Course Structure of

Two Year Applied Master of Science

in

Physics

(Session 2019 – 2020 Onward)

Department of Physics

Veer Surendra Sai University of Technology (VSSUT)

Siddhi Vihar, P.O.: Engineering College Burla,

Sambalpur–768018, Odisha, India

www.vssut.ac.in

Vision

The Department of Physics provides a creative and stimulating environment for the education of future generations of scientists and technocrats. The scientific works of faculties are connected with innovative teaching techniques and competitive research. The Department envisaged to create synergy between Science and Technology along with industrial relevance with a mission for motivation towards research and development.

Mission

M1: To impart knowledge of Physics to all classes of people.

M2: To provide interdisciplinary research environment within the institute.

M3: To promote the knowledge of Physics in the frontier areas of Science and Technology by organizing seminars, conferences and refresher courses

Program Outcomes

PO-1. Achieving good knowledge in Physical Sciences, students will be trained to compete various national level tests.

PO-2. Scientific and analytic training for pursuing higher studies in physical and applied Sciences.

PO-3. Theoretical and computational ideas that help to develop experimental skills.

PO-4. Physical approach that would guide in rationalising complex issues of various branches of science.

PO-5. Real time analysis of basic physics at various levels of matter.

PO-6. Develop the logic and ability for circuits and instrumentations.

Program Educational Outcome (PEO)

PEO-1: To provide quality education in Physical Sciences for producing Scientifically and analytically sound students

PEO-2: To prepare the students in taking challenges available both in theoretical and experimental physics for pursuing quality research

PEO-3: To provide enthusiastic environment for students to develop academic, administrative and social capacities and responsibilities

Program Specific Objective (PSO)

PSO-1: Have thorough exposure to improve the knowledge of various branches of physics to address the physical problems with the help of computational and experimental tools.

PSO-2: Excel the numerical, analytical and observation skills by offering group discussions, technical writings and research oriented activities.

Veer Surendra Sai University of Technology, Burla, Odisha
Model Course Structure for two year M. Sc Applied Physics
(Effective from July-2019)

CODE	1st Semester	L-T-P	Credits
MMA01001	Mathematical Methods	3-1-0	4
MPH01001	Classical Mechanics	3-1-0	4
MPH01002	Quantum Mechanics I	3-1-0	4
MPH01003	Electronics and Instrumentation	3-1-0	4
MPH01004	General Practical I	0-0-3	2
MPH01005	Computational Physics Lab	0-0-3	2
	Audit-I	0-2-0	0
	TOTAL CREDIT		20

CODE	2ndSemester	L-T-P	Credits
MPH02001	Quantum Mechanics- II	3-1-0	4
MPH02002	Statistical Mechanics	3-1-0	4
MPH02003	Electrodynamics	3-1-0	4
MPH02004	Atomic, Molecular Physics & Spectroscopy	3-1-0	4
MPH02005	General Practical –II	0-0-3	2
	Workshop Practice / Soft Skill and Professional English	0-0-3	2
	Audit- II	0-2-0	0
	TOTAL CREDIT		20

CODE	3rdSemester	L-T-P	Credits
MPH03001	Condensed Matter Physics	3-1-0	4
MPH03002	Nuclear and Particle Physics	3-1-0	4
	Elective- I	3-1-0	4
	Open Elective	3-1-0	4
	General Practical –III	0-0-3	2
	Technical Writing and Seminar	0-0-3	2
	TOTAL CREDIT		20

CODE	4th Semester	L-T-P	Credits
	Elective – II	3-1-0	4
	Elective–III	3-1-0	4
	Projects	0-0-3	4
	Advanced Experiments	0-0-3	2
	Comprehensive Viva-voce	0-0-0	2
	TOTAL CREDIT		16

Pool of Subjects for Departmental Electives		
Elective-I	**Elective-II**	**Elective- III**
1. Advanced Experimental Techniques 2. Advanced Quantum Mechanics 3. Programming for computational Physics 4. Quantum Information and Measurement 5. Vacuum Technology	1. Introduction to Non-linear Dynamics 2. Particle Physics 3. Physics of Semiconductor Devices 4. Spectroscopy 5. Thin Film Technology	1. Atmospheric Physics 2. Biophysics 3. Crystallography 4. Laser Physics 5.Soft Condensed Matter Physics

Pool of Subjects for Open Elective (For Other Department Students)
1. Elementary Biophysics 2. Medical Physics 3. Radiation Safety 4. Renewable energy and energy harvesting

Elective -I

Sl. No.	Subject Code	Subject
1	MPHPE301	Advanced Experimental Techniques
2	MPHPE302	Advanced Quantum Mechanics
3	MPHPE303	Programming for computational Physics
4	MPHPE304	Quantum Information and Measurement
5	MPHPE305	Vacuum Technology

Elective -II

Sl. No.	Subject Code	Subject
1	MPHPE401	Introduction to Non-linear Dynamics
2	MPHPE402	Particle Physics
3	MPHPE403	Physics of Semiconductor Devices
4	MPHPE404	Spectroscopy
5	MPHPE405	Thin Film Technology

Elective -III

Sl. No.	Subject Code	Subject
1	MPHPE406	Atmospheric Physics
2	MPHPE407	Biophysics
3	MPHPE408	Crystallography
4	MPHPE409	Laser Physics
5	MPHPE410	Soft Condensed Matter Physics

Open Elective

Sl. No.	Subject Code	Subject
1	MPHOE301	Elementary Biophysics
2	MPHOE302	Medical Physics
3	MPHOE303	Radiation Safety
4	MPHOE304	Renewable energy and energy harvesting

Audit:

Sl. No.	Subject
1	English for Research Paper Writing
2	Disaster Management
3	Sanskrit For Technical Knowledge
4	Value Education
5	Constitution of India
6	Pedagogy Studies
7	Stress Management By Yoga
8	Personality Development through Life Enlightenment Skills

Course: M.Sc. (1stSemester)

Subject: MATHEMATICAL METHODS

Course Objectives: Mathematical Physics deals with mathematical concepts, techniques and essential tools for the studies of advanced Physics. The fundamental objective of this course is to provide some of the basic preparatory tools necessary for the study of advanced and fundamental quantum mechanics, advanced electrodynamics, the theories of relativity, spectroscopy and particle physics.

Module-I: Linear Algebra:

Review of Linear vector spaces: span, Basis sets ï Orthogonality and completeness, Quotient spaces and direct sums, Dual spaces , Linear operatorsï functions of operators, Derivatives of operators, Conjugation of operators, Normal operators, Generators, Projection operators, Matrix representations of linear operators, representation of operators under a change of basis, commutators, diagonalisation of matrices with degenerate Eigen values, Normed space, Banach space and Hilbert space, Parseval and Bessel inequalities (no derivation), Reisz-Fischer theorem (no derivation) and Stone-Weirstrass approximation theorem (no derivation) . (7 Lectures)

Module-II: Tensors:

Tensors as multi linear maps, Tensor products, Metric tensor, Contraction and quotient theorems, Cartesian tensors, Tensor calculus: Introduction to manifolds, parametric curves on a manifold: parameterization and arc length, tangent vectors, Tensor fields over a differentiable manifold, Alternating tensors, Kronecker delta and Levi-Civita symbol, Christoffel symbols, differential forms: basic ideas and applications (13 Lectures)

Module-III: Operator theory:

spectral decomposition theory for finite dimensional vector spaces: spectral theorem (results only), Bounded operators in Hilbert space, Compact sets- bounded, Open and closed subsets, Compact operators , Spectral theorem for compact hermitian operators only (no derivation). (6 Lectures)

Module IV: Finite groups: review of basic group theory: equivalence classes, cosets and quotient groups, representation of groups, Schurôs lemmas and the Great orthogonality theorem (no derivation), Applications to find character and character table (6 Lectures)

Module-V: Continuous groups: Lie groups and Lie algebras, Infinitesimal generators: Matrix and operator forms, Irreducible representations of SO(2) and SO(3) groups, Parameters space for SO(3), Orthogonality relations for SO(3), Unitary groups: SU(2), Relations between SU(2) and SO(3), SU(3) (10 lectures)

TEXT AND REFERENCE BOOKS:

1.SadriHassani: Mathematical Physics: A Modern Introduction to Its Foundations, Springer

2. Anadijiban Das: Tensors: The Mathematics of Relativity Theory and Continuum Mechanics, Springer

3. A.W. Joshi: Elements of Group Theory for Physicists

4. V. Balakrishnan, Mathematical Physics with Applications, Problems and Solutions.

5. A Visual Introduction to Differential Forms and Calculus on Manifolds, Jon Pierre Fortney, Birkhauser 2018.

Course Outcomes:

CO1	Master the abstract foundational mathematical concepts of quantum mechanics
CO2	Be aware of rudimentary operator theory
CO3	Gain an usable familiarity with the aspects of the tensor theory that can be subsequently applied in field and relativity theories
CO4	Apply group theory in atomic and molecular spectroscopy
CO5	Be acquainted with the very basics of Lie group theory for its applications

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	3	3	2	2

Course: M.Sc. (1^{st}Semester)
Subject: CLASSICAL MECHANICS

Course Objectives: Classical Mechanics give the idea of the most fundamental of all physical sciences and subsequently relatively modern and challenging topic like chaotic dynamics at advanced level.

