

Rayat Shikshan Sanstha's

**YASHAVANTRAO CHAVAN
INSTITUTE OF SCIENCE,
SATARA**

(AUTONOMOUS)

Lead college of
Karmveer Bhaurao Patil University, Satara

Reaccredited by NAAC with 'A+' Grade

Proposed Syllabus For

Master of Science

Part - I

PHYSICS

Syllabus to be implemented w .e. f. June 2023 As Per NEP-2020

**Rayat Shikshan Sanstha's
Yashvantrao Chavan Institute of Science, Satara
(Autonomous)**

Syllabus for M.Sc. Part – I

Title: Physics

Year of Implementation: The syllabus will be implemented from June, 2023 onwards.

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.

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 assess 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.

Program Outcomes:

1. The student will post graduate with expertise in the subject.
2. The student will be qualified to continue Ph.D. in his subject.
3. The student will be eligible to research scholar abroad.
4. The student will be qualified to appear for the examinations for jobs in government organizations, private industries, research laboratories, etc.
5. The student will be eligible to appear for jobs with minimum eligibility as science post graduate.

Program Specific Objectives:

1. The students are expected to know the core knowledge and recent developments in the physics.
2. The practical course is designed in consequence with the theory courses to expand the understanding of the several concepts in physics.
3. It is predicted to inspire and improve interest of the students in physics.
4. To grow the power of appreciations, the successes in science and part in society and nature.
5. To develop student sense in recent research areas.

Program Specific Outcomes:

1. Understand the basics and advances of physics.
2. Study, plan and perform experiments in the labs to prove the ideas, values and theories learned in the classrooms.
3. Improve scientific knowledge in physics.
4. Classify their area of attention in academic, research and development.
5. Perform job in various fields like science, engineering, education, banking, business and public service, etc. or be an entrepreneur with precision, analytical mind, innovative thinking, clarity of thought, expression, and systematic approach.

Duration: Two year full time.

Pattern: Semester examination.

Medium of Instruction: English.

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

Level	Semester	Course Code	Course Title	No. of Lectures Per Week	Credits
6	I	MPT 411	Mathematical Methods in Physics	4	4
		MPT 412	Classical Mechanics	4	4
		MPT 413	Quantum Mechanics-I	4	4
		MPT 414 E-I MPT 414 E-II DSE (Elective: Any one among two)	E-I) Atomic and Molecular Physics E-II) Optoelectronics and Photonics	4	4
		MPT415	Research Methodology	4	4
		MPP 416	LAB- I (based on MPT-411, 412 and 413)	2	2
Total					22

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

Level	Semester	Course Code	Course Title	No. of Lectures Per Week	Credits
6	II	MPT 421	Quantum Mechanics II	4	4
		MPT 422	Statistical Mechanics	4	4
		MPT 423	Solid State Physics-I (Physical Properties of Solids)	4	4
		MPT 424 E-I MPT 424 E-II DSE (Elective : Any one among two)	E-I) Condensed Matter Physics E-II) Laser Physics	4	4
		MPT 425	Research Projects		4
		MPP 426	LAB- II(based on MPT-421, 422 and 423)	2	2
Total					22

SEMESTER I
MPT 411: MATHEMATICAL METHODS IN PHYSICS

Course Objectives: student should be able to:

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

Credits=4	SEMESTER-I MPT 411: Mathematical Methods in Physics	No. of hours per unit
UNIT I	Matrix Algebra and Eigen value Problems	(15)
	Matrix multiplication – Inner product, direct product, Diagonal matrices, trace, matrix Inversion, Gauss-Jordan Inversion theorem, problems, Eigenvalues and Eigenvectors, Properties of Eigenvalues and Eigenvectors, Cayly Hamilton 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- Riemann 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.	
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Course Outcomes: After completion of syllabus, student will be able to:

1. define Inner product, direct product, Diagonal matrices, trace, matrix Inversion
2. perform Complex Algebra, Conjugate Complex Numbers and their sum ,Difference, Product and quotient.
3. solve the complex Calculus problems of Residues-Residues Theorem.
4. analyse and apply Fourier transform and inversion theorem.

