis of Nuclear Forces	PPT, Illustration and theoretical derivation	Evaluation through: Online quiz, Problem solving short questions Descriptive answers Open book assignment Formative assessment I
	2	Spin dependence of Nuclear Forces - Meson theory	**4**	Apply Meson theory of nuclear	Derivation and group discussion	

		of nuclear forces- Ground state of deuteron		forces		
	3	Nucleon-nucleon scattering singlet and triplet parameters – Nucleon-Nucleon scattering: Cross-section, Differential Cross-section, Scattering Cross-sections	**4**	Derivation of Nucleon-Nucleon scattering	PPT, Illustration, Theoretical formulation	
	4	Magnetic moment-Quadrupole moment –S and D state admixtures - Effective range theory of n-p scattering at low energies.	**3**	Apply Quadrupole moment –S and D state admixtures	Derivation and group discussion	
II	**Nuclear Models**					
	1	Binding energy & mass defect – Weizacker's formula – mass parabola	**4**	Solve Weizacker' smass formula	PPT, Derivation discussion	Evaluation through: Online quiz, Problem solving short questions Descriptive answers Formative assessment I
	2	Liquid drop model - Bohr - Wheeler theory of fission-Activation energy for fission	**4**	Analyse the liquid drop model of nucleus, Define and derive equations	Derivation, group discussion problem solving	
	3	Shell model-Spin –Orbit coupling-Spins of nuclei-Magnetic moments – Schmidt lines-	**3**	Statement and proof of Shell model of nucleus and Electric quadrupole	Illustration, Theoretical formulation	

		Electric quadrupole moments		moments		
	4	Collective model of Bohr and Mottelson: Nuclear vibration – Nuclear rotation –Nelson model	**4**	Examine the Collective model of Bohr and Mottelsonand its applications	Derivation and group discussion problem solving	
III	**Nuclear Reactions**					
	1	Nuclear reaction - Q- value – Nuclear reaction cross section – Direct Nuclear Reactions	**4**	Explore Nuclear reaction cross section	Derivation, group discussion	Evaluation through: Online quiz, Problem solving Short Questions Descriptive answers Formative assessment I/II
	2	Knock out reaction, Pick-up reaction, Stripping reaction – Compound nucleus theory – Formation – Disintegration energy levels – Partial wave analysis of Nuclear reaction cross-section	**3**	Obtain the Compound nucleus theory	Illustration, Theoretical formulation	
	3	Resonance Scattering and Reaction cross-section (Breit-Wigner dispersion formula) – Scattering matrix	**4**	Derive Breit Wigner dispersion formula	Derivation and group discussion, PPT	
	4	Reciprocity theorem – Breit -Wigner one level formula – Resonance scattering –	**4**	Define, deriveand apply Breit-Wigner one level formula	PPT, Illustration, Theoretical formulation	

		Absorption cross section at high energy.				
IV	**Radioactive Decays**					
	1	Alpha decay - Beta decay – Energy release in beta decay – Fermi theory of beta decay	**4**	Discuss different typesof radioactive decays	Derivation discussion	Evaluation through: Online quiz, Problem solving short questions Descriptive answers Formative assessment II
	2	Shape of the beta spectrum – decay rate Fermi-Curie plot – Fermi & G.T Selection rules	**3**	Define and derive principle and logic of Curie plot	Derivation and group discussion, PPT	
	3	Comparatives half - lives and forbidden decays- Gamma decay - Multipole radiation	**4**	Discuss about different types of Gama decay	Derivation and group discussion	
	4	Angular momentum and parity selection rules – Internal conversion – Nuclear isomerism.	**4**	Analyze charge parity selection and scrutinize the Charge Nuclear isomerism	Derivation and group discussion	
V	**Elementary Particle Physics**					
	1	Classification of elementary particles - Types of interaction between elementary particles – Hadrons and leptons	**3**	AnalyzeFund amental Classification of elementary particles	Discussion PPT	Evaluation through: Online quiz, Problem solving short questions Descriptive answers Assignments, Seminars Formative assessment II
	2	Symmetry and conservation laws – Strangeness and associate production - CPT theorem – classification of hadrons	**4**	Analyse the conservation laws and prove CPT theorem	Derivation and group discussion, PPT	