Module-I : Review: Application of Newton's Laws and Conservation Laws, Constraints: classification, Lagrangian dynamics: displacements classifications, D'Alemberts principle, Nature of forces of constraints, Virtual velocity, Variations, The fundamental equation of classical mechanics, Nature of given forces, Kinetic energy, The central principle, The principle of Hamilton,
Lagrange's principle of least action, Jacobi's principle of least action, Theory of generalized coordinates, Nature of generalized coordinates, the operator for generalized coordinates,
Fundamental equation in generalized coordinates, generalized potentials, velocity dependent potentials

Module-II:
The dynamical problem, Lagrange's multiplier rule, Derivation of Lagrange's equations from the fundamental equation, Derivation from Hamilton's principle, Hamilton's principle from fundamental equation, Special forms of Lagrange's equations: existence of potential, Holonomic systems, Rayleigh's dissipation function, principle of least action, Hamiltonian formulation: Legendre transformations, Hamilton's equations, Hamilton's equation from Hamilton's principle, Integral in variants of Poincare, Liouville's theorem on phase volume, Poisson brackets, Dynamical systems: Hamiltonian systems, Dissipative systems, Cyclic coordinates and conservation theorems

Module-III:
Canonical transforn1ations, Free canonical transformations, Hamilton Jacobi theory: Hamilton's principal function. Jacobi's complete integral, Time independent Hamilton Jacobi equation, Method of separation of variables, Canonical character of a transformation, Lagrangian brackets, Jacobian matrix of a canonical transformation, Invariance of Poisson brackets under canonical transformation, Symmetry, invariance and Noether's theorem.

Module-IV:
Completely integrable systems. Action angle variables, Canonical transformation to action angle variables, Periodic and quasiperiodic motion, Examples: simple harmonic oscillator and central forces. Liouville's integrability theorem,

Module-V:
Rigid body motion: Orthogonal transformations, Euler angles, Coriolis force, Angular momentum and kinetic energy, Inertia tensor, Euler equations, Theory of small oscillations and normal coordinates

TEXT AND REFERENCE BOOKS:

1. J. H. Goldstein, Poole, Classical Mechanics. Narosa (1985)
2. N.L. Rana and P.S. Joag, Classical Mechanics TMH(1991)

Course Outcomes:

CO1	The conservation principles involving momentum, angular momentum and energy and understand that they follow from the fundamental equations of motion
CO2	Have a deep understanding of Newton's laws
CO3	Students learn about Lagrangian and Hamiltonian formulation of Classical Mechanics
CO4	It give the idea of the most fundamental of all physical sciences and subsequently relatively modern and challenging topic like chaotic dynamics at advanced level
CO5	Kinematics and Dynamics of rigid body in detail and ideas regarding Eulerôs equations of motion

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	3	2	1
CO2	2	3	3	3	2	1
CO3	2	3	3	3	2	1
CO4	2	3	3	3	2	1
CO5	2	3	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2	3	3	3	2	1

Course: M.Sc. (1st Semester)

Subject: QUANTUM MECHANICS-I

Course objectives: Introduces the student to a more mature and formal treatment of quantum mechanics beginning with the concepts of Hilbert space and operators. Recent fields Like quantum information theory and related fields have reemphasized the importance of quantum theory fundamentals in a new light requiring a thorough treatment of advanced fundamentals of quantum mechanics.

Module-I: Fundamental preliminaries: Linear vector space, dimension and basis of a finite dimensional vector space, inner product and normed space, infinite dimensional space and Dirac Delta function, Hilbert space, Dirac notations: Bra and Ket vectors, Schmidt normalization, square integrable functions: wave functions, superposition of quantum states using Mach Zehnder interferometer concept (no description of experiment) , theoretical discussion (no description of experiment) of the Stern-Garlach experiment, Observables and Operators: hermitian and unitary operators, commutators, eigen values and eigenvectors of an operator. Matrix representation of operators, simultaneous diagonalisation of commutating matrices with degenerate eigen values, projection operators, infinite dimensional operators, coordinate and momentum representations and transformations between t (13 Lectures)

Module-II: Symmetries, state evolution and composite quantum states: General view on symmetries and conservation laws, symmetries in quantum mechanics: spatial translation ï continuous and discrete, time translation, parity, time reversal, expectation value of an observable, time evolution, wave packets and propagators, Composite systems, tensor products of states and operators on product spaces, density matrix and reduced density matrix, entangled states: Bell states, (11 Lectures)

Module-III: Quantum dynamics: Schrodinger picture, Heisenberg picture, Heisenberg equation of motion, Ehrenfestös theorem, Interaction picture, Solution of simple harmonic oscillator problem by operator method (6 Lectures)

Module-IV: Schrodinger equation for central potential: Introduction to angular momentum operators and spherical harmonics, Hydrogen atom, power series solution for the radial part, energy quantization and eigenstates (5 Lectures)

Module-V: General theory of angular momentum: J_x, J_y, J_z and J^2 and their commutation relations. Matrix representation of J_+, J_- , J_x, J_y, J_z and J^2 , eigen values and eigen states of J_z, J^2 . and J^2, Spin 1/2 particles, Pauli spin matrices and their properties, rotation operator, addition of angular momenta and C.G. coefficients (8 Lectures)

Course outcomes

On completion of the course a student is expected to have a solid basis on the following aspects

1.Mathematical foundations of quantum mechanics with a proper working knowledge of representations of quantum mechanical operators in finite as well as infinite dimensional Hilbert spaces.

2.Evolution of quantum states and the different ópicturesô of quantum mechanics and the operator formalism used in the harmonic oscillator problem

3.Basic knowledge of composite states and the density matrix formalism, Entanglement and Bell states

4.Concept of angular momentum in a central potential and the solution of the hydrogen atom problem.

5.The general angular momentum theory using operator formalism including spin, combination of angular momenta and C.G. coefficients

TEXT AND REFERENCE BOOKS:

1. Principles of Quantum Mechanics , R Shankar, 2nd Ed. Plenum press 1994.
2. Quantum Mechanics: Concepts and Applications, NouredineZettili ,Wiley, 2009.
3. Modern Quantum Mechanics Revised Edition, J. J. Sakurai, Addison Wesley.
4. Quantum Mechanics Vol. I &II, Claude Cohen-Tannoudji, Bernard Diu, et al., Wiley-VCH.
5. Quantum Mechanics: Fundamentals, Kurt Gottfried and Tung-Mow Yan, Springer.
6.Quantum Computing Explained, David McMahon, Wiley.

COURSE OUTCOMESS:	
CO1	Mathematical foundations of quantum mechanics with a proper working knowledge of representations of quantum mechanical operators in finite as well as infinite dimensional Hilbert spaces.
CO2	Evolution of quantum states and the different ‗pictures' of quantum mechanics and the operator formalism used in the harmonic oscillator problem
CO3	Basic knowledge of composite states and the density matrix formalism, Entanglement and Bell states
CO4	Concept of angular momentum in a central potential and the solution of the hydrogen atom problem
CO5	The general angular momentum theory using operator formalism including spin, combination of angular moment and C.G. coefficients

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	3
CO2	3	3	2	2	3	2
CO3	3	2	1	2	3	2
CO4	3	2	2	2	3	2
CO5	3	3	2	3	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); ñ---ñ: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	3	3	2

Course: M.Sc. (1st Semester)
Subject: ELECTRONICS AND INSTRUMENTATION

Course Objectives: This course provides the basic. power, digital electronic and concepts related to instrumentation which are essential to understand the basic electronic devices

Module-I:Network and Network theorems:

Mesh, node, super mesh and super node analysis circuit analysis (D.C. analysis). Reduction of complicated network, Conversion between T and ⍰-section, Bridged T network, Superposition theorem, Reciprocity theorem, Thevenin's theorem, Norton's theorem, Maximum power-transfer theorem.

Module-II: Power Electronics:

JFET, MOSFET, UJT (Principle, construction, operation with characteristics) Multi vibrator, A stable, Mono stable, Bi stable (Principle, Description and Operation), Wave Shaping Circuits: (i) Linear Wave shaping (using RC circuit), (ii) Non linear wave shaping using (Clipper and Clamper)

Module-III: Operational amplifier:

Differential amplifier (Circuit configuration and properties, ideal operational amplifier input and output impedances) Application of OP-AMP: Inverting amplifier, Non-inverting amplifier. adder, substractor, integrator, differentiator, logarithmic amplifier, comparator (Principle Basic circuit operation and theory)

Module-IV: Digital Electronics:

A/D converter and *D/ A* converter, Microprocessor: Basic concepts of Microprocessor, Microprocessor architecture, qualitative idea on 8085, Read only memory, Random access. Microcontroller: Basic Concepts

Module-V:

Instrumentation: Instrumentation amplifier, Electronic Voltmeters, Ammeters & Multimeter, function Generator

TEXT AND REFERENCE BOOKS:

1. J. Millman and C. C. Halkias, Integrated Electronics, Tata McGraw Hill(1995).
2. A.P. Malvino and D.P. Leach, Digital Principles and Applications, Tata McGraw Hill(1991).
3. Matthew N.0., Sadku, Charles K. Alexander, Fundamentals of Electric Circuits. McGrawHill
4. R. Gaekwad, Op-Amps and Linear Integrated Circuits, Prentice Hall of lndia (1995)
5. R. S. Gaonkar, Microprocessor, Architecture: Programming and Appl. with the 8085, PenramIndia
6. Electronic instrumentation, Tata McGraw Hill, H S Kalsi

Course Outcome: The knowledge of this course is expected to provide the operation of various basic electronic devices, and to understand / fabricate the electronic circuits

Course Outcomes:

CO1	Concept to understand and analyze different electrical circuits.
CO2	To understand the theory, concept and applications of various transistors.
CO3	To understand the theory, concept and application of power electronics.
CO4	To understand the theory and concept computational devices and memory.
CO5	To understand the construction and applications of some basic electronic measurement devices.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	3	2	3	2	2
CO3	3	3	3	3	3	2
CO4	3	3	2	2	3	3
CO5	3	2	2	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	3	3	2

