Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics)

(*Minor modifications as approved as Reso. 4 of 61st Senate of SVNIT dated 30.04.2024*)

Sr. No.	Subject	Code	Scheme L-T-P	Credits (Min.)	Notional hours of Learning (Approx.)	
	Third Semester (2nd year of MSc)					
1	Solid State Physics	PH201	3-0-2	4	85	
2	Classical Mechanics	PH203	3-1-0	4	70	
3	Optics	PH205	3-0-2	4	85	
4	State and Properties of Matter	CY205	3-1-2	5	100	
5	Discrete Mathematical Structure	MA205	3-1-0	4	70	
			Total	**21**	**410**	
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	PHV03 / PHP03	0-0-10	5	200 (20 x 10)	
	Fourth Semester (2nd year of MSc)					
1	Mathematical Methods in Physics	PH202	3-1-0	4	70	
2	Quantum Mechanics-I	PH204	3-1-0	4	70	
3	Electromagnetic Theory-II	PH206	3-0-2	4	85	
4	Laser and Photonics	PH208	3-1-0	4	70	
5	Data Structure	CS102	3-1-2	5	100	
			Total	**21**	**395**	
6	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	PHV04 / PHP04	0-0-10	5	200 (20 x 10)	

COURSE OFFERRED TO OTHER DEPARTMENT

Sr. No.	Subject	Code	Scheme L-T-P	Credits (Min.)	Notional hours of Learning (Approx.)
	Third Semester (2nd year of MSc)				
1	Optics (*for Department of Chemistry students*)	PH205	3-0-2	4	85

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - II, Semester - III SOLID STATE PHYSICS PH201	Scheme	L	T	P	Credit
		3	0	2	4

1.	Course Outcomes (COs): At the end of the semester students will be able to
CO1	Explain the basics of crystallography and identify the crystal structures
CO2	Demonstrate the concept of free electron theory of solids
CO3	Interpret the lattice vibrations and thermal properties of solids
CO4	Extend concept of energy band theory by various methods and apply to explain optical properties
CO5	Examine the properties of superconductors and interpret the concept of liquid crystals

2.	Syllabus	
	CRYSTALLOGRAPHY	**09 Hours**
	Symmetry elements in crystals, Single crystals and usage, Defects in crystals, Techniques of growing and studying different crystals, Determination of crystal structures by X-ray diffraction, Formulations of Bragg & Von Laue equations and their equivalence, Laue condition and Ewald's construction, Rotating crystal method, Laue method, Powder crystal methods, Geometrical structure factor, Atomic form factors.	
	FREE ELECTRON THEORY	**06 Hours**
	Drude theory of metals, Sommerfeld theory of metals, Sommerfeld theory of conduction, Failure of the free electron model.	
	LATTICE VIBRATION AND THERMAL PROPERTIES	**08 Hours**
	Vibrations of monoatomic lattice, Normal mode frequencies, Dispersion relation, Quantization of lattice vibrations, Phonon momentum, Inelastic scattering of neutrons by phonons, Surface vibrations, Inelastic neutron scattering. Anharmonic crystal interaction. Thermal conductivity, Lattice thermal resistivity.	
	ENERGY BAND THEORY	**12 Hours**
	Band theory of solids, Periodic potentials and Schrödinger equation, Bloch theorem, Kronig-Penney model, Origin of band gap, Distinction between conductors, Insulators and semiconductors, Electrical resistance of materials, Equation of motion of an electron, Resistivity and conductivity, Brillouin zones, electron motion in one dimension, Effective mass, Concept of a hole, Mobility and temperature dependence, Cyclotron resonance and Hall effect, Tight binding method, Band structure of real semiconductors, High electric field and hot electrons, Optical properties: absorption processes, Photoconductivity, Luminescence.	
	SUPERCONDUCTIVITY AND SUPERFLUIDITY	**10 Hours**

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	Superconductivity: type-I and type-II superconductors, Josephson junctions, Superfluidity, Defects and dislocations, Ordered phases of matter: translational and orientational order, Kinds of liquid crystalline order, Quasi crystals.	
	Practical will be based on the coverage of the above topics separately	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**PRACTICALS**
1	To measure Hall coefficient of Germanium and calculation of charge carrier.
2	To study of the dispersion relation for the mono-atomic lattice. Determination of the cut-off frequency of the mono-atomic lattice.
3	To determine the resistivity and energy band gap of a given material (Ge,Si) using four probe method.
4	To measure the Lande’ g-factor in a free radical using an electron spin resonance spectrometer.
5	To study Crystal Growth by Solution method (KDP).
6	Ultrasonic Interferometer for the measurement of ultrasonic velocity in liquids.
7	Heat Capacity Kit for the measurement of heat capacity of solids.
8	To determine the Temperature Coefficient of a material.
9	To Study Thermoelectric Effect and to measure Seebeck and Peltier Coefficient.
10	To find the resistivity of material using two probe method.