Reference 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)
4. K F Riley, M P Hobson and S J Bence, *Mathematical Methods for Physics and Engineering* (Cambridge: Cambridge University Press, 1997)
5. M. L. Bose, *Mathematical Methods of physical science* (New Jersey: Wiley Publications, 1983)

MPT 412: Classical Mechanics

Course Objectives: student should be able to:

1. understand the laws of rotational motion, two body central force and Rutherford scattering.
2. learn Lagrangian equation of motion, Jacobi integral, energy conservation and concept of symmetry.
3. know Hamilton's formulation and Variational principle
4. study Canonical Transformation and Poisson Brackets

Credits=4	SEMESTER-I MPT 412: Classical Mechanics	No. of hours per unit
UNIT I	Rotational motion and central force problem	(15)
	Inertial forces in rotating frames, Larmour precession, electromagnetic analogy of inertial forces, effect of coriolis force, Foucault'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 canonical transformation.	

Course Outcomes: After completion of syllabus, student will be able to:

1. define inertial forces, Larmour precession, corioles for forces
2. identify generalized coordinates, momenta, cyclic coordinates and utilize Lagrangian formulation
3. describe and apply Hamilton's formulation, variational Principle and Euler's equation.
4. utilize Poisson Brackets, Identities, Poisson theorem, Jacobi- Poisson Brackets, Jacobi Identity for canonical transformation

Reference Books:

1. H. Goldstein, *Classical mechanics* (Publisher : Narosa Pub. House, 2001).
2. Narayan Rana, Pramod Joag, *Classical mechanics*(Publisher:McGraw Hill Edu. 2017).
3. R Takwale, P Puranik, *Introduction to classical mechanics* (Publisher : McGraw Hill Edu.1st edition 2017).
4. J. C. Upadhyaya, *Classical Mechanics* (Publisher: Himalaya Publishing House 2022).

MPT 413: Quantum Mechanics- I

Course Objectives: student should be able to:

1. understand ket and bra spaces, inner products, operators and uncertainty relations.
2. learn Schrödinger wave equation and commutation relations.
3. study Eigen values and Eigen functions of L_2 and L_z operators, Ladder operators, Pauli theory of spins.
4. know perturbation theory, Eigen values and Eigen functions.

Credits= 4	SEMESTER-I MPT 413: Quantum Mechanics- I	No. of hours per unit
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_- , Pauli Theory of spins (Pauli's Matrices), angular momentum as a generator of infinitesimal rotations, Matrix representation of $ j m\rangle$ basis. Addition of angular momenta, Computation of Clebsch-Gordon Coefficients in simple cases ($J_1=1/2, J_2=1/4$)	
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).	

Course outcomes: After completion of syllabus, student will be able to:

1. define ket and bra spaces and inner products and operators
2. solve Schrödinger wave equation - one dimensional problems, well and barriers.
3. compute Clebsch-Gordon Coefficients in simple cases ($J_1=1/2; J_2=1/4$).
4. find Eigen value of energy and Eigen function in the first order approximation.

Reference Books:

1. J. J. Sakurai, Jim Napolitano, *Modern Quantum Mechanics* (Publisher: Cambridge University Press; 3rd edition, 2020).
2. David J. Griffiths, Darrell F. Schroeter, *Introduction to Quantum Mechanics* (Publisher: Cambridge University Press; 3rd edition, 2018).
3. N Zettili, *Quantum Mechanics concept and application* (Publisher : Wiley India Pvt. Ltd; 2nd edition, 2016).
4. P M Mathews, K Venkatesan, *A Textbook of Quantum Mechanics* (Publisher: McGraw Hill Education; 2nd edition, 2017).

MPT 414 E-I: Atomic and Molecular Physics**Course Objectives: student should be able to:**

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

Credits= 4	SEMESTER-I MPT 414 E-I: Atomic and Molecular Physics	No. of hours per unit
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.	
UNITII	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.	

Course outcomes: After completion of syllabus, student will be able to:

1. describe and use ll, ss, jj, LS or Russiel Sounder's coupling for solving numericals.
2. analyse Zeeman effect for two-electrons, Paschen-Back effect for two-electrons,
3. discuss and draw electronic spectra and rotational of diatomic molecules chemical.
4. differentiate between infra-red and Raman spectroscopy.

