Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara (Autonomous)

Syllabus for M.Sc. Part – I

1. **Title:** Physics
2. **Year of Implementation:** The syllabus will be implemented from June, 2021 onwards.
3. **Preamble**:

This syllabus is framed to give advanced knowledge of Physics to postgraduate students at first year of two years of M.Sc. degree course.

The goal of the syllabus is to make the study of Physics popular, interesting and encouraging to the students for higher studies including research.

The new syllabus is based on a basic and applied approach with vigor and depth. At the same time precaution is taken to make the syllabus comparable to the syllabi of other universities and the needs of industries and research.

The syllabus is prepared after discussion at length with number of faculty members of the subject and experts from industries and research fields.

The units of the syllabus are well defined, taking into consideration the level and capacity of students.

4. **General Objectives of the Course:**

1. The students are expected to understand the fundamentals, principles, physical concepts and recent developments in the subject area.
2. The practical course is framed in relevance with the theory courses to improve the understanding of the various concepts in physics.
3. The student can critically and independently asses and evaluate research methods and results.
4. To develop the power of appreciations, the achievements in Physics and role in nature and society.
5. To enhance student sense of enthusiasm for Physics and to involve them in an intellectually stimulating experience of learning in a supportive environment.
6. The candidate has the ability to develop and renew scientific independently, via courses or through Ph. D. studies in Physics.
7. The candidate can understand the roll of Physics in society and has background to consider ethical problems.

5. Duration: Two year full time.

6. Pattern: **S**emester examination.

7. Medium of Instruction: English.

Structure of Course: Final M.Sc. – I Semester – I

Sr. No.	Course Title	Theory: Course Code	Theory: No. of lectures Per week	Theory: Total Hours Per week	Theory: Credits	Practical: Course Title & Code	Practical: No. of lectures per week	Practical: Total Hours Per week	Practical: Credits
1	Mathematical Methods in Physics	MPT 101	4	4	4	**LAB I:** MPP 105	12	12	4
2	Classical Mechanics	MPT 102	4	4	4				
3	Quantum Mechanics-I	MPT 103	4	4	4	**LAB II:** + Project MPP 106	12	12	4
4	Atomic and Molecular Physics	MPT 104	4	4	4				
				Total Credits Theory	**16**	**Total Credits Practical**			**08**

Structure of Course: M.Sc. – I Semester – II

Sr. No.	Course Title	Theory: Course Code	Theory: No. of lectures per week	Theory: Total Hours Per week	Theory: Credits	Practical: Course Title & Code	Practical: No. of lectures per week	Practical: Total Hours Per week	Practical: Credits
1	Quantum Mechanics II	MPT 201	4	4	4	**LAB III** MPP 205	12	12	4
2	Statistical Mechanics	MPT 202	4	4	4				
3	Solid State Physics-I (Physical Properties of Solids)	MPT 203	4	4	4	**LAB IV** + Project MPP 206	12	12	4
4	Condensed Matter Physics	MPT 204	4	4	4				
				Total Credits Theory	**16**	**Total Credits Practical**			**08**

Structure of Course: M. Sc. II Semester- III

Sr. No.	Course Title	Theory: Course Code	Theory: No. of lectures Per week	Theory: Total Hours Per week	Theory: Credits	Practical: Course Title Code	Practical: No. of lectures Per week	Practical: Total Hours Per week	Practical: Credits
Compulsory Courses									
1	Experimental Techniques	MPT 301	4	4	4	**SSP LAB I** MPP 305	12	12	4
2	Electro-dynamics	MPT 302	4	4	4				
3	Solid State Physics- II (Semiconductor Physics)	MPT 303	4	4	4	**SSP LAB II**+ Project MPP 306	12	12	4
Elective Course									
4	i) Nanoscience and Nanotechnology ii) Optoelectronics and Photonics	MPT 304A MPT 304B	4	4	4				
Total Credits Theory					**16**	**Total Credits Practical**			**08**

Structure of Course: M.Sc.-II Semester-IV

Sr. No.	Course Title	Theory: Course Code	Theory: No. of lectures Per week	Theory: Total Hours Per week	Theory: Credits	Practical: Course Title & Code	Practical: No. of lectures Per week	Practical: Total Hours Per week	Practical: Credits
Compulsory Courses									
1	Nuclear and Particle Physics	MPT 401	4	4	4	**LAB III** MPP 405	12	12	4
2	Solid State Physics -III (Thin Solid Films: Deposition and Properties)	MPT 402	4	4	4				
3	Solid State Physics- IV (Energy Conversion and Storage Devices)	MPT 403	4	4	4	**LAB IV** +Project MPP 406			
Elective Course									
4	i) Electronic Devices ii) Laser Physics Special	MPT 404A MPT 404B	4	4	4		12	12	4
Total Credits Theory					**16**	**Total Credits Practical**			**08**

MPT: M: M.Sc., **P:** Physics, **T:** Theory **MPP: M:** M.Sc., **P:** Physics, **P:** Practical

M.Sc. - I
Semester-I

Structure of Course: Final M.Sc. – I Semester – I

Sr. No.	Course Title	Theory: Course Code	Theory: No. of lectures Per week	Theory: Total Hours Per week	Theory: Credits	Practical: Course Title & Code	Practical: No. of lectures per week	Practical: Total Hours Per week	Practical: Credits
1	Mathematical Methods in Physics	MPT 101	4	4	4	**LAB I:** MPP 105	12	12	4
2	Classical Mechanics	MPT 102	4	4	4				
3	Quantum Mechanics-I	MPT 103	4	4	4	**LAB II:** + Project MPP 106	12	12	4
4	Atomic and Molecular Physics	MPT 104	4	4	4				
Total Credits Theory					**16**	**Total Credits Practical**			**08**

MPT 101: Course-I Mathematical Methods in Physics (Credits: 4)

Learning Objectives:

Students will able to:

1. understand the laws of Matrices, eigen values and eigen vectors.
2. study complex algebra.
3. study singularities, Legendre, Hermite, Laguerre, Bessel's function and their applications.
4. study properties of Fourier Series and applications of Fourier Series.