4.	**Books Recommended**
1	Kittle C., Introduction to Solid State Physics, John Willey, 1976.
2	Sastry S. S., Introductory Methods of Numerical Analysis, 2nd Edition, PHI, 2012M. A. Omar, Elementary Solid State physics, Addison-Wesley Pvt. Ltd, New Delhi, 2000.
3	Dekker A. J., Solid State Physics, Macmillan India Ltd, 2000
4	Ashcroft N. W. and Mermin N.D., Solid State Physics, Holt-Saunders International Editing 1981.
5	Harrison W. A., Solid State Theory, Tata McGraw Hill Education, 1970.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - II, Semester - III Classical Mechanics PH203	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes: At the end of the semester, students will be able to
CO1	Relate the terminology and concepts of Newtonian Mechanics, Lagrangian and Hamiltonian approach, Central force, and small oscillations.
CO2	Explain various mechanisms, models, derivations, and approaches associated with classical mechanics.
CO3	Solve numerical problems for various situations in classical mechanics.
CO4	Analyze the results obtained for various physical problems of classical mechanics.

2.	Syllabus:	
	LAGRANGIAN DYNAMICS	**(12 Hours)**
	Constraints: Holonomic and nonholonomic, Scleronomic and rheonomic systems, Degrees of Freedom, Generalized Coordinates and Velocity, Generalized Force, Kinetic Energy, Principle of virtual work, D'Alembert's principle, Lagrange's equation of motion of first kind, Method of Lagrange multiplier, Lagrange's equation of motion of second kind, Energy equation for conservative fields, Cyclic coordinates, Generalized potential, Euler equation with more than one independent variable and also for non-holonomic constraints.	
	HAMILTONIAN DYNAMICS	**(05 Hours)**
	Generalized momentum and conservation theorems, Hamilton's equations, Conservation of energy.	
	VARIATIONAL PRINCIPLE	**(05 Hours)**
	Calculus of variation, deduction of Euler-Lagrange's equations, Hamilton's principle, Δ-variation, principle of least action, Hamilton-Jacobi equation.	
	TWO-BODY CENTRAL FORCE PROBLEM	**(07 Hours)**
	Equivalent one body problem and effective potential, Classification of orbits, Differential equation for orbits, Virial theorem, Kepler's laws and planetary motion, Stability of orbit, Scattering cross section, Rutherford scattering, Hyperbolic orbits.	
	CANONICAL TRANSFORMATION AND BRACKETS	**(09 Hours)**
	Canonical and Legendre transformations, Point transformations, Generating functions, Infinite contact transformations, Poisson's brackets, Angular momentum, Invariance with respect to canonical transformation, Phase space, Liouville's theorem.	
	SMALL OSCILLATIONS AND NORMAL MODES	**(07 Hours)**
	Potential energy in equilibrium, Stable, Unstable and neutral equilibrium, Coupled oscillators, Normal coordinates and normal modes, Secular equation.	

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	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials:**
1.	Problems based on Lagrangian formulation.
2.	Problems based on Euler-Lagrange equations.
3.	Problems based on Lagrange multiplier.
4.	Problems based on Hamilton's equation in different coordinate systems.
5.	Problems based on Two-body central force and scattering cross-section.
6.	Problems based on variational principle.
7.	Problems based on Hamilton's principle.
8.	Problems based on transformations and generating functions.
9.	Problems based on Poisson's bracket.
10.	Problems based on normal mode frequencies.

4.	**BOOKS RECOMMENDED:**
1.	Goldstein H., Classical Mechanics, Narosa, 2018.
2.	Goldstein H., Poole C. P., and Safko J., Classical Mechanics, Third edition, Pearson, 2000.
3.	Landau L. D. & Lifshitz E M, Course on Theoretical Physics, Vol. 1: Mechanics, Addison- Wesley, 2002.
4.	Raychaudhuri A. K., Classical Mechanics, Oxford, 1983.
5.	Abraham R., Marsden J. E., Foundations of Mechanics, 1st Edition, CRC Press, 1994.
6.	Morin D., Introduction to Classical Mechanics with Problems and Solutions, Cambridge University Press, 2009.
7.	Thornton Stephen T. and Marion Jerry B., Classical Dynamics of Particle and Systems, Cengage Publications, 2012.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - II, Semester - III OPTICS PH 205	Scheme	L	T	P	Credit
		3	0	2	4

1.	**Course Outcomes (COs):** **At the end of this course, students should be able to**
CO1	Relate the key theoretical concepts of optics and optical technology, including the propagation of light, various optical phenomenon such as interference, diffraction, polarization and optical instrumentation.
CO2	Explain various underlying principles associated with optics and observe key optical phenomena experimentally.
CO3	Solve problems for various situation in optics by applying the simple optical systems on the basis of lenses, reflectors, prisms, spectrometer, *etc*.
CO4	Analyze the results obtained for various problems of optics and design systems/applications by utilizing the concepts studied.