Course: M.Sc. (1stSemester)

Subject: GENERAL PRACTICAL LAB-I

LIST OF EXPERIMENTS:

1. Four probe method for resistivity measurement
2. Measurement of magnetic field and superposition of magnetic field
3. Planckôs Constant by Total Radiation Method
4. e/m by Zeeman effect (FabryParot Etalon)
5. Measurement of voltage and time period of a waveform using CRO
6. Square wave Response of an RC Circuit
7. Dielectric constant of solid by Lecherôs method
8. Determination of Boltzmann constant using PN Junction diode

Course: M.Sc. (1st Semester)
Subject: COMPUTATIONAL PHYSICS LABORATORY

Module-I

Mathematica Fundamentals review

Basic usage with Notebooks, using variables, lists, vectors and matrices, functions, Basic algebraic operations, Immediate versus delayed assignment of values to variables. Substitution, evaluation and delayed evaluation, functions, rudimentary calculus, plotting, data input and output

Module-II

Mathematica basic programming: Loops and conditional do loops in Mathematica with examples, event monitoring using Mathematica

Module-III

Symbolic and numerical solution of algebraic and ODE's and PDE's in Mathematica:

1. Matrix inversion exercises
2. Eigen value and eigen vectors exercises
3. Schmidt orthogonalisation for a given set of vectors
4. Using DSOLVE to solve. Differential equations symbolically and visualizations
   Projectile in 3D space, motion in a gravitational field
5. Using NDSOLVE to solve partial differential equations symbolically and visulations
   Solution of a set of nonlinear ODE for: 2d anharmonic oscillator, Henon-Heiles oscillator
6. Using NDSOLVE to solve Poisson and Laplace equations for electrostatics, Diffusion equations

TEXT AND REFERENCE BOOKS:

1. Numerical Analysis: Timothy Sauer: Pearson Education (2006)
2. Paul Wellin, Programming with Mathematica: An Introduction: Cambridge University Press(2013).

Course: M.Sc. (2nd Semester)
Subject: QUANTUM MECHANICS-II

Course Objectives: This course helps to comprehend (a) some basic theories, (b) its applications, and the treatment for complex atoms. (c) The scattering theory is introduced to understand the advanced problems in physics.

Module-I: Time independent Perturbation Theory: Non-degenerate and Degenerate Cases, Applications: Zeeman and Stark effects. Time Dependent Perturbation Theory, Probability of state, Sinusoidal Perturbation, Fermiộs Golden rule, Einsteinộs transition probabilities.

Module-II: Variation method, Variation integral and its properties, Application to state of the Helium atom, WKB approximation, turning points, connection formulae, Applications of WKB. Bohr-Somerfield quantization condition.

Module-III: The spinning electron, The Helium atom, The Configurations 1s2s, 1s2p, The consideration of electron spin - Pauli exclusion principle, The accurate treatment of normal helium atom, Excited states of helium atom.

Module-IV: Slaterộs treatment of complex atoms: Exchange degeneracy, spatial degeneracy, Factorization and solution of secular equation, The Method of Self-consistent Field (SCF), Relation of the SCF method to the variation principle.

Module-V: Scattering Theory: Born Approximation, scattering cross section, Greenộs function, scattering from square well, screened coulomb potential, Yukawa potential, Partial Wave analysis, Born-Oppenheim Approximation, Hydrogen molecule ion problem.

TEXT AND REFERENCE BOOKS:
1. S. Gasiorowicz, Quantum Physics, John Wiley (Asia) (2000).
2. P. Atkins, Molecular Quantum Mechanics, Oxford University Press (2005).
3. P. W. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata Mc-Graw Hill (1995).
4. F. Schwabl, Quantum Mechanics, Narosa (1998).
5. Satyaprakash, Advanced Quantum Mechanics, Kedar Nath Ram Nath (2010).
6. L. I. Schiff, Quantum Mechanics, Mcgraw-Hill (1968).
7. B. H. Bransden and C. J. Joachain, Introduction to Quantum Mechanics, Longman (1993)
8. L. Pauling, and E. B. Wilson, Quantum Mechanics: With Applications to Chemistry, Mc-Graw Hill, New York (1935).
9.N. Zettili, Quantum Mechanics - Concepts and Applications 2nd edition, 2009.

Course Outcomes:

CO1	The treatment of many physical problems with advanced theories, and approximation techniques are expected to provide solution for various problems in sciences.
CO2	This course helps to comprehend some basic theories and its applications.
CO3	The treatment for ground and excited levels of atoms is understood
CO4	The scattering theory offers understanding of advanced problems in physics.
CO5	The relativistic and real time analysis of quantum mechanical systems is introduced.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	3	2	1
CO2	2	3	3	3	2	1
CO3	2	3	3	3	2	1
CO4	2	3	3	3	2	1
CO5	2	3	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2	3	3	3	2	1

Course: M.Sc. (2^{nd}Semester)
Subject: STATISTICAL MECHANICS

Course Objectives: The course objectives are, first, to explain the foundations of statistical mechanics and, second, to work through most of the classic examples of statistical mechanics, as well as some current ones. At the end of the course, the student will be able to tackle the statistical mechanics questions that come up in all areas of experimental and theoretical physics.

Module-I: Review of Thermodynamics: Laws of thermodynamics, entropy, potentials.
Statistical Thermodynamics: Macroscopic and microscopic states, Postulates of statistical mechanics, Connection between statistics and thermodynamics, Classical ideal gas, Entropy of mixing and Gibb's paradox (8 Lectures)

Module-II: Ensemble Theory: Phase space, Liouville's theorem, Micro canonical ensemble: examples, **Canonical Ensemble**: Partition function, classical ideal gas, Energy fluctuation, Equipartition and virial theorem, Harmonic oscillators, statistics of Para-magnetism, Grand Canonical Ensemble: Partition function, density fluctuation, correspondence with other ensembles (10 Lectures)

Module-III: Formulation of Quantum Statistics: Density Matrix, Ensembles in quantum statistical mechanics, Maxwell-Boltzmann, Fermi-Dirac and. Bose-Einstein distribution, examples: free particle in a box, harmonic oscillator (10 Lectures)

Module–IV: **Ideal Bose Gas:** Thermodynamics, Bose-Einstein condensation, Phonons Ideal Fermi Gas: Thermodynamics, Theory of White dwarfs (8 Lectures)

Module-V: **Phase Transition**: Thermodynamics of phase transition, phase transition of second kind, Paramagnetic and Ferromagnetic Phasetransition, Discontinuity in specific heat
Ising Model: Definition of Ising model, one dimensional Ising model (6 Lectures)

TEXT AND REFERENCE BOOKS:
1. R.K.Pathria, Statistical Mechanics, Butter worth-Heinemann (1996).
2. K.Huang, Statistical Mechanic, John Wiley Asia (2000).
3. F. Reif, Statistical and Thermal Physics, McGraw-Hill (1985).
4.W. Greiner, LNeise, and H. Stocker, Thermo dynamics and Statistical Mechanics, Springer.
5.L. D. Landau and E. M. Lifshitz, Statistical Physic-I, Pergamon (1980).

COURSE OUTCOMESS:	
CO1	Describe the laws of thermodynamics from both a macroscopic and microscopic point of view. Concept of phase space and density distribution.
CO2	Identify and solve the problems in statistical mechanics using ensemble theory.
CO3	Understand the quantum mechanical formulation of statistical mechanics. Knowledge of different kinds of distribution functions depending on particle nature.
CO4	Describe the differences between systems of bosons, fermions and classical gases from microscopic consideration. Detailed study of Boson gas and Fermion gas.
CO5	Explain phase transitions and magnetization, Knowledge of Ising Model

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	3
CO2	3	3	1	2	3	2
CO3	3	3	2	2	3	3
CO4	3	3	2	3	3	3
CO5	3	3	3	3	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); ñ---ñ: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	2.6	3	2.8

Course: M.Sc. (2^{nd}Semester)
Subject: ELECTRODYNAMICS

Course Objectives: Introduces advanced electrodynamics beginning with dispersion theory. Subsequently this course aims to put the study of electrodynamics in the context of the four dimensional Minkowski space (flat manifold) using special theory of relativity. This is essential as it is the special theory of relativity that truly unified the electric and magnetic fields as manifestations of a single entity. This is carried out by using the concept of tensor fields. This in turn empowers the students to study electrodynamics phenomena in a general and consistent manner finally acquainting himself with field theoretic concepts.