Unit I- Matrix Algebra and Eigen value Problems (15)

Matrix multiplication – Inner product, direct product, Diagonal matrices, trace, matrix Inversion, Gauss-Jordon Inversion theorem, problems, Eigenvalues and Eigenvectors, Properties of Eigenvalues and Eigenvectors, CaylyHamilton Theorem and applications, similar matrices and diagonalizable Matrices, Eigenvalues of some Special Complex Matrices, Quadratics forms, problems.

Unit II- Complex Variables: (15)

Definition of Complex Numbers and variables, Equality of Complex variables, Complex Algebra, Conjugate Complex Numbers, Geometrical representation of Complex Number, Geometrical representations of the sum, difference, product and quotient of Complex Number, Cauchy-Rieman Conditions, Analytic functions, Multiply connected regions, Cauchy Theorem, Cauchy Integration formula, problems

Unit III: Calculus of Residues & Special function: (15)

Singularities- Poles, Branch Points, Calculus of Residues-Residues Theorem, Taylor Series and Laurent's series, Special function (only definitions)- Legendre Hermite, Laguerre function, Generating function, Recurrence relations and Their differential equations, Orthogonality properties.

Unit IV- Fourier- Series, Integral, and Transform: (15)

Definition, Evaluation of Coefficients of Fourier Series (Cosine and Sine Series), Dirichelet's Theorem, Graphical representation of a square wave function, Extension of interval, Complex form of Fourier Series, Properties of Fourier Series (Conversions, Integration, Differentiation, Parseval's Theorem). Fourier Integral- exponential form, Applications of Fourier Series analysis in Physics (Square wave, Full wave rectifier, Expansion of Raman Zeta function), Fourier transform, Inversion theorem, exponential transform Example: Full wave train, Uncertainty principle.

Text Books:

1. Arfken And Weber, *Mathematical Methods For Physicists* (New York: Academic Press, 2005)
2. S R K Iyengar, R K Jain, *Mathematical Methods*, (New Delhi: Narosa Publishing House, 2006)
3. B. S. Rajput, *Mathematical Physics*, (Meerat: Pragati Prakashan, 1999)

Reference Book:

1. K F Riley, M P Hobson and S J Bence, *Mathematical Methods for Physics and Engineering*, (Cambridge: Cambridge University Press, 1997)
2. Introduction to mathematical physics, Balsubramanyam
3. M. L. Bose, *Mathematical Methods of physical science*, (New Jersey: Wiley Publications, 1983)

Learning Outcomes:

Unit – I: **After completion of the unit**, **Student is able to**

1. define Inner product, direct product, Diagonal matrices, trace, matrix Inversion
2. understand Gauss-Jordon Inversion theorem.
3. define Eigenvalues and Eigenvectors
4. understand Theorem and applications of matrices.

Unit – II: **After completion of the unit**, **Student is able to**

1. understand Complex Algebra, Conjugate Complex Numbers and their sum ,Difference, Product and quotient.
2. define Complex Numbers and variables, Equality of Complex variables
3. understand Cauchy Theorem.

Unit – III: **After completion of the unit**, **Student is able to**

1. understand of Calculus of Residues-Residues Theorem.
2. understand Pole Expansion of Meromorphic Functions, Product expansion of entire Functions, problems.
3. **After completion of the unit**, **Student is able to**

define Bessel's function of first kind.

Unit – IV: **After completion of the unit**, **Student is able to**

1. understand Dirichelet's Theorem.
2. understand Fourier Series and its complex form, integral form and exponential form.
3. understand Fourier transform, Inversion theorem.

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MPT 102: Course-II Classical Mechanics (Credits: 4)

Learning Objectives:

Students will able to:

1. understand the laws of rotational motion, two body central force and Rutherford scattering.
2. study Lagrangian equation of motion, Jocobi integral, energy conservation and concept of symmetry.

3. study Lagrangian and Hamiltonian equations and applications.
4. study Canonical Transformation and Poisson Brackets.

Unit I:Rotational motion and central force problem (15)

Inertial forces in rotating frames, Larmour precision, electromagnetic analogy of inertial forces, effect of coriolis force, Focoult's pendulum.

Two body central force ,equation of motion and first integral, Kepler's problem: Inverse-square law of force, central analysis of orbit, Rutherford scattering: Scattering formulae, Different scattering cross section

Unit II: Lagrangian formulation (15)

Introduction, generalized coordinates, Lagrangian equation of motion, Applications of Lagrange's Equation, properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic coordinates, integral of motion, Jacobi integral and energy conservation , concept of symmetry, invariance under Galilean transformation, velocity dependent potential.