	3	Quark model - Isospin multiples - SU(2)- SU(3) multiplets- Gell-Mann - Okubo mass formula for octet and decouplet hadrons	**4**	Explain and derive mass formula for octet and decouplet	Derivation and group discussion	
	4	Phenomenology of weak interaction hadrons and leptons-Universal Fermi interaction – Elementary concepts of weak interactions.	**4**	Define, deriveand apply Universal Fermi interaction – Elementary concepts of weak interactions	Derivation and group discussion, PPT	

PO- Program outcome; LO – Learning outcome; Cognitive Level R – Remember; U – Understand; Ap- Apply, An- Analyze; E-Evaluate; C- Create

Staff-in charges: Ms.C.Nirmala Louis &Ms. R. Krishna Priya

Semester IV
Course Name: Spectroscopy
Course Code: PP2042

Hours/Week	**Credits**	**Total Hours**	**Marks**
6	5	90	100

Learning Objectives

1. To gain knowledge about the basic principles of spectroscopy.

2. To gain insight about the spectroscopic instruments and its applications.

Course Outcome

Cos	**Upon completion of this course, students will be able to:**	**PSO addressed**	**CL**
CO - 1	apply basic spectroscopic techniques. (Microwave, IR, Raman and NMR)	**PSO - 4**	**U**
CO - 2	infer basic spectroscopic techniques. (Microwave, IR, Raman, ESR, NQR and NMR)	**PSO - 6**	**Ap**

CO - 3	understand the molecular interactions in different spectroscopic methods.	**PSO - 1**	**An**
CO - 4	analyze the characteristics of rotational spectra and vibrational energy of molecules.	**PSO - 3**	**An**
CO - 5	utilize various spectroscopic methods suitable for characterizing molecules.	**PSO - 6**	**C**

Modules

Total contact hours: 90 (Including lectures, assignment and tests)

Unit	Section	Topics	Lecture Hours	Learning outcomes	Pedagogy	Assessment/Evaluation
I	**Microwave Spectroscopy**					
	1.	Rotation of Molecules – Rigid Rotor (Diatomic Molecules)	**4**	Define the basis of Semiconductor	PPT, Illustration and theoretical derivation	Evaluation through: Online quiz, Problem solving short questions Descriptive answers Formative assessment I
	2	Expression for the Rotational Constant - Intensity of Spectral Lines	**4**	Derive the expression for the Rotational Constant	Derivation and group discussion,	
	3	Effect of Isotopic Substitution - Molecular Parameters (Bond Length, Bond Angle , Dipole Moment from Rotation Spectra)	**4**	Explain the effect of Isotopic substitution of molecules and derive the Molecular Parameters (Bond Length, Bond Angle from Rotation Spectra)	PPT, Illustration, derivation and group discussion	
	4	Techniques and Instrumentation	**3**	Explain the instrumentation techniques of microwave spectrometer	Derivation and group discussion	
II	**Infrared Spectroscopy**					
	1	Vibrational energy of a diatomic molecule- Infrared selection rules- Vibrating diatomic molecule- IR spectrophotometer	**4**	Derive the vibrational energy of a diatomic molecule	PPT, Derivation discussion	Evaluation through: Online quiz, Problem solving short questions Descriptive answers Formative assessment I
	2	Diatomic vibrating rotator- Vibrations of polyatomic molecules-Fermi resonance	**4**	Derive equation for diatomic vibrating rotator and vibrations of polyatomic molecules	Derivation and group discussion problem solving	
	3	Rotation vibration spectra of polyatomic molecules-	**3**	Explain the normal modes of vibration in	Illustration, Derivation	