Module-I

Dispersion: Normal and Anomalous Dispersion, Dispersion in non-conductors, Frequency dependence of permittivity, Kramers-Kronig relations, Cauchyĝs formula. (5 Lectures)

Module -II

Radiation: Radiation from localized oscillating charges, Near and far zone fields, Multi pole expansion, dipole and quadruple radiation, Centre fed linear antenna, Radiation from an accelerated point charge. Lienard-Wiechart potentials. Power radiated by a point charge: Lienard's formula and its non relativistic limit (Larmor's formula). Angular distribution of radiated power for linearly and circularly accelerated charges. (15 Lectures)

Module-III

Relativistic, Charged Particle Dynamics in Electromagnetic Fields: Motion in uniform static electric and magnetic fields, crossed electric and magnetic fields. (6 Lectures)

Module -IV

Review of Maxwell's equation and Special theory of relativity: Gauge transformations: Coulomb and Lorentz gauges, need for special theory of relativity, Tensor fields, Lorentz transformation as Four vector transformation: velocity, acceleration and force in Minkowski flat manifold, application to electromagnetic theory: ·relation between electric and magnetic fields, transformation of electric and magnetic fields, E.M. field tensors, Covariance of Maxwell's equations (14 Lectures)

Module-V

Lagrangian formulation of Electrodynamics

Lagrangian for a free relativistic particle, for a charged particle in an E M field, Energy momentum tensor and related conservation laws (5 Lectures)

TEXT AND REFERENCE BOOKS:

1. J. D. Jackson, Classical Electrodynamics, John Wiley (Asia) (1999).
2. W. Panofsky and M. Philips, Classical Electricity and Magnetism, Dover Publications

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Capable of handling tensor applications in electrodynamics in the relativistic formalism.
CO2	A depth in handling dynamics of charged particles under various field configurations
CO3	Conversant with classical dispersion theory
CO4	Able to tackle radiation problems for various time varying charge and current distributions
CO5	Acquainted with the rudiments of the field theoretic formulation of electrodynamics

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Course: M.Sc. (2nd Semester)
Subject: ATOMICAND MOLECULAR PHYSICS

Course Objectives:
The course deals principally with atomic structure and the interaction between atoms and fields. Further, it deals with the binding of atoms into molecules, molecular degrees of freedom (electronic, vibrational, and rotational), elementary group theory considerations and molecular spectroscopy.

Module-I:
Quantum state of one electron atoms, Magnetic Dipole moments, Electron Spin, Vector model of atom, Stern Gerlach Experiment, Spin-Orbit Interaction, Hydrogen Fine structure, Pauli's principle: identical particle, Formulation of Pauli's exclusion principle, Slater Determinant.

Module-II:
Central Field Approximation, Atomic orbital and Hund's rule, interaction energy in LS and JJ coupling, Selection rules, Spectra of alkali elements, Spin orbit interaction and fine structure in alkali spectra

Module-III:
Normal and anomalous Zeeman effect-Paschen Back effect-Stark effect, Hyper fine Structure of Spectral lines, The Breadth of Spectral lines, Fine-structure of x-ray emission spectra

Module-IV:
The Born-Oppenheimer Approximation, Types of Molecular Spectra, Types of Molecular Energy states and associated spectra, Pure rotational: Explanation of rotational spectra on the basis of rigid rotator, Vibrational-Rotational spectra: Molecule as harmonic Oscillator, an harmonic Oscillator and vibrating rotator, Diatomic molecule as symmetric top, Thermal distribution of Vibrational and rotational levels

Module-V:
Experimental arrangement, Quantum theory of Raman effect, Raman spectra as molecular spectra, IR versus Raman Spectra, Formation of Electronic spectra, Electronic band spectra in absorption, fine structure, rotational structure of three-branch bands, Frank-Condon Principle, Quantum mechanical formulation of Frank-Condon principle, Intensity distribution in emission and absorption bands. Isotope effect of electronic spectra.

TEXT AND REFERENCE BOOKS:

1. Atomic and Molecular Spectra: Laser by Rajkumar
2. Introduction to atomic spectra- H. E. White
3. Physics of atoms and Molecules-B. H. Bransden and C. J. Joachain
4. Spectroscopy Vol. I, II, III- Walker & Straughen.
5. Introduction of molecular spectroscopy-G. M. Barrow.
6. Spectra of atoms and molecules-P. F. Bernath.
7. Modern spectroscopy-J. M. Holias
8. Spectra of diatomic molecules- Herzberg
9. Fundamentals of molecular spectroscopy-C. B. Benwell
10. Molecular spectroscopy Jeanne L Michele
11. Molecular spectroscopy- J. M. Brown.

Course Outcomes:

CO1	The basic atomic model for one electron atom can be extended to many electrons atoms as well as molecules.
CO2	The different types of coupling and fine structure of spectra give an insight to deal with complex spectra.
CO3	The study of experimentally observed phenomena theoretically provides a critical understanding for further studies in physics.
CO4	The basic idea behind molecular spectra through the application of quantum mechanics provides prerequisite for experimental study.
CO5	The study of different spectra can be helpful to deal with higher research problems of Physics.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	3	2	3	3	2	2
CO3	3	3	2	3	3	2
CO4	3	3	2	3	2	2
CO5	3	2	3	3	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	3	3	2	2

Course: M.Sc. (2nd Semester)
Subject: GENERAL PRACTICAL –II

LIST OF EXPERIMENTS:

1. Determination of Planckõs constant using Photoelectric Effect
2. Frank-Hertz Experiment
3. e/m by Thompsonõs method
4. To determine the resistance and inductance of the given unknown inductor by Maxwell's L/C bridge
5. Determination of Boltzmann Constant using I-V Characteristics of p-n diode
6. Non-Destructive Testing ï Ultrasonic
7. Transistor characteristics (CE, CB and CC modes)
8. Study of solid state power supply for He ï Ne Laser
9. e/m by Milliken oil drop method
10. Magnetic Susceptibility of a Paramagnetic Liquid

Course: M.Sc. (3rd Semester)
Subject: CONDENSED MATTER PHYSICS

Course Objectives:
1. To provide understanding of the entity of a material along with their properties and behaviour.
2. This also gives idea about tailoring the properties of the material for different device applications.
3. An attempt may be made to link condensed matter physics with other branches of physics.

Module-I: Properties of Metallic Lattices
The structure of metals, Defects in crystals; Point and line defects, Lattice defects and configurational entropy, Number of vacancies and interstitials as a function of temperature, Formation of lattice defects in metals, The interpretation of slip, dislocations: Edge and screw dislocations, Interaction between dislocations, Estimates of dislocation densities, The Frank-Read mechanism of dislocation multiplications. (9 Lectures)

Module-II: Ferroelectric Materials
General properties of ferroelectrics, Classification and Properties of representative ferroelectrics, Piezeo, pyro electric effects, Electrostrictive effect, Dipole theory of ferroelectricity and its objections, Ionic displacements and theory of spontaneous polarization, Thermodynamics of ferroelectric transitions, Ferroelectric domains. (7 Lectures)

Module-III: Conductivity of Metals
Features of the electrical conductivity of metals, A simple model leading to a steady state; drift velocity and relaxation time, The Boltzmann transport equation, The electrical conductivity at low temperatures, The thermal conductivity of insulators, The thermal conductivity of metals, The Hall effect in metals (7 Lectures)

Module-IV: Soft Condensed Matter Physics
Perturbations of crystalline order: Weak and strong perturbations, Disordered crystal mesophases, ordered fluid meso phases, Types of liquid crystals, Classification according to molecular order, Polymorphism, Structural features of meso phases, Symmetry and order parameter, mean field theory of nematic liquid crystals, Polarizing microscope (8 Lectures)

Module-V: Physics of Phase Transitions
Introduction, Classification of phase transitions, Thermodynamic stability, Positive response function and convexity of free energy, Continuous phase transitions and its link to critical phenomena, The Ising Model: 1D, 2D, and 3D, Transitions with a change in structure, Transitions with no change in structure, Non-Equilibrium transitions (9 Lectures)

Reference Books:

1. A. J. Dekker, Solid State Physics, Macmillan & Co, Ltd, 1952.
2. S. Chandrasekhar, Liquid Crystals, 2nd Edition, Cambridge University Press, 1992.
3. M. Gitterman, V. Halpern, Phase Transitions: A Brief Account with Modern Applications, World Scientific Publishing Ltd. Singapore, 2004.
4. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.

Course Outcomes:

CO1	The understanding of the entity of a material along with their properties and behavior.
CO2	Provides an idea about tailoring the properties of the material for different device applications.
CO3	An attempt may be made to link condensed matter physics with other branches of physics.
CO4	Theoretical interpretation provides a basis for and experimental investigations.
CO5	Formalism and methodology for in-depth analysis of condensed matter.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	2	2	1
CO2	2	3	2	2	2	1
CO3	2	3	2	2	2	1
CO4	2	3	2	2	2	1
CO5	2	3	2	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2	3	2	2	2	1

Course: M.Sc. (3^{rd} Semester)
Subject: NUCLEAR AND PARTICLE PHYSICS

Course objectives

To understand the basic idea about the properties of nuclear force. To provide an ability to construct the elementary idea to solve the fundamental problems of nuclear physics. To discuss the theoretical aspects of two-nucleon problem with both in bound and scattering states which can be exploited to explain in line with the experimental observations.

MODULE-I: BASIC IDEA ABOUT NUCLEI

Nuclear radius, mirror nuclei method for determination of nuclear radius, Nuclear density (mass density, Nucleon number density), spin, magnetic moment, Quadrupole moment, Mass defect, binding energy, semi empirical mass formula and its application (Mass parabola; prediction of stability of nuclei against beta decay)

MODULE-II: NUCLEAR SHELL MODEL

Magic number.Evidences of shell model, extreme particle shell model with square-well and harmonic oscillator potentials, spin-orbit coupling, determination of total angular momentum, parity, magnetic moment of nuclei using shell model.

MODULE-III: TWO - NUCLEON PROBLEM

Ground state of deuteron, depth and range of relation, non-existence of excited state of deuteron, low energy n-p scattering, scattering length, spin dependence on n-p scattering, effective range theory for n-p scattering, p-p scattering, charge invariance of nuclear force, effective range theory for p-p scattering.

MODULE-IV: RADIO ACTIVITY

Alpha decay, range of alpha particles, range-·energy relation for alpha particles ,Gieger-Nuttal law, Gamow theory of alpha decay.