Unit III: Hamilton's formulation and Variational Principle (15)

Hamilton's function and Hamilton's equation of motion, configuration space, Lagrangian and Hamiltonian of relativistic particles and light rays, Variational Principle, Euler's equation, applications of Variational Principle, shortest distance problem , Brachistochrone problem, Geodesics of a Sphere.

Unit IV: Canonical Transformation and Poisson Brackets (15)

Generating function, condition for conical transformation and problems.

Definition of Poisson Brackets, Identities, Poisson theorem, Jacobi-Poisson Brackets, Jacobi Identity, Invariance of Poisson Brackets under conical transformation.

Reference Books :

1. Goldstein, H. 1980. *Classical mechanics*. Reading, Mass: Addison-Wesley (Units I: pp 13, II: pp. 80 - 82, III: pp. 80 -93 , IV: pp. 93-105).
2. Rana, Narayan Chandra, and Pramod Sharadchandra Joag. 1991. *Classical mechanics*. New
3. Delhi, India: Tata McGraw-Hill Pub. Co.(Units I: pp 118-137 ,II: pp. 55- 88, III: pp.180-189 , IV: pp. 324 - 334).

3.Takwale, R G., and P S. Puranik. 1980. *Introduction to classical mechanics*.(Units I: pp 136-152 ,II: pp. 82- 84, III: pp. 87 , IV: pp. 236 -265).

5. Classical Mechanics– J.C Upadhyaya, Himalaya Publishing House.(Units I: pp 103-114 ,II: pp. 27-74, III: pp. 75-102 , IV: pp. 163- 178).

Learning Outcomes:

Unit – I: **After completion of the unit**, **Student is able to**

1. define inertial forces, Larmour precision, carioles for forces
2. understand Focoult's pendulum, two body central force.
3. understand Kepler's laws
4. Student should able to understand Rutherford scattering: Scattering formulae, Different scattering Cross-section.

Unit – II: **After completion of the unit**, **Student is able to**

1. understanding of inertial Lagrangian equation of motion.
2. understand generalized momenta, cyclic coordinates
3. understand Jocobi integral and energy conservation , concept of symmetry, invariance under Galilean transformation.

Unit – III:

1. understand Hamilton's function and Hamilton's equation of motion,
2. understand configuration space, phase space and state space ,
3. understand Variational Principle, Euler's equation.
4. understand Brachistrochrone problem.

Unit – IV: **After completion of the unit**, **Student is able to**

1. define Generating function.
2. define Poisson Brackets, Identities, Poisson theorem, Jacobi- Poisson Brackets, Jacobi Identity.
3. understand concept Invariance of Poisson Brackets.

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MPT 103: Quantum Mechanics – I (Credits: 4)

Learning Objectives: Students will able to:

1. understand ket and bra spaces, inner products, operators and uncertainty relations.
2. study Schrödinger wave equation and commutation relations.
3. study Eigen values and Eigen functions of L^2 and L_z operators, Ladder operators , Paulli theory of spins.
4. understand perturbation theory, Eigen values and Eigen functions.

Unit I: Fundamental Concepts and Formalism (15)

Why Q.M? Revision; Inadequacy of classical mechanics; sequential Stern Gerlach experiment, analogy with polarization of light, ket and bra spaces and inner products, operators, the associative axiom, base kets and matrix representations, measurements, observables and the uncertainty relations.

Unit II: Quantum Dynamics (15)

Time evolution operator and Schrödinger equation, the Schrödinger, Heisenberg, Interaction picture and comparison of time evolution in all pictures, simple harmonic oscillator, commutation relations (problems). Schrödinger wave equation - one dimensional problems, well and barriers, General formalism of wave mechanics

Unit III: Angular Momentum (15)

Eigen values and Eigen functions of L^2 and L_z operators, Ladder operators L_+ and L_- , Paulli Theory of spins (Paulli's Matrices), angular momentum as a generator of infinitesimal rotations, Matrix representation of Jin|jm> basis. Addition of angular momenta, Computation of Clebsch-Gordon Coefficients in simple cases ($J_1=\frac{1}{2}$; $J_2=\frac{1}{4}$)

Unit IV: Time Independent Perturbation Theory (15)

Introduction of perturbation theory, Eigen value of energy and Eigen function in the first order approximation in case of a system with non degenerate & degenerate energy levels. First order Stark Effect (Ground state and First Excited state of H atom)

Reference Books:

1. J.J. Sakurai , Modern Quantum Mechanics, (30th Edition)
2. A .C. Philips , Introduction to Quantum Mechanics (Wiley publications)
3. Ghatak & Lokhanthan, Quantum Mechanics -Theory and Applications
4. David J Griffith, Introduction to Quantum Mechanics
5. N Zettili, Quantum Mechanics concept and application (Taylor and Francis)
6. Venkatesan and Mathews, Introduction to Quantum mechanics (TMH)
7. L. I Schiff, , Quantum Mechanics by (McGraw-Hill)

Learning outcomes:

Unit – I: **After completion of the unit**, **Student is able to**

1. define and understand ket and bra spaces and inner products, operators
2. understand kets and matrix representations.
3. understand wave function in position and momentum space.

Unit – II: **After completion of the unit**, **Student is able to**

1. understand Time evolution and Schrödinger equation.

2 understand Schrödinger wave equation - one dimensional problems, well and barriers.