		Normal modes of vibration in crystal Interpretation of vibrational spectra-Group frequencies -		crystal Interpret the vibration spectra and Group frequencies	and group discussion problem solving	
	4	Instrumentation-Sample handling techniques-Fourier Transform Infrared spectroscopy-Applications	**4**	Explain the Instrumentation of IR spectrophotometer Discuss its applications	Derivation and group discussion problem solving	
III	**Raman Spectroscopy**					
	1	Introduction-Theory Of Raman Scattering-Rotational Raman Spectra-Vibrational Raman Spectra-Mutual Exclusion Principle	**4**	Devive the theories of Raman spectrometer	Derivation discussion	Evaluation Evaluation through: Online quiz, Problem solving short questions Descriptive answers Formative assessment I/II
	2	Raman Spectrometer-Sample Handling Techniques-Polarization Of Raman Scattered Light-Structure Determination Using IR And Raman Spectroscopy-Raman Investigation Of Phase Transitions	**3**	Explain the Raman Spectrometer and discuss its sample Handling Techniques Discuss the Structure determination Using IR And Raman Spectroscopy	Illustration, Theoretical formulation Derivation and group discussion,PPT	
	3	Resonance Raman Scattering-Nonlinear Raman Phenomena-Preliminaries-Hyper Raman Effect	**4**	Define Nonlinear Raman Phenomena, Preliminaries and Hyper Raman Effect	Derivation and group discussion, PPT	
	4	Stimulated Raman Scattering-Inverse Raman Effect-Coherent Anti-Stokes Raman Scattering.	**4**	Discuss the anti-Stokes lines of Raman Scattering	PPT, Illustration, Theoretical formulation	
IV	**Nuclear Magnetic and Electron Spin Resonance Spectroscopy**					
	1	Basic principles – Quantum theory of NMR - magnetic resonance – relaxation processes	**4**	Explain the basic principles of NMR .relaxation processes	Derivation discussion ,PPT	Evaluation through: Online quiz, Problem solving short questions Descriptive answers Formative assessment II
	2	chemical shifts – spin-spin coupling - Spectra and molecular structure – Fourier Transform NMR Instrumentation – Applications	**3**	Define and derive chemical shifts Explain the Instrumentation and Applications of NMR	Derivation and group discussion, PPT	

	3	Basic principles – Quantum theory – g-factor – Nuclear Interaction and Hyperfine structure – Relaxation effects	**4**	Explain the Nuclear Interaction and Hyperfine structure	Derivation and group discussion	
	4	Hyperfine interaction – line widths – ESR spectrometer – Instrumentation – applications	**4**	Discuss the ESR spectrometer, Instrumentation and its applications	Derivation and group discussion	
V		**Nuclear Quadrupole Resonance and Mossbauer Spectroscopy**				
	1	Basic theory - Nuclear Electric quadrupole interaction – Energy levels – Transition frequency – Excitation and Detection	**3**	Discuss the nuclear electric quadrupole interaction	Discussion PPT	Evaluation through: Online quiz, Problem solving short questions Descriptive answers Formative assessment II
	2	Effect of magnetic field - Instrumentation – Applications. Mossbauer effect - recoilless emission and absorption	**4**	Discuss the effect of magnetic Field and its instrumentation	Derivation and group discussion, PPT	
	3	hyperfine interaction - chemical isomer shift - magnetic hyperfine and electric quadruple interactions	**4**	Explain the magnetic hyperfine and electric quadruple interactions	Derivation and group discussion PPT	
	4	Instrumentation applications.	**4**	Explain the instrumentation and its application	Derivation and group discussion, PPT	

PO- Program outcome; LO – Learning outcome; Cognitive Level R – Remember; U – Understand; Ap- Apply, An- Analyze; E-Evaluate; C- Create

Staff-in charge: Ms.V.Shally & Ms.Jenepha Mary

Semester IV

Course Name: Thermodynamics and Statistical Mechanics

Course code: PP2043

No.of hours per week	No. of credits	Total No. of hours	Marks
6	5	90	100

Learning Objectives

1. To provide a phenomenological introduction to thermodynamics throughthermodynamics postulates, quantities and relations.
2. To understand the micro and macroscopic properties of the matter through the statistical probability laws and distribution of particles and study the transport properties, different phases of maters, equilibrium and nonequilibrium process.