Beta decay, Pauli-neutrino hypothesis, Fermi theory of beta decay, kurie plot

MODULE–V: NUCLEAR REACTION

Nuclear reaction, Q-Value of reaction, Derivation of reaction cross-section, optical theorem, Shadow scattering, Compound Nucleus model (Bohr Theory), Resonance, Breit-Wigner dispersion formula for l=O, optical model, Nuclear Fission, Nuclear fusion.

References

1. Theory of Nuclear Structure: M. K. Pal (East-West Press, New Delhi)1982.
2. Nuclear Physics: Theory and Experiments by R. R. Roy and B. P. Nigam (New Age, New Delhi)2005
3. Basic Ideas and Concepts in Nuclear Physics by K. Hyde (Institute of Physics) 2004.
4. Concepts of Nuclear Physics by B. L. Cohen (Tata Mc Graw Hill),2004.
5. Nuclear physics: Experimental and Theoretical, H. S. Hans (New Academic Science) 2nd ed 201l.
6. Introductory Nuclear Physics: By K S Krane (John Wiley) 1988.
7. Theoretical Nuclear Physics by J M Blattand Victor F Wefaskopf (Springer-Verlag, NewYork) 1979.

Course Outcomes:

CO1	Basic idea about nuclear physics leads to the advanced studies in nuclear reaction and generation of nuclear energy through nuclear reactor.
CO2	The nuclear observables can be used to study higher nuclear phenomena both theoretically and experimentally.
CO3	The idea behind two-nucleon problem can be extended to many body problem and advanced learning in high energy physics.
CO4	The concept of radio activities can be exploited to apply various in various field of modern technology.
CO5	The concept of nuclear reaction can used to study the energy formation in stellar system.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	3	2	3	3	2	2
CO3	3	3	2	3	3	2
CO4	3	3	2	3	2	2
CO5	3	2	3	3	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	3	3	2	2

Course: M.Sc. (3rd Semester) ELECTIVE PAPER –I

Subject: To be offered by the Department from the following pool of subjects

Pool of Subjects for Departmental Electives-I
1. Advanced Experimental Techniques
2. Advanced Quantum Mechanics
3. Programming for computational Physics
4. Quantum Information and Measurement
5. Vacuum Technology

Course: M.Sc. (3^{rd}Semester) (ELECTIVE- I-1)

Subject: ADVANCED EXPERIMENTAL TECHNIQUES

Module-I: Radiation Sources, Detectors and Sensors
Sources of Electromagnetic Radiations: Different types of radiations (X - rays, UV-VIS, IR, microwaves and nuclear) and their sources.
Detectors: X-rays, UV-VIS, IR, microwaves and nuclear detectors
Sensors: Sensorôs characteristics, Classification of sensors, Operation principles of sensors, Resistive, capacitive, inductive, electromagnetic, thermoelectric, elastic, piezoelectric, piezoresistive, photosensitive and electrochemical sensors. (13 Lectures)

Module-II: Structural Characterization -X-ray Diffraction ï Production of X-rays, Types (continuous and characteristics), Braggôs diffraction principle, Techniques used for XRD ï Laueôs method, Rotating crystal method, Powder (Debye Scherrer) method, Derivation of Scherrer formula for size determination, Neutron Diffraction: Principle, Instrumentation and Working (7 Lectures)

Module-III A: Thermal Analysis-Thermal analysis: Principle, Instrumentation and Working: Thermo-gravimetric (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC); Graphical analysis affecting various factors. (4 Lectures)
Module-III B: Spectroscopic characterization (principle, instrumentation and working): Infra Red (IR), Fourier Transform Infra-Red (FTIR), Ultraviolet-Visible (UV-VIS), Diffused Reflectance Spectroscopy (DRS), X-ray Absorption (XPS), Electron Spin Resonance (ESR). (4 Lectures)

Module-IV: Microscopic techniques: Optical Microscopy: Principle, Instrumentation and Working of optical microscopes, Electron Microscopy: Principle, Instrumentation and Working of Scanning Electron Microscope (SEM), Field Emission Scanning Electron Microscope (FESEM), Transmission Electron Microscope(TEM), Scanning Tunneling Microscope(STM) and Atomic Force Microscope(AFM). (6 Lectures)

Module-V: Electrical and Magnetic Characterization-Electrical characterization: Measurement of resistivity by four-probe method, Impedance and ferroelectric measurements.
Magnetic Characterization: Principle, Instrumentation and Working of Vibrating Sample Magnetometer (VSM), Analysis of Hysteresis loop, SQUID Technique: Principle, Instrumentation and Working. (6 Lectures)

TEXT AND REFERENCE BOOKS:
1. Experimental Physics: Modern Methods by R. A. Dunlap (1997 Ed.) ï Oxford University Press
2. Instrumentation: Devices and Systems, C.S. Rangan, G.R. Sarma and V.S.V. Mani, Tata Mc Graw Hill Publishing Co. Ltd.
3. Instrumental Methods of Chemical Analysis, G. Chatwal and S. Anand, Himalaya Publishing House
4. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt, J.A. Dean, CBS Publishers
5. Characterization of Materials, John B. Wachtman & Zwi. H. Kalman, Pub. Butterworth Heinemann
6. Elements of X-ray diffraction, Bernard Dennis Cullity, Stuart R. Stock, (Printice Hall, 2001

Course Outcomes:

CO1	Have demonstrated sufficient skills on the instrument, both in theory and in practice, to keep the instrument in good shape
CO2	Be able to communicate the technique on an advanced research level to fellow researchers
CO3	Be able to coordinate/administrate the use of the technique/instrument in a research organization Be able to coordinate/administrate the use of the technique/instrument in a research organization Be able to coordinate/administrate the use of the technique/instrument in a research organization
CO4	Have gained a clear understanding of different vacuum pumps and the production and maintenance of vacuum systems and its uses and needs in Physics
CO5	Have grasped the idea of Cryogenics technology and its applications

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Course: M.Sc. (3^{rd}Semester) (ELECTIVE- I-2)
Subject: ADVANCED QUANTUM MECHANICS

Course Objectives:

1. To understand the various applications of quantum mechanics
2. To impart knowledge of advanced quantum mechanics for solving relevant physical problems
3. To understand the world of quantum field theory, and quantum electrodynamics.

Module-I: Relativistic Quantum Mechanics

Introduction, Klein-Gordon (KG) equation, current and probable density (continuity equation), KG equation in electromagnetic field, Diracọs relativistic equation, covariant and adjoint forms of Dirac equation, Spin-orbit energy, Negative energy states of electron.

Module-II: Quantization of Fields

Introduction, Relativistic Lagrangian and Hamiltonian of a charged particle in an EM field, Lagrangian and Hamiltonian formulations of field, Quantum equation for the field, Second quantization, Quantization of KG equation, Creation, Annihilation and number operators, Occupation number representation.

Module-III: Quantum Field theory

Canonical quantisation, Free propagators Quantization of fields, Real and charged scalars Second quantisation of real scalar field, Second quantisation of complex scalar field, Second quantisation of Dirac field, Second quantisation of Electromagnetic fields

Module-IV: Quantum Electrodynamics

Nonlinear Lagrangians, Fermions in an External Field, Interaction of Electrons with the Radiation Field: Quantum Electrodynamics (QED): The Lagrangian and the Hamiltonian Densities, Equations of Motion of Interacting Dirac and Radiation Fields.

Module-V: Interaction

Coupling of electron and electromagnetic field, The Interaction Representation (Dirac Representation), Wickọs Theorem, Feynman Diagrams and Rules of Quantum Electrodynamics

TEXT AND REFERENCE BOOKS:

1. J.J. Sakurai, Modern Quantum Mechanics, Addison-Wesley (2011)
2. G. Baym, Lectures on Quantum Mechanics, Benjamin/Cummings (1973)
3. F. Schwabl, Quantum Mechanics, Springer (1990)
4. D.J. Griffiths, Introduction to Quantum Mechanics, Pearson (2005)
5. Satyaprakash, Advanced Quantum Mechanics, Kedar Nath Ram Nath (2010).
6. **W. Greiner, J. Reinhardt**, Quantum Electrodynamics, Springer-Verlag, Berlin (2009).
7. J. D. Bjorken, S. D. Drell, Relativistic Quantum Mechanics, McGraw Hill (1978).

Course Outcomes:

CO1	Understanding of various applications of quantum mechanics
CO2	Knowledge of advanced quantum mechanics for solving relevant physical problems
CO3	Concepts of quantum field theory and quantum electrodynamics are explored.
CO4	Learners are expected to identify, understand, design, set up, and carry out the various physical phenomena to provide the theoretical predictions using advanced quantum mechanics.
CO5	Implementation of theoretical formalism for real time physical problems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	1
CO2	3	2	3	2	2	1
CO3	3	2	3	2	2	1
CO4	3	2	3	2	2	1
CO5	3	2	3	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	3	2	2	1

Course: M.Sc. (3rdSemester) (ELECTIVE-I-3)
Subject: PROGRAMMING FOR COMPUTATIONAL PHYSICS

Course Objective: Computational physics makes use of different programming languages as well as packages to reach its goal. In this course the student is introduced to the venerable Fortran 90 language which is still going strong in Physics research activities and acquaints oneself with the store house of subroutines available for scientific calculations. Recently however Python has become very popular with the physics community and the student is also exposed to Python programming so that he can make his choice depending on the problem at hand.