3. understand Uncertainty relation of x and p states.

Unit – III: **After completion of the unit**, **Student is able to**

1. understand Eigen values and Eigen functions of L^2 and L_z operators.
2. understand of Paulli Theory of spins.
3. understand Computation of Clebsch-Gordon Coefficients in simple cases ($J_1=1/2$; $J_2=1/4$).

4. define Central forces.

Unit – IV: **After completion of the unit**, **Student is able to**

1. understand perturbation theory.
2. understand Eigen value of energy and Eigen function in the first order approximation.

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MPT 104: Course-IV Atomic and Molecular Physics (Credits: 4)

Learning Objectives:

Students will able to:

1. understand vector atom model and couplings.
2. study Zeeman Effect, Paschen-Back effect and Stark effect.
3. study classification of molecules, electronic and rotational spectra of diatomic molecules.
4. understand the vibrating diatomic molecule and harmonic oscillators.

Unit I: Vector atom model for two valence electron system (15)

Types of coupling- ll, ss, LS or Russel Sounder's coupling, Pauli Exclusion principle and terms arising from different states, coupling schemes for two valence electron system, -factors for LS coupling, Lande interval rule, jj-coupling and -factors for jj coupling, Selection rules for LS and jj coupling and intensity relations.

Unit II: Zeeman Effect, Paschen-Back effect and Stark effect (15)

The magnetic moment of the atom, Zeeman effect for two-electrons, Intensity rules for Zeeman effect, Paschen-Back effect for two-electrons, Stark effect of hydrogen, weak field stark effect in hydrogen, strong field Stark effect in hydrogen, origin of hyperfine structure of Hydrogen atom, relativistic corrections for energy levels of Hydrogen atom, Principles of Resonance spectroscopy (ESR and NMR)

Unit III: Rotational Spectroscopy (15)

Classification of molecules: Linear, symmetric tops, spherical tops, asymmetric tops Rotational spectra: the rigid diatomic molecule, spectrum and selection rules of a rigid rotator, non-rigid rotator, energy spectrum and selection rules of a non-rigid rotator**,** techniques and instrumentations of microwave spectroscopy, chemical analysis by microwave spectroscopy.

Unit IV: Vibrational and Electronic spectroscopy (15)

The vibrating diatomic molecule: the energy spectrum and selection rules of diatomic molecule, the simple harmonic oscillator, energy spectrum and selection rules of simple harmonic oscillator, Morse function, the anharmonic oscillator, energy spectrum and selection rules of anharmonic oscillator, the diatomic vibrating-rotator, energy spectrum and selection rules of the diatomic vibrating-rotator, techniques and instrumentation of infra-red spectroscopy, chemical analysis by infra-red spectroscopy, Born-Oppenheimer approximation, Electronic spectra of diatomic molecules, Franck Condon Principle, electronic structure of diatomic molecule, chemical analysis by electronic spectroscopy. Raman spectroscopy.

Reference books:

1) H.E. White, Introduction to Atomic Spectra (McGraw Hill, 1934), pp 114-210, 215-235,

2) C.N. Banwell, Elaine M Maccash, Fundamentals of Molecular Spectroscopy, Edn. 3, (Tata McGraw Hill, 1983), pp. 40-69, 197, 215, 234, 72-111

3) G. Herzberg, Spectra of Diatomic Molecules, Vol. I (Van Nostrand Reinhold Company, 1950).

4) G.M. Barrow, Introduction to Molecular Spectroscopy (McGraw Hill, 1962).

5) J.M. Brown, Molecular Spectroscopy (Oxford University Press, 1998).

6) G. Aruldas, Molecular Structure and spectroscopy (EEE PHI, 2010)

Learning outcomes:

Unit – I: **After completion of the unit**, **Student is able to**

1. understand ll, ss, jj, LS or Russiel Sounder's coupling
2. understand coupling schemes for two valence electron system.
3. understand Selection rules for LS and jj coupling and intensity relations

Unit – II: **After completion of the unit**, **Student is able to**

1. understand of Zeeman effect for two-electrons, Paschen-Back effect for two-electrons,
2. understand Stark effect of hydrogen.
3. understand origin of hyperfine structure.
4. understand of concept principles of Resonance spectroscopy (ESR and NMR)

Unit – III: **After completion of the unit**, **Student is able to**

1. understand electronic spectra and rotational of diatomic molecules chemical
2. understand of Classification of molecules Linear, symmetric tops, spherical tops, asymmetric tops

3 understand instrumentations of microwave spectroscopy.

Unit – IV: **After completion of the unit**, **Student is able to**

1. understand vibrating diatomic molecule the simple harmonic oscillator,
2. understand of techniques and instrumentation of infra-red spectroscopy.

3 understand chemical analysis by infra-red spectroscopy.