Course Outcomes

Cos	Upon completion of this course, students will be able to:	PSO addressed	CL
CO - 1	understand the basic concepts related to thermodynamics, microstates and macrostates	**PSO - 4**	**U**
CO - 2	apply principles to find relation between grand canonical and canonical partition functions	**PSO - 1**	**Ap**
CO - 3	solve the Bose-Einstein, Fermi-Dirac and Maxwell-Boltzmann distributions	**PSO - 4**	**C**
CO - 4	analyze the origin of transport and non-equilibrium processes	**PSO - 3**	**An**
CO - 5	understand the concept of heat capacities and phase transitions	**PSO -4**	**U**

Teaching Plan

Credits: 5 **Total Hours: 90 (Incl. Seminar &Test)**

Unit	Module	Topics	Lecture hours	Learning outcome	Pedagogy	Assessment/ Evaluation
I	**Thermodynamics, Microstates and Macrostates**					

	1	Basic postulates of thermodynamics – Phase space and ensembles – Fundamental relations anddefinition of intensive variables – Intensive variables in the entropic formulation	4	Understand the concepts of thermodynamics	PPT, Descriptive lecture	Evaluation through: quiz, Problem solving Descriptive answers short questions Formative assessment (I CIA)
	2	Equations ofstate – Euler relation, densities - Gibbs-Duhem relation for entropy - Thermodynamic potentials–Maxwell relations – Thermodynamic relations	4	To study the different relations and equations of thermodynamics	Illustration, Descriptive lecture	
	3	Microstates and macrostates – Ideal gas –Microstate and macrostate in classical systems – Microstate and macrostate in quantum systems–	4	Understand the basic concept of thermodynamical states	Illustration, Descriptive lecture	
	4	Density of states and volume occupied by a quantum state	3	To study DOS of systems	Illustration, Descriptive lecture	
II	**Microcanonical, Canonical and Grand CanonicalEnsembles**					
	1	Microcanonical distribution function – Two level system in microcanonical ensemble – Gibbsparadox and correct formula for entropy	4	Understand the concept of ensembles	PPT Illustration, Descriptive	Evaluation through: quiz,

					lecture	short questions Descriptive answers Problem solving Formative assessment (I&II CIA)
	2	The canonical distribution function – Contact with thermodynamics	3	To acquire knowledge on distribution function of thermodynamics	Lecture, Seminar	
	3	Partition function and free energy of an ideal gas - the grand partition function	4	To understand the concepts of partition function	Descriptive lecture	
	4	Relation between grand canonical and canonical partition functions – One-orbitalpartition function	4	Understand the relation between partition functions	Descriptive lecture, seminar	
III	**Bose-Einstein, Fermi-Dirac and Maxwell-BoltzmannDistributions**					
	1	Bose-Einstein and Fermi-Dirac distributions –Chemical potential of bosons –Number density of photons and Bose condensation	4	To learn about Bose-Einstein distribution and bosons	Illustration, Descriptive lecture	Evaluation through: quiz, short questions Descriptive answers Formative assessment (I CIA)
	2	Thermodynamic quantities – Non-interactingBose gas and thermodynamic relations - The principle ofdetailed balance	3	To understand the basic thermodynamic quantities	Lecture, Seminar	
	3	Thermodynamic relationsfor non-interacting Fermi gas – Fermi gas at zero and low temperature – Fermi energy and Fermimomentum	4	To know the relations concerned with fermi gas	Descriptive lecture	
	4	Maxwell-Boltzmann distribution law for microstates in a classical gas – Physical interpretation of the classical limit – Fluctuations in different ensembles	4	To gain knowledge on Maxwell-Boltzmann distribution and classical interpretation	Group Discussion, Lecture, seminar	
IV	**Transport and Non-Equilibrium Processes**					
	1	Derivation of Boltzmann transport equation for change of states without and with collisions –Boltzmann equation for quantum statistics – Equilibrium distribution in Boltzmann equation	5	To have a clear idea on Boltzmann equations	PPT Illustration, Descriptive lecture.	Evaluation through quiz,Descriptive answers

	2	Transport processes; One speed and one dimension - All speeds and all directions – Conservedproperties - Distribution of molecular velocities – Equipartition and Virial theorems	5	To understand transport, speed, velocity and properties	Lecture, Group discussion	short questions
	3	Randomwalk - Brownian motion - Non-equilibrium process; Joule-Thompson process - Free expansionand mixing - Thermal conduction - The heat equation.	5	To study the concept of expansion and conduction	Lecture, seminar	Assignment, Formative assessment (II CIA)
V	**Heat Capacities, Ising Model and Phase Transitions**					
	1	Heat capacities of heteronuclear diatomic gas – Heat capacities of homonuclear diatomic gas –Heat capacity of Bose gas	4	To acquire knowledge on heat capacity of gases	PPT Illustration, Descriptive lecture	Evaluation through: quiz, short questions
	2	One-dimensional Ising model and its solution by variational method– Exact solution for one-dimensional Ising model	4	To get a brief idea on Ising model	Descriptive lecture	Descriptive answers
	3	Phase transitions and criterion for phasetransitions – Classification of phase transitions by order and by symmetry	4	To learn about phase transitions and its classifications	Descriptive lecture, Seminar, Assignment	Problem solving
	4	Phase diagrams forpuresystems – Clausius-Clapeyron equation – Gibbs phase rule	3	To study the phase diagrams and phase rules	Illustration, Descriptive lecture	Formative assessment (II CIA)