2.	**Syllabus**	
	GEOMETRIC OPTICS	**06 Hours**
	Image formation, Magnification, Prisms, mirrors, Thin lenses, Eyepiece, Fiber waveguides, Blindspot, Cactus guides, Telescopes, Microscopes, Cameras, Aberrations: chromatic, spherical and coma.	
	LIGHT PROPAGATION	**05 Hours**
	Reflection, Refraction, Transmission and polarization, Total internal reflection and reflection from metals.	
	COHERENCE AND INTERFERENCE	**12 Hours**
	Coherence time, Coherence length, Fresnel's Biprism, Interference with multiple beams, Thin films, Anti-reflecting coatings, Newton's rings, Michelson interferometer, Fabry-Perot, Technological applications of interference.	
	DIFFRACTION AND HOLOGRAPHY	**11 Hours**
	Fraunhofer & Fresnel zones, Zone plates, Diffraction through single slit, double slit and grating, Resolving power, 2-D Fourier transforms (various apertures, including variable), Holography, Optical image processing, Focusing with a zone plate, Babinet's Principle.	
	POLARIZATION AND ITS APPLICATIONS	**11 Hours**
	Fresnel equations, Birefringence, Calcite double refraction, Circular birefringence, Principles of use of uniaxial crystals in practical polarizers, Compensators and wave plates, Production and analysis of completely polarized light, Optical activity, Polarimeters, Faraday rotation, Applications to DNA analysis, Photonic devices, Displays, Quantum cryptography.	
	Practical will be based on the coverage of the above topics separately	**(45 Hours)**

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	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

3.	**Practicals**
1.	To study the variation of refractive index with the wavelength and hence to determine the dispersive power of the material of a given prism.
2.	To determine the wavelength of Sodium light by using bi-prism.
3.	To determine the wavelength of sodium light by Newton's Ring method.
4.	Michelson's interferometer with laser light.
5.	Magnetostriction in a metallic rod using Michelson interferometry.
6.	Fabry-Perot interferometer with sodium light source.
7.	To measure the wavelength of spectral lines of mercury source using diffraction grating and spectrometer.
8.	Diode Laser Diffraction Experiment (single slit, double slit, multiple slits, fine wire, cross wire, wire mesh, transmission grating, coarse grating, circular aperture).
9.	Verify the lass of Malus. Also, determine the specific rotation of the cane sugar solution using a Polarimeter.
10.	To study the Interference, Diffraction, and Polarization of Microwave.

4.	**Books Recommended**
1	Pedrotti, F. L., Pedrotti L.M. and Pedrotti L. S., Introduction to Optics. 3rd Edition), San Fransisco: Benjamin Cummings, 2006.
2	Hecht E., *Optics*, Pearson Education, 2019.
3	Jenkins F. A. and White H. E., *Fundamentals of optics*, Tata McGraw Hill, 2017.
4	Griffiths D. J., Introduction to Electrodynamics, 3rd Ed. Prentice – Hall of India Private Limited, 1999.
5	Ghatak A. K., Optics, McGraw Hill, 7th edition, 2020.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - II, Semester - III STATES AND PROPERTIES OF MATTER CY 205	Scheme	L	T	P	Credit
		03	0	02	04

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Memorize the basic theoretical knowledge of solids and liquids applicable in multidisciplinary fields.
CO2	Learn concepts of solutions and apply thermodynamic treatment in liquids.
CO3	Acquire fundamental knowledge of colloidal state.
CO4	Classify states of matter based on physical properties.
CO5	Perform the experiments related to physical chemistry approach which includes solution preparation and titration.

2.	Syllabus	
	SOLID STATE	**(08 Hours)**
	Unit cell, Bravais lattice and its types, Miller indices, X-ray diffraction, Bragg's law and its derivation, Calculation of basis per unit crystal, volume, density per unit cell, Diffraction techniques (Qualitative treatment only): single crystal and powder, Structure elucidation of ZnS (Wurtzite and blende), Specific heat of solids (Dulong Petit law, Einstein's theory, Debye correction qualitatively), Band theory, Superconductivity, Point defects (Schottky and Frenkel).	
	LIQUID STATE	**(10 Hours)**
	General features of liquid state (short and long range order/disorder, hole theory), intermolecular forces, Vapor pressure, Young and Laplace equation, effect of temperature on vapour pressure, determination of vapour pressure - static and dynamic methods, effect of vapour pressure on boiling points, Surface tension, Surface energy, excess pressure, capillary action, Contact angle, spreading of liquids, temperature dependence of surface tension, measurement of surface tension, viscosity of liquids, temperature dependence of viscosity of liquids, Poiseuille's equation and measurement of viscosity.	
	COLLOIDAL CHEMISTRY	**(09 Hours)**
	Colloids: Definition, general properties of colloids (optical and electrical), Types of colloidal system (Foam, aerosol, emulsion, smoke), Classifications of colloids (lyophilic and lyophobic), preparation and purification of colloids, properties of colloids (optical, and kinetics). Associated colloids, emulsions, gels, applications of colloids.	
	SOLUTIONS	**(09 Hours)**
	Types of solutions, ideal and non-ideal solutions, Raoult's law, applications of Raoult's law, thermodynamic properties of ideal solutions, vapor pressure and thermodynamics of non-ideal systems, general considerations (excess functions), solvents and solutes of non-ideal solutions, mixing quantities (ΔH_{mix}, ΔV_{mix}, ΔG_{mix}, ΔS_{mix}), molecular interpretation of the entropy of mixing, determination of mixing quantities.	