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MPP 105: LAB I (Credits: 4)

Learning Objectives:

Students will able to:

1. Measure counts of radioactive radiation
2. Measure charge of an electron
3. Understanding of photo catalytic dye degradation
4. Measure intensity by Lux meter
5. Measure Hall coefficient
6. Understand concept of LVDT by measuring emf
7. Understand concept of neutron diffraction
8. Understand concept of FP Etalon
9. Understanding of XRD pattern
10. Measure lattice constant

Experiments:

1. Counting statistics G M Tube
2. ‘e’ by Millikan’s oil drop method
3. Photo catalytic dye degradation of given sample
4. Intensity measurement by Lux meter
5. Hall Effect
6. L.V.D.T.
7. Neutron Diffraction
8. Fabry-Parrot etalon
9. Crystal Structure (F.C.C. & B.C.C.)
10. Lattice Dynamics

Learning outcomes: After completion of the unit, **Student is able to**

1. measure counts of radioactive radiation
2. measure charge of an electron
3. understanding of photo catalytic dye degradation of sample.
4. measure intensity by Lux meter
5. measure Hall coefficient
6. understand concept of LVDT by measuring emf
7. understand concept of neutron diffraction

8. understand concept of FP Etalon
9. understanding of XRD pattern
10. measure lattice constant

MPP 106: LAB II +Project (Credits: 4)

Learning Objectives: Students will able to:

1. Understand concept of temperature transducer
2. Determine heat capacity
3. Understand concept of stair case ramp generator
4. Determine frequency response of negative feedback amplifier
5. Understand concept of astable multivibrator
6. Understand concept of monotable multivibrator
7. Determine Stefan's constant
8. Understand B-H curve
9. Determine thermal conductivity
10. Determine Planck's constant

Experiments:

1. Temperature Transducer
2. Heat Capacity
3. Staircase Ramp Generator
4. Negative Feedback Amplifier
5. Astable Multivibrators
6. Monostable Multivibrators
7. Stefan's Constant
8. B-H Curve
9. Thermal & electrical conductivity of copper
10. Planks Constant

Learning outcomes: After completion of the unit, **Student is able to**

1. understand concept of temperature transducer
2. determine heat capacity
3. understand concept of stair case ramp generator
4. determine frequency response of negative feedback amplifier
5. understand concept of Astable multivibrator
6. understand concept of monotable multivibrator
7. determine Stefan's constant

8. understand B-H curve
9. determine thermal conductivity
10. determine Planck's constant

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M.Sc. – I Semester II

Structure of Course:

		Theory				Practical			
Sr. No.	Course Title	Course Code	No. of lectures per week	Total Hours Per week	Credits	Course Title & Code	No. of lectures per week	Total Hours Per week	Credits
1	Quantum Mechanics II	MPT 201	4	4	4	**LAB III** MPP 205	12	12	4
2	Statistical Mechanics	MPT 202	4	4	4				
3	Solid State Physics-I (Physical Properties of Solids)	MPT 203	4	4	4	**LAB IV** + Project MPP 206	12	12	4
4	Condensed Matter Physics	MPT 204	4	4	4				
				Total Credits Theory	**16**			**Total Credits Practical**	**08**

MPT 201: Quantum Mechanics-II (Credits: 4)

Learning Objectives:

Students will able to:

1. understand Time-dependent perturbation theory and degeneracy.
2. study basic principle of variation method, application to their ground state of Hydrogen atom, first excited state of harmonic oscillator, WKB method and its applications
3. Study scattering theory.
4. understand Semi classical theory of radiation and Selection rules.

Unit I: Time dependent Perturbation (15)

Time-dependent Perturbation Theory, Two State Problem, Transition probability for constant and harmonic perturbations, Fermi's Golden rule.

Unit II: Approximation methods (15)

Variational method: Basic principle, Application to their ground state of Hydrogen atom and first excited state of harmonic oscillator, WKB method and its applications.

Unit III: Scattering Theory (15)

Laboratory and centre of mass frames, scattering amplitude, differential scattering cross section and total scattering cross section : scattering by spherically symmetric potentials; Method of partial waves; Phase shift; Ramsauer-Townsend effect; scattering by a perfectly rigid sphere and by square well potential. The Born approximation, applications and validity of the Born approximation.

Unit IV: Theory of Radiation (15)

Semi classical theory of radiation; Transition probability for absorption and induced emission; Electric dipole and forbidden transitions, Selection rules. (Zettili pp. 586-596)

Text and Reference Books:

1. J.J. Sakurai , Modern Quantum Mechanics, (30th Edition)
2. A .C. Philips , Introduction to Quantum Mechanics (Wiley publications)
3. Ghatak & Lokhanthan, Quantum Mechanics -Theory and Applications
4. David J Griffith, Introduction to Quantum Mechanics by
5. N Zettili, Quantum Mechanics concept and application (Taylor and Francis)
6. Venkatesan and Mathews, Introduction to Quantum mechanics (TMH)
7. L. I Schiff, , Quantum Mechanics by (McGraw-Hill)

Learning Outcomes:

Unit – I: **After completion of the unit**, **Student is able to**

1. understand Time-dependent perturbation theory.
2. understand Non degenerate case and applications
3. understand Stark effect, Fermi's Golden rule.

Unit – II: **After completion of the unit**, **Student is able to**

1. understand of Variational method.
2. understand problem of Hydrogen atom.
3. understand WKB method and its applications.

Unit – III: **After completion of the unit**, **Student is able to**

1. understand the Lippman-Schwinger Equation, Born Approximation,
2. understand of Optical Theorem.
3. understand Low energy scattering and bound state, Resonance scattering, Scattering by hard sphere, Coulomb scattering.

Unit – IV: **After completion of the unit**, **Student is able to**

1. understand semi classical theory of radiation
2. understand of transition probability for absorption and induced emission;
3. understand electric dipole and forbidden transitions, Selection rules.