PO- Program outcome; LO – Learning outcome; Cognitive Level U – Understand; Ap- Apply, An- Analyze; K- Knowledge

Course Instructor : Dr. M. Priyadharshini and Ms. P. AjiUdhaya

Semester IV
Course name: Advanced Nano Physics
Course code: PP2045

Hours/Week	Credits	Total Hours	Marks
6	5	90	100

Learning Objectives

1. To understand the theoretical aspects of low dimensional semiconductor systems.
2. To learn the structures, properties, characterization and applications of nanomaterials.

Course Outcome

COs	Upon completion of this course the students will be able to:	PSO addressed	CL
CO- 1	Identify how basic physics can be used to describe the behaviour of electrons in nano-scale materials.	**PSO-1**	**R**
CO- 2	Explain the variation in the electron distribution in nanostructures for different dimensions (Quantum well, Quantum wires & quantum dots)	**PSO-3**	**U**
CO- 3	Analyze magneto electronics and applications of Nanotechnology in various fields.	**PSO-6**	**An**
CO -4	Explain Laser effect in Quantum well, Quantum wires and quantum dots .	**PSO-2**	**U**
CO- 5	Compare the structure and properties of Carbon nanostructures and their applications in the emerging nanotechnology	**PSO-6**	**E**
CO -6	Discuss the fabrication and characterization techniques of nanomaterials	**PSO-2**	**U**
CO -7	Develop key concepts in Single electron transistor, Spintronics and Giant magnetoresistance	**PSO-4**	**C**

Modules

Total contact hours: 90 (Including lectures, assignment and tests)

Unit	Section	Topics	Lecture Hours	Learning outcomes	Pedagogy	Assessment/Evaluation
I	**Introduction to Nano and Types of Nanomaterials:**					
	1	Need and origin of nano, Nano and energetic-Top-down and bottom-up approaches	4	To understand the importance of nano	Lecture Discussion with PPT Illustration	
	2	Introductory ideas of 1D, 2D and 3D nanostructured materials	4	be able to distinguish between 1D, 2D and	Lecture discussion	Evaluation through: Online quiz,

				3D nanomaterials		Formative assessment I
	3	Quantum well: Quantum well infrared detector- quantum well laser- quantum cascade laser- Quantum wire: Production- VLS growth mechanism- structure and uses-	4	understand the concept quantum well and its applications	PPT Illustration	
	4	Quantum dots: Description- Exciton confinement in quantum dots – Epitaxially self-assembled quantum-dot- Application: Quantum dot laser	3	To learn about the synthesis and applications of quantum dots	Lecture discussion	
II	**Carbon Nanostructures**					
	1	Carbon molecules and carbon bond - C60: Discovery and structure of C60 and its crystal -Superconductivity in C60 -Fullerene	4	To understand the significance of C60 in nanotechnology	PPT and group Discussion	Evaluation through: Online quiz, Short questions Descriptive answers Formative assessment I
	2	Carbon Nano Tubes (CNT): Types- Fabrication: Electric Arc-discharge method- Laser method	4	To be able to synthesize carbon nanotubes	Lecture Discussion with PPT Illustration	
	3	Solar production of carbon nanotubes - Chemical vapour deposition– Electronic structure – Electrical properties	3	To understand the different synthesis methods in CNT production	PPT Illustration	
	4	Vibrational properties – Mechanical	4	To learn the different applications	Lecture Discussion with	