References:

1. H. E. White, *Introduction to Atomic Spectra* (Publisher: McGraw Hill Edu., 2019).
2. Raj Kumar, *Atomic and Molecular Physics*, (Publisher: Campus Books International 2013).
3. S.N. Ghoshal, *Atomic Physics (Modern Physics)* (Publisher: S Chand & Company 2010).
4. S P Kuila, *Concepts of Atomic Physics* (Publisher: New Central Book Agency (NCBA), 1st Edition 2017).

MPT 414 E-II: Optoelectronics and Photonics

Course Objectives: student should be able to:

1. understand concepts of light emitting materials.
2. study different modulators and electro-optic devices.
3. know principle of optical fibers and their types.
4. learn second, third order non linear optical media and concepts of optical digital computer

Credits= 4	SEMESTER-I MPT 414 E-II: Optoelectronics and Photonics	No. of hours per unit
UNIT I	Optoelectronic devices	(15)
	Photoconductivity, Light dependent resistor, photodiode, phototransistor, solar cell, metal semiconductor detector, Liquid crystal display, charged coupled devices, light emitting diode Laser diode: Spontaneous and stimulated emission, laser	

	structures, time response of lasers, advanced semiconductor laser structures, temperature dependence of laser output. PIN photodiode, Avalanche photodiode, Heterojunction photodiode, Organic light emitting diodes (OLED) , way to perceive colors, conventional, transparent, inverted and flexible OLEDs, Organic thin films transistors (OTFT), OTFT based display technology; Organic laser-Lasing process, optically pumped lasing structures, applications; Organic multilayer, photodetectors; organic photovoltaic cells.	
UNIT II	Optoelectronic modulators	(15)
	Polarization of Light, Elliptical polarization, Optics of anisotropic media: The index ellipsoid, Birefringence, Optical activity, Electro-optic effect, Electro-optic modulators, Acousto-optic modulators, use of optoelectronic modulator, Kerr modulator- Kerr effect, Magneto-optic modulator – Faraday effect, Acousto-optic effect, Electro-optic Devices: Wave retarders, rotators and optical isolators, Intensity Modulators, Phase Modulators, Traveling Wave Modulator, Acousto-optic Devices: Raman-Nath acousto-optic modulator, Acousto-optic deflector, parametric oscillation	
UNIT III	Fiber optics	(15)
	Basic characteristics and ray propagation in an optical fibers, Step –index and graded-index fibers, Multipath dispersion, pulse dispersion, material dispersion, combined effect of multipath and material dispersion, rms pulse width. Modes In planar waveguides – TE modes of a symmetric step-index planar waveguide, power distribution and confinement factor, wave propagation in a cylindrical wave guide, single mode fiber and its characteristic parameters, dispersion and attenuation in SMF, Optical fiber cable and connections, Dispersion compensation mechanism, Dispersion-tailored and dispersion compensating fibers, Birefringent fibers and polarization mode dispersion, Fiber bandwidth. fiber material and its fabrication, Erbium-doped fiber amplifiers, Fiber Bragg gratings. Photonic Crystal and Holey fibers. Fiber optic communications: Analog and digital fiber optic communication system, System architectures, Nonlinear effects in fiber optic: Stimulated Raman Scattering, Stimulated Brillouin Scattering, Self Phase Modulation, Cross Phase Modulation, Four wave mixing, Optical Solitons optical amplifiers : semiconductor optical amplifier, Fiber Raman amplifier	

UNIT IV	Non-linear Optics	(15)
	Non-linear optical media, second order non-linear optics- SHG, Three wave mixing. Third order non-linear optics, THG and self-phase modulation, Coupled wave theory of three-wave mixing. Four wave mixing and Optical Phase conjugation. Frequency conversion, Parametric Amplification and Oscillation. Self focusing of light. Optical Bistability Concept Optical digital computer - Optical components for binary digital computer, Optical Switches- SEED , Photonic logic gates	

Course outcomes: After completion of syllabus, student will be able to:

1. describe concepts of photodiodes, LEDs, OLEDs based displays
2. explain electro-optic and magneto-optic phenomenon's and devices based on it
3. analyse principle of optical fibers, analog and digital fiber optic communication system
4. utilize second, third order non linear optical media for the concepts of optical digital computer and optical switches.