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MPT 202: Course –VI Statistical Mechanics (Credits: 4)

Learning Objectives:

Students will able to:

1. understand specification of state of system, postulate of equal priori probability. Thermodynamic laws and its applications.
2. study ensemble and its application to thermodynamic system.
3. Study MB, BE and FD distributions and free electron theory of metals.
4. understand first and second order phase transitions.

Unit I: Introduction of Statistical Mechanics and thermodynamics (15)

Specification of state of system, Macroscopic and microscopic states, phase space, ⌠ space, ℘ space, constraints on a system,(These points required needed to explain state of system) postulate of equal apriori probability. Fluctuations of physical quantities, Statistical Equilibrium, problems. (Problems are required to solve no. of Macroscopic and microscopic states in given system)

Thermodynamics -Thermodynamic Laws and its applications, Thermodynamic Functions–Entropy ,Internal energy, Helmholtz free energy, Gibbs free energy,(These are the Thermodynamic Functions & it is necessary to understand the concept) Enthalpy, Connection between statistics and thermodynamics – Entropy in terms of microstates, change in entropy with volume and temperature.

Unit II: Statistical Ensembles Theory (15)

Micro canonical Ensemble– Micro canonical distribution, Entropy and specific heat of a perfect gas, Entropy and probability distribution.

Canonical Ensemble– Canonical Distribution, partition function, Calculation of free energy of an ideal gas, Thermodynamic Functions, Energy fluctuations, Applications of Canonical Ensemble.

Grand Canonical Ensemble– Grand Canonical distribution, Thermodynamic Functions, Number and Energy fluctuations.

Unit III: Formulation of Quantum Statistics (15)

Distinction between MB, BE and FD distributions, Quantum distribution functions – Boson and Fermion gas and their Boltzmann limit, Partition function. Ideal Bose gas, Bose Einstein Condensation, Photon gas, Liquid He4: Second Sound. Ideal Fermi gas: Weakly and strongly degenerate, (It is covered in solid state physics Course)

Unit IV: Phase Transitions and Critical Phenomenon (15)

Phase Transitions, Conditions for phase equilibrium, First order Phase Transition: Clausius - Clayperon equation, Second order phase transition, Ehrenfest equation (It is condition for Second order phasetransition), The critical indices.

Text and Reference books:

1. B. B. Laud, Fundamentals of Statistical Mechanics (New Age International Private Limited Publisher, 2020) 47-200.
2. L. D. Landau, Statistical Physics (Butterworth-Heinemann Publisher, 1996) 158-183.

3. F. Reif, Fundamentals of Statistical and Thermal Physics (Waveland Press Publisher, 2010) 48-60.
4. S. K. Sinha, Introduction to Statistical Mechanics (Narosa Publisher, 2009) 202-348.
5. A. K. Saxena, Introduction to Statistical Mechanics (New Delhi, Narosa Publishing House Pvt. Ltd.Publisher, 2016) 52-102.

Learning Outcomes :

Unit – I: **After completion of the unit**, **Student is able to**

1. define specification of state of system, Macroscopic and microscopic states, phase space.
2. understand Fluctuations of physical quantities, Statistical Equilibrium.
3. understand Thermodynamic Laws and its applications.
4. define Entropy, Free energy, Internal Energy, Enthalpy.

Unit – II: **After completion of the unit**, **Student is able to**

1. understand of distinction Micro canonical, Ensemble Canonical Ensemble and Grand Canonical
2. understand Micro canonical distribution, Canonical Distribution and its applications
3. understand Thermodynamic Functions, Number and Energy fluctuations

Unit – III: **After completion of the unit**, **Student is able to**

1. understand Distinction between MB, BE and FD distributions, Quantum,
2. understand of Boson and Fermion gas, Photon gas
3. understand Bose Einstein Condensation

Unit – IV: **After completion of the unit**, **Student is able to**

1. understand Phase Transitions, Conditions for phase equilibrium, First order Phase Transition, Second order phase transition.
2. understanding of Clausius - Clayperon equation.
3. understand the critical indices.

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MPT203: Course-VII Physical Properties of Solid (Credits: 4)

Learning Objectives:

Students will able to:

1. Understand the Drude model and DC electrical conductivity.
2. Study Band theory of solid.
3. Understand Electronic levels in periodic potential.

4. Study Transport Properties of Metals like Sommerfeld theory of electrical conductivity, The mean free path in metals, Thermal scattering and thermal conductivity of metals.
5. Study Phonons, Plasmons, Polaritons, and Polarons
6. Study magnetic properties of materials
7. Understand various theories of paramagnetism

Unit 1: Theory of metals ` **(15)**

Basic assumptions of Drude Model, Collision or relaxation times, DC electrical conductivity , Ground state properties of electron gas (Ref1 pp.109 to 119).Sommerfeld theory of metals, Failures of the free electron model. Band theory of solid, Brillouin zones Electron Levels in a Periodic Potential : Introduction, The tight-binding method, Linear combinations of atomic orbitals, Application to bands from s-Levels, Wannier functions, Other methods for calculating band structure, Independent electron approximation, general features of valence band wave functions, Cellular method, Muffin-Tin potentials, Augmented plane wave (APW) method, Pseudopotentials