Module I: Introduction to Fortran 90: Basic structure of a Fortran 90 program: variables, Assignment statements, list directed input and output, Data types: Real, Integer, Character, Complex, Derived data types, control structures: branches, do loops, conditional do loops, array variables

Module II: Procedures and Structured Programming: Subroutines, Statement, Modules, sharing data using Modules, Module Procedures, Passing Procedures as Arguments to other Procedures, Internal Procedures, Scope and Scoping units, Recursive Procedures

Module III: Introduction to Python: Introduction to Python tools and libraries NumPy, Matplotlib, SciPy, f2Py Elementary Python programs, data types, conditionals and do loops, working examples of simple Python programs, ·

Module IV: Python libraries: using Num Py for fast numerical calculations, use of Matplotlib for visualization, f2Py for porting Fortran codes to Python, array manipulation in Python, data handling in Python

Module V: Programming examples: ODE applications using Fortran 90 and/or Python for Eigen values, projectiles, scattering, nonlinear dynamics problems, PDE examples in electrostatics and wave equations, molecular dynamics.

TEXT AND REFERENCE BOOKS:

1. Fortran 95/2003 for Scientists & Engineers, Stephen Chapman, McGraw -Hill.
2. Computational Physics Problem Solving using Python: R. H. Landau, M. J. *Paez*and C. C. Bordeianu, Wiley-VCH

Course Learning outcomes

1. A student who has taken this course will be able to carry out scientific programming to solve Physics problems on his/her own.
2. The portability of Fortran to Python will allow him/ her to successfully use the large store of legacy codes in Fortran in his Python programming effectively extending his programming scope.
3. Most importantly the student will gain a wider perspective being able to choose his tool best suited to the problem at hand.

Course Outcomes:

CO1	The student will be aware of basic Fortran90 for solving simple programming problems
CO2	Fortran programs for real life computational physics problem will require competence in using subroutines and incorporating them as and when required
CO3	Basic facility in the Python programming will attained
CO4	Python programming skills to solve computational physics problems will be acquired along with linking Fortran programs with python subprograms to enable computations
CO5	Certain real life problems will be addressed using the Fortran90 and Python programs

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	1
CO2	2	3	3	3	2	1
CO3	3	3	3	3	2	1
CO4	2	3	3	3	2	1
CO5	2	3	2	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2.4	3.0	3.0	3.0	2.0	1.0

Course: M.Sc. (3^{rd}Semester) (ELECTIVE-I-4)
Subject: QUANTUM INFORMATION AND MEASUREMENT

Module-I

Probability and information, the double slit experiment, Interference and information: Feynmanôs rules for interference, MZI and superposition, qubits,

Module -II

Which way information and complimentarity, quantum erasers and, interaction free measurement, density matrices and reduced density matrices, Schmidt decomposition, entanglement in bipartite systems, decoherence, Von Neumann measurements and back-action, pointer states, superselection rules, envariance

Module-III

Bell states, EPR experiments, quantum error correction, ñno cloningò theorem, dense coding , teleportation, GHZ states, POVMs, non-orthogonal state discrimination, tomography and quantum states.

Module–IV Quantum logic circuits: single quibit and two quibit gates, universal quantum gates, realization of simple algorithms and experiments using quantum gates.

Module-V

IBM- Q quantum computer and its use to carry out quantum state manipulations to demonstrate superposition, entanglement, envariance.

TEXT AND REFERENCE BOOKS:

1.A first Introduction to Quantum Computing and Information- Bernard Zygelman-Springer (2018)

2. Quantum Computing Explained-Wiley-Inter science, David McMahon- ,IEEE Computer Society (2008)

3. Quantum Measurement Theory and its Applications, Kurt Jacobs, C.U.P, 2014

4. Quantum information, Stephen M. Barnett, Oxford University Press, 2008

5. Decoherence and the Quantum-to-Classical Transition, Maximilian A. Schlosshauer- (The Frontiers Collection) Springer (2007)

6. Quantum Computing A Gentle Introduction-(Scientific and Engineering Computation), Eleanor Rieffel, Wolfgang Polak-The MIT Press (2011)

Course Outcomes:

CO1	Understand quantum information theory, quantum computation, quantum cryptography and related topics
CO2	Understand density operators, quantum superposition, entanglement, nonlocality, teleportation
CO3	Understand quantum channels, quantum algorithms, measurement theory, Bell inequalities, no-cloning theorems
CO4	Familiarity with quantum graph states, topological quantum computation
CO5	Aware of some state-of-the-art physical implementations

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Course: M.Sc. (3rdSemester) (ELECTIVE-I-5)

Subject: VACUUM TECHNOLOGY

Module-I

Introduction to vacuum technology, kinetic theory of gases, impingement rate of molecules on a surface, average velocity of gas and mean free path, gas transport properties (thermal conductivity, viscosity and diffusion), various ranges of vacuum, gas conductance of a vacuum line, gas impedance of a vacuum line, pumping speed, flow of gases through apertures, elbows, tubes etc. for viscous and molecular flow regimes, pump down time. (8 Lectures)

Module-II

Vacuum generation (Pumps): Principles of pumping concept, Diaphragm pump, Rotary Vane pump, Turbo molecular pump, Diffusion pump, Cryopump, Getter pump, Sputter ion pump, Orbitron pump. (10 Lectures)

Module-III

Vacuum Gauges: Mc Leod, Thermocouple (Pirani), Penning, Hot cathode ionization (triode type), Bayard-Alpert Leak detection, Vacuum system design. (8 Lectures)

Module-IV

Low temperatures techniques: Refrigeration principle (including thermodynamical aspects) and low temperature production techniques (Throttling process). (4 Lectures)

Module-V

Analysis of gas at low pressures: Residual gas analyzers, Quadrupole mass spectrometer. Leaks and their detection: Types of leaks, Leak rate, leak size, mass flow; Leak detection methods: Pressure rise and drop tests, Tests using vacuum gauges, Bubble immersion test, Foam-spray test, Halogen and Helium leak detectors. Applications of Vacuum technology. (10 Lectures)

TEXT AND REFERENCE BOOKS:

1. Hand Book of Thin Film Technology, Maissel and Glange
2. Vacuum Physics and Techniques, T. A. Delchar, Chapman and Hall
3. Vacuum Technology, A. Roth, (North Holland, Elsevier Science B.V. 1990)
4. High Vacuum Techniques, J. Yarwood, (Chapman and Hall, Londong, 1967)
5. Experimental Principles and Methods below 1K, O. U. Lounasmaa, (Academic Press, 1974)
6. Thermometry at Ultra Low Temperatures, W. Weyhmann

Course Outcomes:

CO1	Apply basic vacuum principles such as the behavior of gas and behavior of a vacuum system while evaluating a pump down.
CO2	Consider basic mechanisms and characteristics of vacuum system components such as pumps, valves and gauges while troubleshooting.
CO3	Be able to perform basic operations of a vacuum system such as measuring pressure correctly, venting a vacuum system, a rough pump down and a high vacuum pump down with correct valving sequence.
CO4	Be able to perform simple maintenance of vacuum systems including installation or replacement of various pipes, fittings, valves, gauges, and simple pumps.
CO5	Be able to perform vacuum trouble-shooting including leak isolation and detection.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	3	2	3	3	3
CO3	3	2	2	3	3	2
CO4	3	3	3	2	2	2
CO5	2	3	2	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	3	3	3

Course: M.Sc. (3rd Semester)

Subject: GENERAL PRACTICAL – III

LIST OF EXPERIMENTS:

1. Geiger-Muller counter
2. Specific heat measurement of solids (calorimetry)
3. Hydrogen Spectra and Rydberg Constant
4. Energy band gap of a semiconductor using diode
5. ESR (Electron spin resonance)
6. Determination of Stefan constant
7. Determination of range of Beta-rays from Ra and Cs
8. Determination of wavelength of ultrasonic waves using Kundtôs tube method.
9. Determination of velocity of ultrasonic waves in a given liquid using ultrasonic Interferometer.
10. To measure to coefficient of absorption of sound of given materials at different frequencies
11. e/m by magnetron valve
12. V-I Charactristic of solar cell
13. Study of LCR circuit

Course: M.Sc. (4th Semester) ELECTIVE PAPER –II
Subject: To be offered by the Department from the following pool of subjects

Pool of Subjects for Departmental Elective-II
1. Introduction to Non-linear Dynamics
2. Particle Physics
3. Physics of Semiconductor Devices
4. Spectroscopy
5. Thin Film Technology

Course: M.Sc. (4^{th} Semester) (ELECTIVE –II-1)
Subject: INTRODUCTION TO NONLINEAR DYNAMICS

Course Objectives: The course aims to introduce the students to abstract mathematical concepts that are integral for a proper grasp of the standard techniques used in nonlinear dynamics.

Module- I: Introduction to nonlinearity

Linear and nonlinear differential equations, Vector fields, Phase space and differential equations, Stability of steady states, Linearization of nonlinear systems, Oscillating solutions of nonlinear systems, limit cycles ,examples, Discrete time systems, Linear and nonlinear maps, Stability of the fixed points of maps, The logistic map, Iterations of maps (14 Lectures)

Module- II: Bifurcations

Saddle-Node bifurcation, Tranŝs critical bifurcation, Pitchfork bifurcation, Hopf bifurcation, Flip bifurcation, Period doubling bifurcation. (8 Lectures)

Module-III: Deterministic chaos

Definitions and examples, Unpredictability and determinism, Poincare' sections, Strange attractors, The Lorenz system , logistic map, Lorenz system, Rossler systems. (7 Lectures)

Module-IV: Linear and nonlinear waves

Linear dispersive wave propagation, solution of the related initial value problem using Fourier transform methods, wave packet and dispersion, nonlinear dispersive waves: Russelŝs Great Wave of Translation, Cnoidal and solitary waves, Korteweg- de Vries equation and the Solitary waves and Cnoidal wave solutions. (8 Lectures)

Module-V: Applications

Chaos in classical mechanics and electronics, Ecological systems: Simple and modified Lotka-Volterra equations for predator-prey mechanisms and species competition, Population dynamics and economic systems: application of the logistic equation, Biological and physiological systems: glycolysis (8 Lectures)

TEXT AND REFERENCE BOOKS:

1. H. Steven, and Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering

2. Nonlinear Dynamics, Integrability Chaos and patterns, M. Lakshamanan and S Rajasekar, Springer

3.An Exploration of Dynamical Systems and Chaos , John Argyris, Gunter Faust, Maria Haase, Rudolf Friedrich, Springer (2015)

4.Differential Equations, Dynamical Systems, and an Introduction to Chaos ,Morris W. Hirsch, Stephen Smale and Robert L. Devaney , Academic Press (2012)

5. Chaos and Integrability in Nonlinear Dynamics An Introduction, M. Tabor, Wiley Inter science

Course Outcome: On completion of this course, the student is expected to have mastered the basic techniques for analyzing linear and nonlinear dynamical systems. It also equip the students to apply various numerical techniques to characterize different kinds of nonlinear dynamical systems.