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	THERMODYNAMICS OF LIQUIDS	**(09 Hours)**
	Activity and activity coefficients, fugacity, calculation of fugacity at low pressures, partial and apparent molar properties (chemical potential, enthalpy and volume), physical significance of partial molar quantities, relation between partial molar quantities, chemical potential, Gibbs-Duhem equation, applications of Gibbs-Duhem equation methods for their determination of partial molar quantities (slope – intercept method).	
	Practical will be based on the coverage of the above topics separately	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practical**
1	Preparation of Solution, Calibration and Standard Deviation.
2	To determine the partition coefficient of I_2 between CCl_4 and water.
3	To determine the surface tension of a given solution by drop weight/count (stalagmometer) method.
4	To determine the rate constant of decomposition of H_2O_2 by acidified KI solution.
5	To prepare colloidal solution of (i) gelatin (ii) Sulphur (iii) Ferric hydroxide (iv) Molybdenum blue sol
6	To study the coagulation of the hydrophobic solution with monovalent, bivalent and trivalent counter ions and find out their coagulation value.
7	To determine the heat of neutralisation of weak acid (say acetic acid) and calculate its heat of ionisation.
8	Determine the solubility of benzoic acid and heat of dissolution.
9	Demonstration: To determine the viscosity coefficient of a given solution by Ostwald Viscometer.
10	Determine the heat of solution of two ionic compounds: NH_4Cl and $CaCl_2$.

4.	**Books Recommended**
1	B. R. Puri, L. R. Sharma, M.S. Pathania, Principles of Physical Chemistry, 47th edition, Vishal Publications, New Delhi, 2017.
2	G. Raj, Advanced Physical Chemistry, 4th edition, Goel Publishing House, Meerut, 1990.
3	A. R. West, Solid State Chemistry and its Applications, 2nd edition, student edition, John Wiley & Sons, New York, 2014.
4	P. Atkins, J. de Paula, J. Keeler Atkins' Physical Chemistry, 11th edition.
5	K. J. Laidler, Chemical Kinetics, 3rd edition, 2003.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics) **M.Sc. - II, Semester - III** **DISCRETE MATHEMATICAL STRUCTURE** **MA205**	**Scheme**	**L**	**T**	**P**	**Credit**
		3	**1**	**0**	**4**

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	apply knowledge of Mathematical Logic in programming
CO2	analyze the problems for developing the solution, its correctness and performance using graphs
CO3	analyze the real-world problems using group theory, relations, lattices and Boolean algebra
CO4	develop an algorithm using Asymptotic analysis
CO5	design solutions for various types of problems in different disciplines like information security, optimization, mathematical analysis

2.	**Syllabus**	
	MATHEMATICAL LOGIC AND PROGRAM VERIFICATION	**(10 Hours)**
	Propositions, logical operators and propositional algebra, Predicates and quantifiers, Interaction of quantifiers with logical operators, Logical interference & proof techniques, Formal verification of computer programs (elements of Hoare logic).	
	GRAPH THEORY	**(10 Hours)**
	Graphs, Definition and basic concepts of finite and infinite graph, Incidence and Degree, Isomorphism, Subgraph, Walk, Path & Circuits, Operations on graphs, Connected Graph, disconnected graph and Components, Complete graph, Regular graph, Bipartite graph, Euler's graph, Hamiltonian paths and Circuits, Weighted graphs, Applications, Directed & Undirected graphs, Connectivity of graphs.	
	TREES	**(06 Hours)**
	Definition & properties of trees, Pendent vertices in a tree, Distance between two vertices, Centre, Radius and diameter of a tree, Rooted and binary trees, Representation of Algebraic structure by Binary trees, Binary search trees, Spanning trees and fundamental circuits.	
	LATTICES	**(06 Hours)**
	Definition and properties of lattice, Sublattice, Distributive and modular lattices, Complemented and bounded lattices, Complete lattices.	

	BOOLEAN ALGEBRA	**(06 Hours)**
	Introduction, Definition, Properties of Boolean algebra, Boolean variables, Boolean expression, Boolean function, Min term, Max term, Canonical forms, Switching network from Boolean expression, Karnaugh map method.	
	ASYMPTOTIC ANALYSIS	**(07 Hours)**
	Complexity analysis, Time and storage analysis, Big-oh, Big-Omega, Big–Theta notation, Illustration and application to real problems.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**

(Total Contact Time: 45 Hours + 15 Hours= 60 Hours)

3.	**Tutorials**
1	Tutorial on Mathematical Logic and Verification
2	Tutorial on Graph Theory
3	Tutorial on Trees
4	Tutorial on Lattices
5	Tutorial on Boolean Algebra
6	Tutorial on Asymptotic Analysis