Unit 2: Transport Properties of Metals **(15)**

Some features of the electrical conductivity of metals, A simple model leading to a steady state, Drift velocity and relaxation time, The Boltzmann transport relation, The Sommerfeld theory of electrical conductivity, The mean free path in metals, Thermal scattering, The electrical conductivity at low temperature, The thermal conductivity of metals**,** Dielectric Properties of insulators. Macroscopic electrostatic Maxwell equations, Theory of Local Field, Theory of polarizability, Clausius- Mossotti relation, Long- wavelength optical modes in Ionic crystals

Unit 3: Phonons, Plasmons, Polaritons, and Polarons **(15)**

Vibrations of monatomic lattices: first Brillouin zone, group velocity, Long wavelength limit, Lattice with two atoms per primitive cell. Quantization of lattice vibrations, Phonon momentum**,** Dielectric function of the electron gas, Plasma optics, Dispersion relation for Electromagnetic waves, Transverse optical modes in a plasma, Longitudinal Plasma oscillations, Plasmons, Polaritons, LST relations, Electron- electron interaction, Electron- phonon interaction: Polarons,

Unit 4: Magnetic Properties of Materials **(15)**

Introduction, Magnetic permeability, Magnetisation, Electric current in atoms-bohr magnetron, Electron spin and magnetic moment due to nuclear spin **,** Diamagnetism**,** Paramagnetism, Langevin's with experiment classical theory of paramagnetism, Weiss theory of paramagnetism, quantum theory of paramagnetism, Comparison of theory with experimental results**,** Ferromagnetism, Spontaneous Magnetisation in ferromagnetic materials, quantum theory of ferromagnetism, Magnetic resonance, Nuclear magnetic resonance **(NMR),** The resonance condition **,**The structure of ferrite, The saturation magnetization, Elements of neels theory

Reference Books:

1. Ashcroft, Neil W., and N. David Mermin. 2003. *Solid state physics*.(Units 1pp. 1 to 304,II pp. 534-643)
2. Kittel, Charles, and Paul McEuen. 2019. *Introduction to solid state physics*. Hoboken, NJ: John Wiley & Sons. (Units 3pp. 89-640)
3. Dekker, Adrianus J. 1981. *Solid State Physics*.(Units 1pp. 3-299, II pp. 395-397)
4. Pillai, S. O. 2018. *Solid state physics*.(Units 1pp.293-700, II pp. 427-485)
5. Saxena, B. S., R. C. Gupta, and P. N. Saxena. 1993. *Fundamentals of solid state physics*. Meerut: Pragati Prakashan.(Units IV pp.351-397)

Learning Outcomes:

Unit – I: **After completion of the unit**, **Student is able to:**

1. understand Drude Theory of metals and Basic assumptions of Model, Collision or relaxation times, DC electrical conductivity
2. understand ground state properties of electron gas.
3. understand Band theory of solid.
4. understand electronic levels and various method for calculation of electronic levels
5. explain independent electron approximation, general features of valence band wave functions

Unit – II: **After completion of the unit**, **Student is able to:**

1. understanding of features of the electrical conductivity of metals
2. define steady state, Drift velocity and relaxation time
3. understand Sommerfeld theory of electrical conductivity, The mean free path in metals, Thermal scattering
4. understand Dielectric properties of insulators. Macroscopic electrostatic Maxwell equations, Theory of Local Field, Theory of polarizability, Clausius- Mossott Relation

Unit – III: **After completion of the unit**, **Student is able to:**

1. understanding of Vibrations of monatomic lattices: first Brillouin zone
2. define group velocity, Long wavelength limit, Lattice with two atoms per primitive cell.
3. understand Quantization of lattice vibrations, Phonon momentum
4. understand Transverse optical modes in a plasma, Longitudinal Plasma oscillations, Plasmons,

Unit – IV: **After completion of the unit**, **Student is able to:**

1. understand Magnetic permeability, Magnetisation
2. understanding of Paramagnetism and theories of paramagnetism

3. understand Ferromagnetism, Spontaneous Magnetisation in ferromagnetic materials
4. to understand the structure of ferrite, The saturation magnetization, Elements of neels theory
5. understand Magnetic resonance and NMR

MPT 204: Course-VIII Condensed matter Physics – I (Credits: 4)

Learning Objectives: Students will able to:

1. study crystal growth and imperfections in crystals.
2. study dielectricity, ferroelectricity and its consequences.
3. study ferromagnetism and Antiferromagnetism its applications.
4. understand semiconducting and Superconducting Properties of materials.

Unit I: Crystal growth and Imperfections in crystals (15)

Crystal growth:- Nucleation and growth- Homogeneous and heterogeneous nucleation- classification of crystal growth techniques - melt growth, Bridgman, Czochralski techniques.

Imperfections : Classification of imperfections- point defects - schottky and freckle defects- Expressions for equilibrium defect concentrations o Colour centers- Production of colour centres- line defects- Dislocations- Edge and Screw dislocations- Burger Vector- Estimation of dislocation densities- Mechanism of creep- (Wahab pp. 150-190)

Unit II: Dielectrics and Ferroelectrics (15)

Dielectrics: Introduction, Dipole moment, various types of polarization, electronic, ionic and orientation polarization, Langevin's theory, Lorentz field, Local electric effect and its expression Clausius- Mosotti equation and Lorentz-Lorentz relation (Related to C-M relation), measurement of dielectric constant, Applications of dielectrics.