Course Outcomes:

CO1	On completion of this course, the student is expected to have mastered the basic techniques for analyzing linear and nonlinear dynamical systems
CO2	It also equip the students to apply various numerical techniques to characterize different kinds of nonlinear dynamical systems
CO3	The students to abstract mathematical concepts that are integral for a proper grasp of the standard techniques used in nonlinear dynamics
CO4	Able to describe the concepts of various linear and non linear waves and its implementation to solve the mathematical problems.
CO5	Able to get the idea of chaos with its different application in various systems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Course: M.Sc. (4^{th} Semester) (ELECTIVE-II-2)
Subject: PARTICLE PHYSICS

Module-I

Standard Model of Particle Physics, Particle Classification, Fermions and Bosons, Lepton Flavours, Quark Flavours, Electromagnetic, Weak and Strong Processes.

Module-II

Isospin, Strangeness, Hypercharge, Baryon and Lepton number, Baryon and Lepton number conservation, Gell Mann- Nishijima Scheme, Quarks in Hadrons, Mesons and Baryons Octet.

Module-III

Yukawaĝs Theory, Neutrinos, Parity, Parity Conservation and non-conservation, Time reversal, Consequence of Time Reversal Invariance, Charge Conjugation.

Module -IV

G-Parity, Statement of CPT theorem and its consequence, Proof of equality of mass and life time for particle and anti-particle.

Module-V

Unitary symmetry and the classification of state, Hadrons and SU(3) multiplets, Application of SU(3) flavour symmetry and broken SU(3) flavour symmetry, Gell Mann-Okubo mass formula for baryons and mesons, Coleman-Glashow relation.

TEXT AND REFERENCE BOOKS:

1. Elementary Particle Physics: D. J. Griffiths
2. Concepts of Particle Physics : Gottifried and Weisskiof
3. Particle Physics: R. Omnes

Course Outcomes:

CO1	Basic idea about nuclear physics leads to the advanced studies in nuclear reaction and generation of nuclear energy through nuclear reactor.
CO2	The basic idea of two-nucleon problem can be extended to many body problem and advanced learning in high energy physics.
CO3	The concept of nuclear reaction can used to study the energy formation in stellar system
CO4	understand the basic forces in nature and classification of particles and study in detail conservations laws and quark models in detail
CO5	be able to gain knowledge about various nuclear models and potentials associated

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	3	3	2	2	3
CO3	3	2	2	3	3	3
CO4	3	3	2	3	2	2
CO5	3	2	3	2	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	3	3	2	3

Course: M.Sc. (4th Semester) (ELECTIVE-II-3)
Subject: PHYSICS OF SEMICONDUCTOR DEVICES

Course Objectives: To introduce to students the theory and applications of semiconductor device physics for electrical, electronics and computer engineering, and to know the characteristics of different semiconductor devices.

Module-I- Semiconductor fundamentals:
Quantum theory of solids, formation of energy bands, mathematical formulation of Kronig-Penney model, E-K-diagram in 2-Dand 3-D, Direct and indirect band gap semiconductor, energy bands in solids, classification of solids based on band theory, donor and acceptor in energy band model, effective mass of electron and hole, density of states, Fermi ï Dirac distribution function for electron and holes, Fermi energy and temperature dependence of Fermi energy

Module-II - Thermal equilibrium and Carrier transport phenomena:

Thermal equilibrium: Equilibrium distribution of electron and holes, the n_o and p_o equations, the intrinsic carrier concentration, the intrinsic Fermi-level position, extrinsic semiconductor, equilibrium distribution of electron and hole in extrinsic semiconductor, the n_o -p_o product, degenerate and non-degenerate semiconductor, Fermi energy level as a function of concentration and temperature with graphical representation, complete ionization, freeze out condition, partial ionization, compensated semiconductor,

Module-III- Carrier transport phenomena

Electron and hole mobility, drift current density and conductivity, carried iffusion: diffusion current, total current density, Einstein relationship between diffusion coefficient and motilities.

Module-IV- Semiconductor devices

P-N Junction: Depletion layer model, reverse biased PN junction, C-V characteristics, junction breakdown, carrier injection under forward bias, current continuity equation, excess carrier in forward biased, I-V characteristic, **BJT:** Introduction to BJT, collector and base current, current gain, base width modulation, Ebers-Moll model **MOS capacitor**: Flat band condition, surface accumulation, surface depletion, threshold condition and threshold voltage, MOS C-V characteristics

Module-V- Photonic Devices

Radioactive transition and optical absorption, Light emitting diodes (Visible, organic, infrared), Phtodetector: Photoconductor, Photodiode (construction, working, theory), Solar cell (solar radiation-n junction solar cell).

TEXT AND REFERENCE BOOKS:

1.D.Neamann: Semiconductor Physics and Semiconductor Devices, Tata McGrew Hill
2. C.C.Hu,Modern: Semiconductor Devices for Integrated circuits ,Pearson(2010)
3. S.M.Sze:Semiconductor Devices ñPhysics and Technology),WILEY(2009)
4. R. A. Smith, Semiconductors, Academic Press (1978).
5. K. Seeger, Semiconductor Physics: An introduction, Springer Verlag (1991).
6. C. Hamaguchi, Basic semiconductor physics, Springer Verlag (2001).

Course Outcome: The students are expected to have the knowledge about the basic materials and properties of semiconductors with application to various circuits and devices.

Course Outcomes:

CO1	The students are expected to have the knowledge about the basic materials and properties of semiconductors with application to various circuits and devices
CO2	The theory and applications of semiconductor device physics for electrical, electronics and computer engineering, and to know the characteristics of different semiconductor devices
CO3	Analyze dc circuits and relate ac models of semiconductor devices with their physical Operation
CO4	student will be able to understand the current voltage characteristics of semiconductor devices
CO5	Evaluate frequency response to understand behavior of Electronics circuits

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Course: M.Sc. (4^{th}Semester)(ELECTIVE-II-4)
Subject: SPECTROSCOPY

Course Objectives: The objectives of this course are to introduce the theory of the various instruments and the signals produced when analyzing compound, and to equip the student with enough information to be able to interpret signals from spectroscopic instruments.

Module-I : Microwave spectroscopy

Pure rotational spectra of diatomic molecules - Polyatomic molecules - Study of linear molecules and symmetric top molecules - Hyperfine structure and quadruple moment of linear molecules - Experimental techniques - Molecular structure determination - Stark effect - inversion spectrum of ammonia - Applications to chemical analysis.

Module-II: Infrared spectroscopy

Vibrational spectroscopy of diatomic and simple ploy atomic molecules - Harmonic Oscillator ï An harmonic Oscillator - Rotational vibrators - Normal modes of vibration of Polyatomic molecules - Experimental techniques - Applications of infrared spectroscopy - H2O and N2O molecules - Reflectance spectroscopy.

Module-III: Raman Spectroscopy

Classical theory of Raman Scattering - Raman effect and molecular structure - Raman effect and crystal structure - Raman effect in relation to inorganic, organic and physical chemistry - Experimental techniques - Coherent anti-Stokes Raman Spectroscopy - Applications of infrared and Raman spectroscopy in molecular structural confirmation of water and CO2 molecules. Module-IV : NMR and NQR Techniques Theory of NMR - Bloch equations - Steady state solution of Bloch equations - Theory of chemical shifts - Experimental methods - Single Coil and double coil methods - Pulse Method - High resolution method - Applications of NMR to quantitative measurements. Quadruple Hamiltonian of NQR - Nuclear quadruple energy levels for axial and nonaxial symmetry - Experimental techniques and applications.

Module-IV: ESR and Mossbauer Spectroscopy

Quantum mechanical treatment of ESR - Nuclear interaction and hyperfine structure - Relaxation effects - Basic principles of spectrographs - Applications of ESR method. M.Sc. Physics : Syllabus (CBCS) 14 Mossbauer effect - Recoilless emission and absorption - Mossbauer spectrum - Experimental methods - Massbauer spectrometer - Hyperfine interactions - Chemical Isomer shift - Magnetic hyperfine interactions - Electric quadruple interactions - Simple biological applications.