4.	**Books Recommended:**
1	K. H. Rosen, Discrete Mathematics and its Applications, 6th Edition, McGraw-Hill, 2006.
2	B. Kolman, R. C. Busby, and S. Ross, Discrete Mathematical Structure, 5th Edition, Prentice Hall Inc., 2003.
3	J. P. Tremblay and R. Manohar, Discrete Mathematical Structure with Applications to Computer Science, McGraw Hill Book Co., 1999.
4	N. Deo, Graph Theory with Applications to Engineering & Computer Science, Prentice Hall of India Pvt. Ltd., 2000.
5	D. F. Stanat and D. F. McAllister, Discrete Mathematics in Computer Science, Prentice-Hall, Englewood Cliffs, New Jersey, 1977.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics) M.Sc.-II, Semester-IV Mathematical Methods in Physics PH202	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes: At the end of the semester students will be able to
CO1	Define groups, rings, vector spaces, similar matrices, row space, column space, null space, linear functional and dual space.
CO2	Show that the eigenvalues for a Hermitian matrix is always real, Legendre polynomials forms a complete basis set.
CO3	Extend the concept of vectors to tensors and classify the tensors according to their rank, dimension and transformation law.
CO4	Explain the Frobenius method for solving the second order ordinary differential equations.
CO5	Solve the second order ODE including Bessel, Hermite, Legendre, hypergeometric and confluent hypergeometric equations.
CO6	Apply the tensors and metric connections in the problems related to special theory of relativity, general theory of relativity and curved spaces.

2.	Syllabus:	
	VECTOR SPACES & LINEAR TRANSFORMATION	(12 Hours)
	Binary operations and relations, Introduction to Groups, Rings, Fields, Subspaces, Vector Spaces and Subspaces, Basis and dimension, Linear independence of vectors, Coordinates, Homomorphism and Isomorphism of Vector Spaces, Change of basis Linear transformation, Algebra of linear transformations, Non-singular transformations, Representation of linear transformations by matrices, Row space, Column space, Null space, Rank-nullity theorem, Duality and transpose, Linear functional and dual space	
	EIGEN VALUES & EIGEN VECTORS	(11 Hours)
	Eigen values and Eigen vectors of a matrix, Properties of Eigen-values and Eigen vectors of orthogonal, Hermitian and unitary matrices, Echelon form and rank of matrix, Minimal & characteristic polynomials, Similar matrices, Diagonalization and function of matrices, Cayley-Hamilton theorem and inverse of a matrix.	
	TENSOR ANALYSIS	(08 Hours)
	Vectors and indices: Transformation properties of vectors, Covariant and contravariant vectors; From vectors to tensors: Algebraic properties of tensors, Metric tensor: Index raising and lowering, Index contraction, Differentiation of tensors: Covariant derivative, Christoffel symbol and metric connection, Vector identities using tensors.	
	FROBENIUS METHOD & SPECIAL FUNCTIONS	(14 Hours)
	Series solution to ordinary differential equations (ODE), Singular points and their classification, Frobenius method for second order ODE, Solution to Bessel, Hermite, Legendre, Hypergeometric	

	and confluent hypergeometric differential equations. Generating function and recurrence relations for Legendre polynomials, Associated Legendre functions, Spherical harmonics, Legendre functions of the second kind, Vector spherical harmonics, Bessel function of the first kind, Neumann functions, Modified Bessel's functions, Asymptotic form of Bessel and Neumann functions, Spherical Bessel's function.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials:**
1.	Problems based on the concepts of groups, fields, rings and subspace.
2.	Problems to the understand difference between the basis, dimension, and coordinates.
3.	Some quantum mechanical and classical mechanical problems based on linear transformation and matrix algebra.
4.	Proof of rank-nullity theorem, problem based on the properties of eigen values of Hermitian matrix.
5.	Problems based on minimal polynomial, characteristic polynomial, and diagonalization of a matrix.
6.	Problems based on the Cayley-Hamilton theorem and its application to find the inverse of matrix.
7.	Problem based on the transformation law and algebraic properties of covariant and contravariant tensor.
8.	Problems based on metric tensor and metric connection of curved spaces.
9.	Problems based on the concept of singularity and classification of singularities in ordinary differential equation.
10.	Problems based on Bessel function, Legendre function, and spherical harmonics, and recurrence relations.

4.	**Books Recommended**
1.	Starkovich S. P., The structures of mathematical physics: An introduction, Springer, 2022
2.	Schobeiri M. T., Tensor analysis for engineers and physicists - with application to continuum mechanics, turbulence, and Einstein's special and general theory of relativity, Springer, 2021
3.	Balakrishnan V., Mathematical physics: Applications and problems, Springer, 2020
4.	Limaye B.V., Functional analysis, New Age International Publishers, 2014
5.	Grinfeld P., Introduction to tensor analysis and the calculus of moving surfaces, New York: Springer, 2013.
6.	Riley K. F., Hobson M. P., and Bence S. J., Mathematical methods for physics and engineering: a comprehensive guide. Cambridge university press, 2006.
7.	Hoffman K. and Kunze R., Linear algebra, PHI, 1991.
8.	Kreyszig E., Introductory functional analysis with applications, John-Wiley & Sons, 1989.
9.	Lang S., Introduction to linear algebra (Undergraduate text in Mathematics), Springer, 1986.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - II, Semester - IV QUANTUM MECHANICS-I PH204	Scheme	L	T	P	Credit
		3	1	0	4

1.	**Course Outcomes:** **At the end of the semester students will be able to**
CO1	Remembering the origin of quantum theory and interpret the wave function properties
CO2	Interpret the Fourier transform and delta functions and their uses in quantum mechanics
CO3	Explain the central potential and utilize it to describe the energy spectrum of hydrogen atom
CO4	Identify symmetries in quantum mechanics and interpret the angular momentum and spin in general
CO5	Apply the Schrödinger's time-independent equation in solving various quantum models
CO6	Apply various quantum mechanical methods for solving many-body problem using time-independent Schrödinger equation.