Ferroelectrics :Piezo, pyro and ferroelectric crystals, Spontaneous polarization, classification and properties of ferroelectrics, ferroelectric domains- oxygen ion displacement theory Application of ferroelectrics.

Unit III: Ferromagnetism and Anti-ferromagnetism (15)

Ferromagnetism: Introduction, Weiss molecular field theory-Temperature dependence of spontaneous magnetization, Heisenberg model, Hysteresis curve (property of Ferromagnetic materials), Exchange interaction, ferromagnetic domains- Magnetic bubbles, Bloch wall, Thickness and energy, ferromagnetic spin waves, Magnons- Dispersion relations.

Anti-ferromagnetism: Introduction, Two sub lattice model of anti-ferromagnetism, ferrimagnetism, ferrites, structure, Applications, Multi ferroics.

Unit IV: Semiconducting and Superconducting Properties. (15)

Semiconductors: Kronig Penny Model (revision and significance), Nearly free electron approximation, tight binding approximation, Derivation of width of band in SC, BCC & FCC structure, intrinsic semiconductor: band model, calculation of electron & hole concentration, electrical conductivity, extrinsic semiconductor: impurity states and band model,calculation of electron & hole concentration, electrical conductivity.

Superconductors: Critical temperature, Meissner effect, type-I, type-II superconductors, BCS Theory of superconductivity, flux quantization, Josephson Effects: ac and dc (Types of Josephson Effects), SQUID, high- Tc super conductivity.

Reference Books:-

1. Saxena and Gupta, Fundamentals of Solid State Physics (Meerut, Pragati Publications, 2016) 355-437.
2. M.A.Wahab, Solid State Physics (Narosa Publisher, 2009) 150-558.
3. C. Kittle, Introduction to Solid State Physics (Wiley Publisher, 1979) 257-482.
4. R. K.Puri and V. K. Babbar, Solid State Physics (S. Chand Publication, 2010) 88-122.
5. A. J. Dekker, Solid State Physics (Laxmi Publisher, 2008) 132-430.

Learning outcomes:

Unit – I: **After completion of the unit**, **Student is able to**

1. understand concept of Crystal growth.
2. understand melt growth, Bridgman, Czochralski techniques.
3. understand imperfections- point defects and dislocations
4. understand Experimental determination of point defects and dislocations

Unit – II: **After completion of the unit**, **Student is able to**

1. understanding of electronic , ionic and orientation polarization
2. understand Langevin's theory and measurement of dielectric constant.
3. understand Piezo, pyro- and ferroelectric crystals.
4. understand of oxygen ion displacement theory

Unit – III: **After completion of the unit**, **Student is able to**

1. understand Weiss molecular field theory of Ferromagnetism
2. understanding of Temperature dependence of spontaneous magnetization
3. understand two sub lattice model of anti- ferromagnetism.
4. understand ferrimagnetisms and ferrites.

Unit – IV: **After completion of the unit**, **Student is able to**

1. define energy band gap in semiconductor.
2. understand of impurity levels in doped semiconductors.
3. understand superconductors: Critical temperature, Meissner effect.
4. understand BCS Theory of superconductivity.

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M. Sc. – I, Semester – II
MPP 206: LAB III (Credits: 4)

Learning Objectives: Student will able to

1. Measure Young's modulus
2. Measure thermal diffusivity of Brass
3. Know Concept of Fourier analysis of various waves
4. Understand concept of passive filters
5. Understand working of solar cell
6. Study of AC bridge
7. Measure mutual inductance
8. Understand concept of band gap
9. Understand concept of series and parallel resonant circuits
10. Calculate specific capacitance

Experiments: Group I

1. Young's modulus
2. Thermal diffusivity of brass
3. Fourier analysis
4. Passive filters
5. Solar cell
6. A.C. bridges
7. Mutual inductance of coil
8. Band gap energy
9. Series & parallel resonant circuits
10. Specific capacitance calculation of given material

Learning outcomes: Student should able to

1. measure Young's modulus.

2. measure thermal diffusivity of Brass
3. know Fourier analysis of various waves
4. understand concept of passive filters
5. understand working of solar cell
6. study of AC bridge
7. measure mutual inductance
8. calculate energy of band gap
9. understand concept of series and parallel resonant circuits
10. calculate specific capacitance

M. Sc. – I Semester – II
MPP 207: LAB IV + Project (Credits: 4)

Learning Objectives:
Student will able to:

1. Understand concept of LDR
2. Measure resistivity of sample
3. Measure thermo electric power
4. Understand ESR
5. Study XRD pattern
6. Determine Rydberg constant
7. Measure dissociation energy
8. Measure magnetic susceptibility
9. Differentiation using Python
10. Integration using Python

Experiments: Group II

1. LDR
2. Resistivity by four Probe
3. Thermoelectric power
4. Electron Spin Resonance
5. Crystal structure of thin film
6. Rydberg constant
7. Dissociation energy of iodine molecule
8. Magnetic susceptibility of ferric chloride solution
9. Numerical differentiation using Python
10. Numerical integration using Python

Learning outcomes:

Student should able to
1. understand concept of LDR
2. measure resistivity of sample
3. measure thermo electric power
4. understand ESR
5. study XRD pattern
6. determine Rydberg constant
7. measure dissociation energy
8. measure magnetic susceptibility
9. obtain differentiation using Python
10. obtain integration using Python

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