		properties – Applications (fuel cells, chemical sensors, catalysts) – Filling of carbon nanotubes - CNT emitters		of carbon nanotubes	PPT Illustration	
III	**Fabrication of Nanomaterials**					
	1	Synthesis of oxide nanoparticles by sol-gel method - Synthesis of metallic nanoparticles Electrochemical deposition method	4	To be able to differentiate the synthesis methods in nanomaterial preparation	Lecture discussion	Evaluation Evaluation through: Online quiz, Short questions Descriptive answers Formative assessment I/II
	2	Sonochemical reduction method – Lithography -- Atomic layer deposition - Synthesis of semiconductor nanoparticles	3	To be able to synthesize semoconductor nanoparticles	Lecture Discussion with PPT Illustration	
	3	Arrested precipitation method- Core shell structures – Bio synthesis of nanoparticles using plants	4	To understand the techniques in bio synthesis of nanoparticles	Lecture discussion	
	4	Preparation of magnetic nanomaterials - Super paramagnetism - Coulomb blockade – Single electron transistor	4	To understand the preparation and applications of magnetic nanomaterials	PPT and group Discussion	
IV	**Characterization of Nanomaterials**					

	1	Principles, experimental set-up, procedure and utility of X-ray diffraction (XRD), Scanning electron microscopy (SEM)	4	To understand the principles, experimental set-up, procedure and utility XRD and SEM	Lecture Discussion with PPT Illustration	Evaluation through: Online quiz, Problem solving short questions Descriptive answers Formative assessment II
	2	Atomic force microscopy (AFM), Scanning tunneling microscope (STM) and scanning probe microscopy (SPM), Fourier transform infrared spectroscopy	3	To be able to interpret the structural properties using AFM, STM, SPM and FTIR	Lecture discussion	
	3	Quantum cellular Automata-Spintronics - Giant magnetoresistance	4	To understand the concept giant magnetoresistance	PPT Illustration	
	4	Quantum Hall effect - Quantum spin Hall effect - Fractional quantum Hall effect	4	To understand the concept Quantum Hall effect	Lecture Discussion with PPT Illustration	
V	**Applications**					
	1	Molecular electronics and nanoelectronics - Nanorobots - Biological applications of nanoparticles	3	To understand the importance of nanoelectronics	PPT Illustration	Evaluation through: Online quiz, Problem solving short questions Descriptive answers Formative assessment II
	2	Catalysis by gold	4	To be able	Lecture	

		nanoparticles – Band-gap engineered quantum devices -Nanomechanics		to mention the importanc e of nanomech anics	Discuss ion with PPT Illustrat ion	
	3	Photo electro chemical cells – Photonic crystals – Plasmon waveguides. Sensors – MEMS/NEMS – Solar cells – Displays	4	To learn the applicatio ns of nanoparti cles in NEMS	Lecture discus sion	
	4	Optical switches – Graphene electronics – Biosensors – Biomarkers and Bio imaging – Targeted drug delivery	4	To learn the applications of nanoparticles in medical field	PPT Illustratio n	

PO- Program outcome; LO – Learning outcome; Cognitive Level R – Remember; U – Understand; Ap- Apply, An-Analyze; E-Evaluate; C- Create

Staff-in charge: Ms. A. Lesly Fathima & Sr. S. Sebastiammal

Head of the Department: Dr. C. Nirmala Louis

		Moseley's law, Absorption of X-rays (Classical theory), Absorption Edge, X-ray diffraction		involved in X-ray diffraction	with PPT Illustration	Quiz Assignment Formative assessment I
		The Laue equations, Equivalence of Bragg and Laue equations, Interpretation of Bragg equation, Ewald construction		To understand the equivalence of Bragg and Laue equations	Lecture discussion	

		Reciprocal lattice, Reciprocal lattice to SC, BCC and FCC crystals, Importance properties of the Reciprocal lattice –		To be able to draw the reciprocal lattice to SC, BCC and FCC crystals	Lecture Illustration	
		Diffraction Intensity, The Powder method, Powder Diffractometer, The Laue method, The Rotating Crystal method, Neutron Diffraction, Electrondiffraction		To acquire knowledge on Neutron Diffraction and Electrondiffra ction		
	Crystal Imperfections and Ordered PhasesofMatter					
		Point imperfections, Concentrations of Vacancy, Frenkel and Schottky imperfections		To evaluate the different imperfections involved in crystal	Lecture with PPT Illustration	Evaluation through Online quiz Assignment Formative assessment II
		Line Imperfections Burgers Vector, Presence of dislocation, surface imperfections, Polorans,Excitons.		To understand the concept dislocation	Question-answer session Lecture	
		Ordered phases of		To acquire	Lecture	