2.	**Syllabus:**	
	ORIGINS OF QUANTUM THEORY & APPLICATIONS	**(10 Hours)**
	The conceptual aspect, The state vectors, Bra-Ket notation, Hilbert space, Operators, Eigenfunctions, Eigenvalues, Commutation relations, Fourier transform, Kronecker and Dirac delta functions, Interpretation of the wave function, The postulates of quantum mechanics.	
	SCHRÖDINGER EQUATION AND RELATED PROBLEMS	**(10 Hours)**
	Equation of motion, Hamiltonian, Time dependent Schrödinger equation (TDSE), Time-independent Schrödinger equation (TISE), TISE for solving particle in Infinite potential box, Step potential, Potential well, Rectangular potential barrier, Simple Harmonic Oscillator (SHO), etc.	
	CENTRAL POTENTIALS, ANGULAR MOMENTUM AND RADIAL SCHRÖDINGER EQUATION	**(10 Hours)**
	Spherically symmetric potentials, Angular momentum and its components in Spherical coordinate system, Eigenvalues of angular momentum, Spherical harmonics, Atomic orbitals, Reduced Radial Schrödinger Equation, Effective potential, Radial probability density distributions.	
	HYDROGEN ATOM PROBLEM	**(05 Hours)**
	The two-body problem, Solution of Hydrogen atom problem, Energy eigenvalue and eigenfunction, Energy spectrum of Hydrogen atom.	
	IDENTICAL PARTICLES, SPIN AND PAULI EXCLUSION PRINCIPLE	**(04 Hours)**
	The identity of particle, Quantum numbers, Spins and Statistics, Pauli's exclusion principle.	
	QUANTUM MECHANICAL METHODS FOR SOLVING MANY-BODY SYSTEM	**(06 Hours)**
	The Variational principle, 1^{st} and 2^{nd} order time-independent perturbation theory, The WKB approximation.	

Subject Code: ##nXX; ##: Department Identity, n: Year, XX: Subject Sequence number XX: last digit 0 (subject offered in both ODD and EVEN semesters, XX: 01 to 30 – last digit ODD and EVEN for ODD and EVEN semesters (Mandatory Core), XX: 31 to 50 (Optional Core), XX: 51 to 99 (Elective), Subjects list for Minor and Honor (M/H#1-4), Subjects list for Specialization track (#1-4) EG: Engineering Subject, SC: Science Subject (offered combinedly by departments) (SVNIT Surat)

	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials:**
1.	Numerical exercise on various pre-quantum principles and quantum postulates.
2.	Problems related to Braket algebra, Eigenstates and eigenvalues, Operators, The postulates of quantum mechanics, Operators, Commutation relations, Fourier transform, Kronecker and Dirac delta functions.
3.	Numerical exercise on the applications of various quantum models.
4.	Problems based on the angular momentum operators, radial Schrödinger equation, effective potential, etc.
5.	Numerical exercise related to Hydrogen atom problem and applications.
6.	Problem based on Identical Particles, Spin and Pauli Exclusion Principle.
7.	Numerical exercise related to applications of Variational principle.
8.	Numerical exercise related to applications of time-independent perturbation theories.
9.	Problems related to the WKB approximation.

4.	**BOOKS RECOMMENDED:**
1.	Schiff L.I., Quantum Mechanics, McGraw Hill Education, 4th Edition, 2017.
2.	Ghatak A.K. and Loknathan S., Quantum Mechanics: Theory and Applications, Laxmi Publications, 2015.
3.	Zettili N., Quantum Mechanics: Concepts and Applications; Wiley; 3rd Edition, 2022.
4.	Bransden B. H. and Joachain C. J., Quantum Mechanics, Pearson Education; 2nd Edition, 2004.
5.	Mathews P.M. and Venkateshan K., A Text book of Quantum Mechanics; McGraw Hill Education, 2nd Edition, 2017.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - II, Semester - IV Electromagnetic Theory II PH206	Scheme	L	T	P	Credit
		3	0	2	4

1.	**Course Outcomes:** **At the end of the semester students will be able to**
CO1	Build the concept of Maxwell's equations and make use of them to determine the boundary conditions.
CO2	Explain the conservation laws in electrodynamics.
CO3	Demonstrate the propagation characteristics of electromagnetic waves in bounded and unbounded mediums.
CO4	Simplify the Maxwell's equations by writing them in terms of potentials and find out its solutions.
CO5	Analyze the various sources of electromagnetic radiations.
CO6	Summarize the various aspects of electrodynamics from the perspective of relativity.