References:

1. Jixiang Yan, Tsinghua University Press, *Optical Electronics: An Introduction* (De Gruyter Textbook, 2019).
2. Ajoy Ghatak, *Optical Electronics* (Publisher: Cambridge India, 2017).
3. Tetsuzo Yoshimura, *Optical Electronics: Self-Organized Integration and Applications* (Publisher: Pan Stanford Publishing Pte Ltd; 1st edition, 2012).

MPT 415: Research Methodology

Course Objectives: student should be able to: -

1. understand fundamentals of research methods
2. learn design and measurement concepts of research
3. know data collection and analysis tools
4. get knowledge of scientific report writing

Credit= 4	SEMESTER-I MPT 415: Research Methodology	No. of hours per unit
UNIT I	Fundamentals of Research Methods	(15)
	Definition of research, Research ethics and morality, Role and objectives of research, Applications and types of research, Research process and steps in it, Collecting and reviewing the literature, Conceptualization and Formulation of: research problem, identifying variables, constructing hypothesis and Synopsis.	

UNIT II	Research Design and Measurement Concepts	(15)
	Selecting and defining a research problem, Need for research design, Features of a good research design, Different research designs, Scales of measurements, Nominal, Ordinal, Interval and ratio scales, Errors in measurements, Validity and Reliability in measurement, Scale Construction Techniques.	
UNIT III	Literature Searching	(15)
	Search engines, database, science direct, Scifinder, Scopus, Web of science, INFLIBNET, Research Matrices: Citation index, H index, Impact factor, i10 index, etc. Plagiarism: introduction, types and awareness, detection tools	
UNIT IV	Review Writing	(15)
	Discussions, Conclusion, referencing and various formats for reference writing, Review writing, Use of Mandalay software, Bibliography, Thesis Writing, Formats of publications in research journals	

Learning outcomes: After completion of syllabus, student will be able to:

1. explain fundamental methods of research
2. evaluate, design and measure the concepts of research
3. differentiate different research matrices
4. write scientific report

Reference:

1. Kothari C.R., “*Research Methodology, Methods and Techniques*” (Second revised edition, New Age International Publication, 2004).
2. Saravanavel P., “*Research Methodology*” (Kitab Mahal, Sixteenth edition, 2007).
3. Ranjit Kumar, “*Research Methodology, a step-by-step guide for beginners*” (Pearson education Australia, Second edition 2005).
4. Mark Saunders, Philip Lewis, Adrain Thornhiu, “*Research Methods for Business Students*” (Pearson Education ltd, Seventh edition, 2016)

MPP 416: LAB I

Practical Course based on MPT-411, 412 and 413

Course Objectives: student should be able to:

1. Determine heat capacity
2. Understand concept of stair case ramp generator
3. Determine frequency response of negative feedback amplifier
4. Understand concept of astable multivibrator

Credits =2	SEMESTER-I	No. of hours per unit
	MPP 416: LAB I	(60)
	<ol style="list-style-type: none"> 1. Heat Capacity 2. Staircase Ramp Generator 3. Negative Feedback Amplifier 4. Astable Multivibrators 5. Monostable Multivibrators 6. Stefan's Constant 7. Planks Constant 8. Photocatalytic dye degradation of given sample 9. Intensity measurement by Lux meter 10. Hall Effect 11. L.V.D.T. 12. Neutron Diffraction 13. Fabry-Parrot etalon 14. Lattice Dynamics 15. Study and verify Simpson's 1/3 Rule for Numerical Integration 16. Study and verify Simpson's 3/8 Rule for Numerical Integration 17. Study and verify trapezoidal Rule for Numerical Integration 18. Study and verify Runge-Kutta method for Numerical Integration 19. B-H Curve 20. Temperature Transducer 	

Course outcomes: After completion of syllabus, student will be able to:

1. calculate the heat capacity value of given material
2. demonstrate the concept of stair case ramp generator using CRO
3. determine frequency response of negative feedback amplifier using CRO
4. illustrate the Astable multivibrator using IC 555

SEMESTER II

MPT 421: QUANTUM MECHANICS-II

Course Objectives: student should be 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. learn scattering theory.
4. know Semi classical theory of radiation and Selection rules.