		matter: Translational and orientation order - Kinds of liquid crystalline order - Quasi crystals - Superfluidity.		knowledge on Ordered phases of matter	discussion with illustration, SLO	
	LatticeDynamics					
		Theory of elastic vibrations in mono and diatomic lattices, Phonons, Dispersion relations, Phonon momentum		To understand the concept lattice vibration and derive the dispersion relation	Lecture Discussion	Evaluation through Online quiz Formative assessment II
		Heat Capacity: Specific heat capacity of solids, Dulong and Petit’s law, Vibrational modes		To acquire knowledge on phonon heat capacity	Lecture Discussion	
		Einstein model, Density of modes in one and three dimensions, Debye Model of heat capacity, Anharmonic Effects: Explanation for Thermal expansion, Conductivity and resistivity, Umklapp process.		To be able to determine the density of states	Brain storming session. Lecture Illustration	
	TheoryofElectrons					
		Energy levels and Fermi-Darac distribution for a free electron gas, Periodic boundary condition and free electron gas in three dimensions		To have clear idea about Fermi-Darac distribution for a free electron gas	Lecture with PPT	Short test Formative assessment III
		Heat capacity of the electron gas, Ohm’s law, Matthiessen’s rule, Hall effect and magnetoresistance,Wiedemann - Franz law, Nearly free electron model and		To acquire knowledge on Heat capacity of the electron gas and Bloch function	Brain storming session. Lecture Illustration	

		the origin and magnitude of energy gap, Bloch functions, Bloch theorem				
		Motion of an electron in a periodic potential, Kronig - Penney model, Approximate solution near a zone boundary, Metals, semiconductors and insulators		To acquire knowledge on Motion of an electron in a periodic potential	Lecture with PPT Illustration	

PO- Program outcome; LO – Learning outcome; Cognitive Level U – Understand; Ap- Apply, An- Analyze;
Course instructors: Dr.A.Lesly Fathima and Sr.S.Sebastiammal

Semester II
Introductory Astronomy, Astrophysics & Cosmology (Elective – II (b))
Subject code: PP2025

No. of hours per week	No. of credits	Total no. of hours	Marks
6	5	90	100

Objectives:

The course enables the students to understand and realize the historical evolution of Universe and principles involved in Astrophysics.

CO	Upon completion of this course, students will be able to:	PSO addressed	CL
CO - 1	perceive the historical evolution of solar system and universe.	PSO - 3	E
CO - 2	describe the principles of physics in the formation of astronomical objects like planets-satellites – asteroids and comets.	PSO - 1	U
CO - 3	gain experience with measurement techniques and equipment and develop the ability to assess uncertainties and assumptions.	PSO - 2	An
CO - 4	develop analytical skills and the ability to understand the astronomical situation.	PSO - 7	U
CO - 5	analyse the formation of binary stars, multiple stars, neutron stars and black holes.	PSO - 4	An
CO - 6	interpret the observations of galaxies, dark matter, quasars and pulsars.	PSO - 5	E
CO - 7	achieve a good understanding of physical laws and principles.	PSO - 6	C