2.	**Syllabus:**	
	ELECTRODYNAMICS	**(07 Hours)**
	Electromotive force and motional emf, Faraday's law of electromagnetic induction and energy in the magnetic fields, Maxwell's equations, Maxwell's correction in ampere's law, Maxwell's equations in matter, Boundary conditions.	
	CONSERVATION LAWS IN ELECTRODYNAMICS	**(06 Hours)**
	The continuity equation, Poynting's theorem, Newton's third law in electrodynamics, Maxwell's stress tensor, Conservation of momentum and angular momentum	
	ELECTROMAGNETIC WAVES	**(10 Hours)**
	Waves in one dimension, Electromagnetic waves in vacuum and in matter, Absorption and dispersion in matter, Guided waves	
	POTENTIALS AND FIELDS	**(08 Hours)**
	Scalar and vector potentials, Gauge transformations, Coulomb gauge and Lorentz gauge, Retarded potentials, Jefimenko's equations, Lienard-Wiechert potentials, The fields of a moving point charge	
	RADIATION	**(07 Hours)**
	Electric and magnetic dipole radiation, Radiation from an arbitrary source, Power radiated by a point charge, Radiation reaction.	
	ELECTRODYNAMICS AND RELATIVITY	**(07 Hours)**

	Special theory of relativity and relativistic mechanics, Relativistic electrodynamics, Field tensor, Electrodynamics in tensor notation.
	Practicals will be based on the coverage of the above topics separately **(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)

3.	**Practicals**
1.	To determine the reduction factor of the given tangent galvanometer and also to find out the horizontal component of earth's magnetic field.
2.	To study the variation of magnetic field with distance along the axis of a circular coil carrying current.
3.	Hysteresis or BH curve experiment (Magnetic material characterization).
4.	To determine the magnetic susceptibility of a para magnetic material by Quincke's method.
5.	To find the temperature coefficient of resistance of a given coil.
6.	To determine the magnetic moment of a bar and horizontal intensity of earth's magnetic field using a deflection magnetometer.
7.	To determine the reduction factor of the given galvanometer.
8.	To determine the self inductance of the coil using Anderson's bridge.
9.	To experimentally demonstrate the concept of quantization of energy levels according to Bohr's model of atom (Frank- Hertz experiment). **Or** To determine e/m by helical method.
10.	To calculate/determine the permittivity and the permeability of the AIR.

4.	**BOOKS RECOMMENDED:**
1.	David J. Griffiths, Introduction to Electrodynamics, 3rd Edition, Pearson Education, 2008.
2.	John David Jackson, Classical Electrodynamics, 3rd Edition, Wiley, 2018.
3.	Matthew N. O. Sadiku, Elements of Electromagnetics, 6th Edition, Oxford university press, 2014.
4.	L. D. Landau, E. M. Lifshitz, The Classical Theory of Fields, Course of Theoretical Physics: Vol. 2, 3rd Edition, Pergamon Press, 1967.
5.	David K. Cheng, Field and Wave Electromagnetics, 2nd Edition, Pearson Education, 2001.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics) M.Sc. - II, Semester - IV Laser and Photonics PH208	Scheme	L	T	P	Credit
		3	1	0	4

1.	Course Outcomes: At the end of the semester students will be able to
CO1	Explain laser cavities and calculate cavity modes.
CO2	Explain electro-optics and acousto-optic effects and design modulators based on them.
CO3	Identify various light sensing detectors and analyse noise characteristics in measurements.
CO4	Interpret the various non-linear optical effects in materials.
CO5	Analyse various photonic materials and their peculiar properties.
CO6	Analyse various loss mechanisms in optical fiber based light transmissions.

2.	Syllabus:	
	PHYSICS OF LASERS	**(08 Hours)**
	Fundamentals of light-matter interactions, Einstein's coefficients, Laser rate equations, Laser system and its components, Laser modes, Laser beam-parameters and characteristics, Line broadening mechanisms, Cavity modes, Quality factor, Mode selection, Q-switching, Mode locking in lasers, Various types of lasers.	
	LASER MODULATORS	**(07 Hours)**
	Electro-optics (EO) effects, Manifestation of EO effects in KDP, $LiNbO_3$ and $LiTaO_3$, Acousto-optic effect, General considerations on modulator design, Acousto-optics modulators, Raman-Nath and Bragg diffraction, Deflectors, Tunable filters.	
	LIGHT DETECTION AND MEASUREMENTS	**(07 Hours)**
	Detection of optical radiation, Photomultiplier tubes, Semiconductor photodiodes, Avalanche photodiodes, Single photon detectors, Dark current, Thermal noise, Shot noise. Measurement systems, Spectroscopy (Spectral and Temporal measurement systems), CCD, Monochromater, Pulse width measurement.	
	NON-LINEAR OPTICAL EFFECTS	**(08 Hours)**
	Second harmonic generation, Sum and difference frequency generation, Optical parametric amplification, Chirped pulse amplifier, Self-phase modulation, Stimulated Raman scattering, Stimulated Brillouin scattering.	
	PHOTONIC MATERIALS AND DEVICES	**(08 Hours)**
	Optical properties of anisotropic media, Wave refractive index, Liquid crystals, Magneto-optics, Photo refractive materials, Self-focusing and Kerr effect, Basics of holography.	
	OPTICAL FIBER	**(07Hours)**
	Total Internal Reflection and optical fibers, Fiber components, Step index and graded index optical	

	fibers, Light transmission in optical fibers, Losses, Attenuation, Dispersion.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials**
1.	Calculations based on laser rate equations and threshold pump conditions.
2.	Problem based on laser cavity design and modes.
3.	Modulators design problems.
4.	Laser power calculations and problems based on optical power measurements.
5.	Problems based on spectroscopic measurements and noise analysis.
6.	Numerical questions based on the aspects covered in the section of non-linear optics.
7.	Problems based on photonic materials.