Credits=4	SEMESTER-II MPT 421: Quantum Mechanics-II	No. of hours per unit
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	

Course Outcomes: After completion of syllabus, student will be able to:

1. discuss Stark effect and Fermi's Golden rule.
2. solve the problems of hydrogen atom.
3. analyse Low energy scattering and bound state, Resonance scattering, Scattering by hard sphere, Coulomb scattering.
4. describe the electric dipole and forbidden transitions and selection rules.

Reference Books:

1. J. J. Sakurai, Jim Napolitano, *Modern Quantum Mechanics*, (Publisher: Cambridge University Press; 3rd edition, 2020).
2. David J. Griffiths, Darrell F. Schroeter, *Introduction to Quantum Mechanics*, (Publisher: Cambridge University Press; 3rd edition, 2018).
3. N Zettili, *Quantum Mechanics concept and application*, (Publisher : Wiley India Pvt. Ltd; 2nd edition, 2016).
4. P M Mathews, K Venkatesan, *A Textbook of Quantum Mechanics*, (Publisher: McGraw Hill Education; 2nd edition, 2017).

MPT 422: Statistical Mechanics

Course Objectives: student should be 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. know MB, BE and FD distributions and free electron theory of metals.
4. learn first and second order phase transitions.

Credits=4	SEMESTER-II MPT 422: Statistical Mechanics	No. of hours per unit
UNIT I	Introduction of Statistical Mechanics and thermodynamics	(15)
	Specification of state of system, Macroscopic and microscopic states, phase space, Γ space, μ 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 phase transition), The critical indices.	

Course Outcomes : After completion of syllabus, student will be able to:

1. define specification of state of system, Macroscopic and microscopic states, phase space.
2. distinguish between Micro canonical, Ensemble Canonical Ensemble and Grand Canonical
3. distinguish between MB, BE and FD distributions
4. discuss phase transitions, conditions for phase equilibrium, First order Phase Transition, Second order phase transition.

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.

MPT 423: Physical Properties of Solid

Course Objectives: student should be able to:

1. understand the Drude model and DC electrical conductivity.
2. study Transport Properties of Metals like Sommerfeld theory of electrical conductivity, The mean free path in metals, Thermal scattering and thermal conductivity of metals.
3. know Phonons, Plasmons, Polaritons, and Polarons
4. learn magnetic properties of materials

Credits=4	SEMESTER-II MPT 423: Physical Properties of Solid	No. of hours per
UNIT I	Theory of metals	(15)
	Basic assumptions of Drude Model, Collision or relaxation times, DC electrical conductivity, Ground state properties of electron gas, 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 II	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 III	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 IV	Magnetic Properties of Materials	(15)
	Introduction, Magnetic permeability, Magnetisation, Electric current in atoms-Bohr magnetron, Electron spin and magnetic moment due to nuclear spin, Langevin's with experiment classical theory of paramagnetism, Weiss theory of paramagnetism, quantum theory of paramagnetism, Comparison of theory with experimental results, 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	

Course Outcomes: After completion of syllabus, student will be able to:

1. describe Drude Theory of metals and Basic assumptions of Model, Collision or relaxation times, DC electrical conductivity
2. discuss steady state, Drift velocity and relaxation time
3. analyse Quantization of lattice vibrations, Phonon momentum
4. explain the structure of ferrite, the saturation magnetization and 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)

MPT 424 E-I: Condensed Matter Physics – I**Course Objectives: student should be able to:**

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

Credits=4	SEMESTER-II MPT 424 E-I: Condensed matter Physics – I	No. of hours per unit
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)	
UNITII	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- T _c super conductivity.	

Course outcomes: After completion of syllabus, student will be able to:

1. discuss concept of crystal growth.
2. analyse Langevin's theory and measurement of dielectric constant.
3. describe two sub lattice model of anti-ferromagnetism.
4. explain BCS theory of superconductivity

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. Kittel, 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.