Modules

Credit:5 **Total Hours:90 (Incl. Seminar & Test)**

Unit	Module	Topics	Lecture hours	Learning outcome	Pedagogy	Assesment/Evaluation
I	**History of Astronomy**					
	1	Introductory History of Astronomy- Ptolemy‟s Geocentric Universe-Copernicus‟ Heliocentric Universe	4	To understand basic concepts of Astronomy	Illustration and PPT	Evaluation through: quiz Formative assessment Evaluation through test Multiple choice questions
	2	Tycho Brahe and Galileo‟s Observations-Kepler‟s Laws ofPlanetary Motion-Newtonian Concept Of Gravity	3	To know the physical significance of Tycho Brahe and Galileo‟s Observations and Laws Physics	Illustration, PPT	
	3	Highlights of Einstein‟s Special and General Theory Of Relativity	4	To know the Highlights of Einstein‟s Special and General Theory of Relativity	Lecture Discussion	
	4	Curved Space Time-Evidence of Curved Space Time-Bending Of Light- Time Dilation	4	To have a knowledge on Bending of Light- Time Dilation	Lecture Discussion and Group Discussion	
II	**Stars & Galaxies**					
	1	Stars and Galaxies-Distances-Trigonometric Parallax-Inverse Square Law	3	To understand the basic concepts of Stars and Galaxies	Illustration and PPT, Videos	Evaluation through: quiz Formative assessment Evaluation through short answers
	2	Magnitude of Stars-Apparent Magnitude-Absolute Magnitude and Luminosity	4	Knowledge on Magnitude of Stars	Illustration and PPT, Videos	
	3	Color and Temperature-Composition of Stars-Velocity, Mass and Sizes of Stars-Types of Stars	4	To acquire knowledge on Color and Temperature-	Illustration , PPT, Lecture and Discussion	

				Types of Stars		
	4	Temperature Dependence-Spectral Types- Hertzsprung-Russell (HR) Diagram-Spectroscopic Parallax	4	To acquire a knowledge on Spectral Types and HR Diagram	Illustration , PPT, Lecture and Discussion	
III	**Lives And Death of Stars**					
	1	Stellar Evolution-Mass Dependence-Giant Molecular Cloud-Protostar-Main Sequence Star-Subgiant, Red Giant, Supergiant-Core Fusion	4	To understand the basic concepts of Stellar Evolution, Mass Dependence and Giant Molecular Cloud	Illustration , PPT, Lecture and Discussion	Evaluation through: quiz Formative assessment. Evaluation through: quiz,
	2	Red Giant (Or) Supergiant-Planetary Nebula(Or) Supernova-White Dwarfs-Novae And Supernovae-Neutron Stars-Pulsars	4	To acquire knowledge on Supernova-White Dwarfs-Novae And Supernovae-Neutron Stars-Pulsars	Illustration , PPT, Lecture and Discussion	
	3	Black Holes-Detecting Black Holes The Sun- Its Size and Composition- Sun‟s Interior Zones-Sun‟sSurface	4	To understand the basic concept of Black Holes and The Sun	Illustration , PPT and Videos	
	4	Photosphere-Chromosphere-Corona-Sun's Power Source-Fusion Reaction Mechanism.	3	To be able to distinguish between Photosphere-Chromosphere and Corona	Illustration , PPT and Videos	
IV	**Cosmology I**					
	1	Introduction to Cosmology-Basic Observations and implications-Olbers' Paradox - Expanding Universe	4	To understand the basic concepts of Cosmology	Illustration, Theoretical formulation	Evaluation through: quiz, Problem solving
	2	Gravitational Redshift-Doppler Effect-Hubble's Law and the	4	To understand and analyze the spectral shift	Illustration, Theoretical formulation	

		Age of the Universe			and Problem solving	
	3	Cosmological Principle-The Perfect Cosmological Principle- Observation and interpretation of Cosmic Microwave background Radiation (CMBR)	5	To understand and analyze the various Cosmological Principles	Descriptive lecture and Theoretical formulation	
	4	Evidence Supporting the General Big Bang Theory-Salient features of Steady State Theory	2	To understand and analyse the Big Bang theory and the Steady State theory	Descriptive lecture and Theoretical formulation	
V	**Cosmology II**					
	1	Fate of the Universe-Dependence on Mass (Curvature of Space)-Critical density-Open Universe-Closed Universe.	5	To understand basic concepts of the universe	Illustration, Theoretical formulation	
	2	Homogenous and Isotropic Freidman-Robertson-Walker Universes- Deriving the Geometry of the Universe from the Background Radiation	6	Understand and analyze the geometry of the universe	Illustration, and Problem solving	
	3	Flatness Problem-Horizon Problem-Inflation and its effect on the universe-The Cosmological Constant.	4	To understand and analyze the various cosmological problems	Illustration, Theoretical formulation	

PO- Program outcome; LO – Learning outcome; Cognitive Level R – Remember; U – Understand; Ap- Apply, An-

Analyze; E-Evaluate; C- Create

Course Instructor**:**Dr.V.Shally&Ms.S.J.Jenepha Mary