4.	**Books Recommended**
1.	Yariv A. and Yeh P., Photonics, 6th Ed., Oxford University Press, 2007.
2.	Ghatak A. and Thyagarajan K., Optical Electronics, Cambridge University Press, 2009.
3.	Saleh B.E.A. and Teich M.C., Fundamentals of Photonics, 2nd Ed., Wiley, 2007.
4.	Silfvast W. T., Laser Fundamentals, 2nd Ed., Cambridge University Press, 2004.
5.	Boyd R.W., Nonlinear Optics, 3rd Ed., Academic Press, 2007.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Second Year of Five Years of Integrated M.Sc. (Physics) M.Sc. II, Semester – IV DATA STRUCTURES CS102	Scheme	L	T	P	Credit
		3	1	2	5

1.	Course Outcomes (COs): At the end of the course, students will be able to
CO1	Recognize the need of different data structures and understand its characteristics.
CO2	Apply different data structures for given problems.
CO3	Design and analyze different data structures, sorting and searching techniques.
CO4	Evaluate data structure operations theoretically and experimentally.
CO5	Solve for complex engineering problems.

2.	Syllabus	
	BASICS OF DATA STRUCTURES	**(02 Hours)**
	Review of Concepts: Information and Meaning, Abstract Data Types, Internal Representation of Primitive Data Structures, Arrays, Strings, Structures, Pointers.	
	LINEAR LISTS	**(06 Hours)**
	Sequential and Linked Representations of Linear Lists, Comparison of Insertion, Deletion and Search Operations for Sequential and Linked Lists, Doubly Linked Lists, Circular Lists, Lists in Standard Template Library (STL), Applications of Lists.	
	STACKS	**(06 Hours)**
	Sequential and Linked Implementations, Representative Applications such as Recursion, Expression Evaluation Viz., Infix, Prefix and Postfix, Parenthesis Matching, Towers of Hanoi, Wire Routing in a Circuit, Finding Path in a Maze.	
	QUEUES	**(06 Hours)**
	Operations of Queues, Circular Queue, Priority Queue, Dequeue, Applications of Queues, Simulation of Time Sharing Operating Systems, Continuous Network Monitoring System Etc.	
	SORTING AND SEARCHING	**(04 Hours)**
	Sorting Methods, Bubble Sort, Selection Sort, Quick Sort, Radix Sort, Bucket Sort, Dictionaries, Hashing, Analysis of Collision Resolution Techniques, Searching Methods, Linear Search, Binary Search, Character Strings and Different String Operations.	
	TREES	**(08 Hours)**
	Binary Trees and Their Properties, Terminology, Sequential and Linked Implementations, Tree Traversal Methods and Algorithms, Complete Binary Trees, General Trees, AVL Trees, Threaded Trees, Arithmetic Expression Evaluation, Infix-Prefix-Postfix Notation Conversion, Heaps as Priority Queues, Heap Implementation, Insertion and Deletion Operations, Heapsort, Heaps in Huffman Coding, Tournament Trees, Bin Packing.	

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	MULTIWAY TREES	**(04 Hours)**
	Issues in Large Dictionaries, M-Way Search Trees, B Trees, Search, Insert and Delete Operations, Height of B-Tree, 2-3 Trees, Sets and Multisets in STL.	
	GRAPHS	**(06 Hours)**
	Definition, Terminology, Directed and Undirected Graphs, Properties, Connectivity in Graphs, Applications, Adjacency Matrix and Linked Adjacency Chains, Graph Traversal, Breadth First and Depth First Traversal, Spanning Trees, Shortest Path and Transitive Closure, Activity Networks, Topological Sort and Critical Paths.	
	Tutorials will be based on the coverage of the above topics separately.	**(14 Hours)**
	Practicals will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 14 Hours + 30 Hours = 89 Hours)	

3.	**Tutorials**
1	Problems on Array
2	Problems on Stack and Queue
3	Problems on Linked List
4	Problems on Trees
5	Problems on Graph

4.	**Practicals**
1	Implementation of Array and its applications
2	Implementation of Stack and its applications
3	Implementation of Queue and its applications
4	Implementation of Link List and its applications
5	Implementation of Trees and its applications
6	Implementation of Graph and its applications
7	Implementation of Hashing function and collision resolution techniques
8	Mini Project (Implementation using above Data Structure

5.	**Books Recommended**
1.	Trembley and Sorenson, An Introduction to Data Structures with Applications, 2nd Edition, Tata McGraw Hill, 1991
2.	Tanenbaum and Augenstein, Data Structures using C and C++, 2nd Edition, Pearson, 2007.
3.	Horowitz and Sahani, Fundamentals of Data Structures in C, 2nd Edition, Silicon Press, 2007.
4.	T. H. Cormen, C. E. Leiserson, and R. L. Rivest, Introduction to Algorithms, 3rd Edition, MIT Press, 2009.
5.	Robert L. Kruse, C. L. Tondo and Brence Leung, Data Structures and Program Design in C, 2nd Edition, Pearson Education, 2001.

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