MPT 424 E-II: Laser Physics

Course Objectives: student should be able to:

1. understand principles of lasing action.
2. study different types of resonators.
3. know switching phenomenon's.
4. learn different laser systems

Credits=4	SEMESTER-II MPT 424 E-II: Laser Physics	No. of hours perunit
UNIT I	Basic Laser Principle and Laser System	(15)
	Summary of black body radiation, Quantum theory for evaluation of the transition rates and Einstein coefficients-allowed and forbidden levels-metastable state; population inversion; rate equations for three level and four level lasers, threshold of power calculation, various broadening mechanism, homogeneous and inhomogeneous broadening. Basic Laser System: Basic concept of construction of laser system, various pumping system, pumping cavities for solid state laser system, characteristics of host materials and doped ions	
UNIT II	Optical beam propagation and Resonators	(15)
	Paraxial ray analysis, wave analysis of beams and resonators, propagation and properties of Gaussian beam, Gaussian beam in lens like medium, ABCD law-Gaussian beam focusing Resonators: Stability of resonators-‘g’ parameter, various types of resonators, evaluation of beam waist of such combination, design aspect of resonator for various types of lasers, unstable resonator and their application	
UNIT III	Q-switching and Ultrafast Phenomenon	(15)
	Giant pulse theory, different Q-switching techniques: mechanical Q-switching, electrooptic Q-switching, acousto-optic Q-switching, dye Q-switching, Raman-Nath effect. Ultrafast Phenomenon: Principle of generation of ultrafast pulses (mode locking), basic concepts for measurement of fast processes, Streak technique, Stroboscopy, sampling technique, nonlinear optical methods for measuring ultrashort pulses	
UNIT IV	Different laser systems	(15)
	Gas Lasers: (i) Molecular gas lasers- CO ₂ laser & N ₂ (ii) ionic gas laser – Ar ⁺ laser (iii) gas dynamic laser (iv) high pressure pulsed gas laser Solid State Laser: (i) Nd:YAG laser, (ii) Nd:Glass laser, comparison of performances (iii) Tunable solid state laser: Ti:sapphire laser; Alexandrite laser Chemical Laser: HF laser, HCl laser, COIL Excimer laser; Color centre laser; Free electron laser; semiconductor diode laser	

Course outcomes: After completion of syllabus, student will be able to:

1. utilize fundamental concepts related to pumping systems, metastable state, population inversion and stimulated emission.
2. design different aspects of resonator for various types of lasers
3. discuss Q switching and ultrafast phenomenon's

4. explain lasing action in different types of lasers like CO₂, N₂, Nd:YAG etc.

References:

1. M. Singh, *Lasers: Theory, Principles and Applications* (Publisher: Vei; 1st edition,2012).
2. K.R. Nambiar, *Lasers: Principles, Types and Applications* (Publisher: New age publishers; 1st Edition, 2004).
3. William S. C. Chang, *Principles of Lasers and Optics* (Publisher: Cambridge University Press 2007).

MPT-425 Research Project

Credit 4	MPT-425 Research Project	No. of hours 60
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MPP 426: LAB II

Practical course based on MPT 421, 422 & 423

Course Objectives: student should be able to:

1. Measure Young’s modulus
2. Measure thermal diffusivity of Brass
3. Understand concept of passive filters
4. Understand concept of magnetic susceptibility

Credits=4	SEMESTER-II MPP 426: LAB II	No. of hours per unit
	MPP 426: LAB II	(60)
	<ol style="list-style-type: none"> 1. Young’s modulus 2. To study the shape of the LASER beam: divergence angle, cross section and to evaluate beam spot. 3. Passive filters 4. Thermal & electrical conductivity of copper 5. Mutual inductance of coil 6. Band gap energy 7. Series & parallel resonant circuits 8. LDR 9. Resistivity by four Probe 10. Data plotting using Origin software 11. Rydberg constant 12. Dissociation energy of iodine molecule 13. Magnetic susceptibility of ferric chloride solution 14. Numerical differentiation using Bisection method 15. Numerical differentiation using Secant method 16. Numerical differentiation using Newton Raphson method 17. Crystal structure of thin film 	

	18. A.C. bridges 19. Fourier analysis 20. Electron Spin Resonance	
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Course outcomes: After completion of syllabus, student will be able to:

1. measure Young's modulus.
2. measure thermal diffusivity of Brass
3. demonstrate concept of passive filters
4. demonstrate working of Series & parallel resonant circuits