Module-V:

Photoelectron spectroscopy: Principles, Koopmans theorem, Photo ionization process, ESCA or XPS, Chemical shift in ESCA, Binding energy, instrumentation Auger Electron spectroscopy (AES), AES Instrumentation, Applications of AES, Scanning Auger Microprobe (SAM)

TEXT AND REFERENCE BOOKS:

1. C.N. Banwell and E.M. McCash, 1994, Fundamentals of Molecular Spectroscopy,4thEdition, Tata McGraw-Hill Publications, New Delhi.
2. G. Aruldas, 2001,Molecular Structure and Spectroscopy, Prentice- Hall of India Pvt. Ltd., New Delhi.
3. D.N. Satyanarayana, 2004, Vibrational Spectroscopy and Applications,New Age International Publications, New Delhi.
4. Atta Ur Rahman, 1986,Nuclear Magnetic Resonance, SpingerVerlag, New York.
5. Towne and Schawlow, 1995, Microwave Spectroscopy, McGraw-Hill,
6. Raymond Chang, 1980,Basic Principles of Spectroscopy, Mc Graw-Hill, Kogakusha, Tokyo.
7. D.A. Lang, Raman Spectroscopy, Mc Graw-Hill International, N.Y.
8. John Ferraro, Introductory Raman Spectroscopy, Academic Press (2008)
9. H. Kaur, Spectroscopy, A Pragati edition (2018)

Course Outcome: Students can understand the usage of different spectroscopic techniques to determine the molecular structure, energy levels, its application to physical and chemical analysis.

Course Outcomes:

CO1	know about different atom model and will be able to differentiate different atomic Systems, different coupling schemes and their interactions with magnetic and electric fields.
CO2	Have gained ability to apply the techniques of microwave and infrared spectroscopy to elucidate the structure of molecules
CO3	Be able to apply the principle of Raman spectroscopy and its applications in the different field of science & Technology
CO4	To become familiar with different resonance spectroscopic techniques and its applications
CO5	to find solutions to problems related different spectroscopic systems

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	3	2
CO2	3	2	2	2	2	2
CO3	3	3	3	2	3	2
CO4	3	3	3	3	3	3
CO5	2	2	2	2	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	2	2	3

Course: M.Sc. (4^{th}Semester)(ELECTIVE-II-5)
Subject: THIN FILM TECHNOLOGY

Module-I: Introduction to thin films

Overview of vacuum techniques, Comparison of thin and thick films, Theory of growth of thin films: Nucleation, condensation, Capillarity model, comparison of models, various stages of film growth.

Module-II: Deposition Techniques

Physical Vapor Deposition, Chemical Vapor Deposition, Molecular Beam Epitaxy, Sputtering, Spray pyrolysis, Dip coating and Spin coating, Photolithography, Electron-beamed position, Pulsed Laser Ablation.

Module-III: Electrical Properties

Source of Resistivity in Metallic conductors, Influence of thickness on the resistivity of thin films, Hall Effect & Magneto resistance in thin films, Fuch- Sondhemir theory,T C Randits effects.

Module-IV: Mechanical properties

Adhesion & its measurement with mechanical and nucleation methods, stress measurement by using optical method. Optical properties: Absorption and transmission.

Module-V: Applications of Thin Films

Resistors, capacitors, junction devices (Metal semiconductor junction) Solar cells,! Cs, Optical coating, Thin film sensors (gas and humidity), Thin films for information storage, electro acoustics and telecommunication.

TEXT AND REFERENCE BOOKS:

1. Hand book of Thin Film Technology: Maissel and Giang,(Mc Graw Hill)
2. Thin Film Phenomena: K .L. Chopra,(McGrawHill)
3. Material Science of Thin Films: M .Ohring, (Academic Press)
4. Thin Film Process:J .L. Vossen and Kern,(Academic Press)
5. Vacuum Technology (2^{nd} revised edition),A .Roth,(North Hollad)

Course Outcomes:

CO1	Discuss the differences and similarities between different vacuum based deposition techniques
CO2	Evaluate and use models for nucleating and growth of thin films
CO3	Asses the relation between deposition technique, film structure, and film properties
CO4	Discuss typical thin film applications
CO5	Motivate selection of deposition techniques for various applications

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	3	2	1
CO2	2	3	3	3	2	1
CO3	2	3	3	3	2	1
CO4	2	3	3	3	2	1
CO5	2	3	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2	3	3	3	2	1

Course: M.Sc. (4th Semester) ELECTIVE PAPER –III
Subject: To be offered by the Department from the following pool of subjects

Pool of Subjects for Departmental Elective-III
1. Atmospheric Physics
2. Biophysics
3. Crystallography
4. Laser Physics
5. Soft Condensed Matter Physics

Course: M.Sc. (4th Semester)(ELECTIVE-III-1)
Subject: ATMOSPHERIC PHYSICS

Module–I:Elements of earth's atmosphere: Review of origin and composition of the atmosphere, major components- nitrogen, oxygen, argon; minor components-water vapor, dust particles, ozone; vertical variations in compositions- homo sphere, heteoro sphere, ionosphere; auroras; thermal structure of the atmosphere- troposphere, stratosphere, mesosphere, thermosphere; horizontal distribution of temperature, pressure and density, distribution of winds, horizontal and vertical winds, land breeze and sea breeze.

Module–II: Atmospheric observations: Importance of meteorological observations, measurement of temperature and humidity, measurement of wind and pressure, measurement of precipitation, upper air observations- radiosonde, rawinsonde, rocketsonde, pyrgeometer, pyrheliometer. Radar, Doppler weather radar, applications.

Module–III: Radiation and energy budget: Electromagnetic spectrum of radiation, black body radiation- Plankös law, thermodynamical equilibrium, radiometric quantities, atmospheric absorption of Solar radiation-absorption and emission of radiation by molecules, absorptivity and emissivity, Kirchhoff's law, reflectivity and transmitivity, absorption of solar radiation by the atmosphere, Beer's law, indirect estimate of solar radiance at the top of the atmosphere, vertical profile of absorption; scattering of solar radiation, atmospheric absorption and emission of infrared radiation.

Module–IV: Atmospheric dynamics: Large scale motions, vorticity and divergence, streamline and trajectories, dynamics of horizontal flow- apparent and real forces, equation of motion, geostrophic wind, effect of friction, gradient wind, thermal wind, suppression of vertical motions, conservation law for vorticity, potential vorticity; primitive equations- -pressure asave11ical coordinate, hydrostatic balance, thermodynamic energy equation, solution of the primitive equations, applications atmospheric general circulation.

Module-V: Monsoon over India: Morphology of monsoon circulation, symmetric and asymmetric monsoon; Formation of monsoon disturbances, Structure of monsoon disturbances, Wind. temperarue and pressure distribution over India in the lower, middle and upper atmosphere during pre, post and mid-monsoon season; Intra-seasonal variability of monsoon, Inter-annual variability of monsoon-anomalous over India and Asia, El Nino Southern Oscillation and dynamical mechanism for their existence.

TEXT AND REFERENCE BOOKS:

1. Basics of Atmospheric Science, AChandrasekar, PHI Publications, 2010.
2. Atmospheric Science-An Introductory Survey, John M Wallace and Peter V Hobbs, Academic Press, Elsevier,2006.
3. The atmosphere , Frede{ickKLutgensand Edward J Ta.rbuck, Pearson Prentice Hall,2007.
4. Radar Mett:orology by S Raghavan, Kulwer Academic Publishers,2003
5. An introduction to Dynamic Meteorology,Holton JR, AcademicPress NY2006.
6. A course in Dynamic meteorology, Naval Pandarinath,B S Publications,2006.
7. The Physics of Monsoons, R N Keshvamurthy and M Shankar Rao,Allied Publishers.1992.

Course Outcomes:

CO1	Be able to describe the basic structure of an atmosphere and the climate system.
CO2	Be able to use fundamental thermodynamics to derive expressions for the variation of temperature, pressure, and air density with height.
CO3	Know the components of the Earthôs radiation balance.
CO4	Understand the scale approximations to the equations of motion (e.g. hydrostatic and geostrophic approximations).
CO5	Be familiar with mechanism of monsoon in India.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	3	2
CO2	3	2	2	2	2	2
CO3	3	3	3	2	3	2
CO4	3	3	3	3	3	3
CO5	2	2	2	2	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	2	2	3

Course: M.Sc. (4th Semester)(ELECTIVE –III-2)
Subject: BIOPHYSICS

Objective: This paper helps to understand the applications of various microscopic tools in cell biology. This paper helps the reader to understand the fundamentals of macro molecular structure and the analytical techniques in characterizing bimolecular interactions and its structure

Module-I: Cell Organization Cell as the basic structural unit-Origin & organization of Prokaryotic and Eukaryotic cell-Cell size & shape-Fine structure of Prokaryotic & Eukaryotic cell organization (Bacteria, Cyanobacteria, plant & Animal cell) ï Internal architecture of cells-cell organelles - compartment & assemblies membrane system ï Ribosome ï Polysomes ï Lysosomes -Peroxisomes-Connection between cell & its environment ï Extra cellular Matrix.

Module-II: Tools in Cell Biology Light microscope ï Resolving Power ï Phase contrast microscope-Detection of small differences in refractive indices ï Interference microscope-, Dark field microscope - Polarization microscope- Fluorescence microscope- Cytophotometry methods- Flow cytometry & cell sorting-Electron microscopy - specimen preparation- Scanning Electron Microscopy (SEM) ï Transmission Electron Microscopy (TEM)- Applications.

Module-III: Macromolecular structure Nucleic acid structure: Chemical structure of the nucleic acid-Conformational possibilities of monomers and polymers- Double helix structure of DNA-Polymorphism of DNA-DNA nanostructures and the structure of transfer RNA. Proteins structure: Amino acids and the primary structures of proteins-Secondary-Tertiary-Quaternary structure and virus structure.

Module-IV: Separation Techniques Centrifugation: Principle of centrifugation- Analytical ultracentrifugation- Differential centrifugation- Density gradient centrifugation. Chromatography: Principles of chromatography- Paper chromatography- Thin layer chromatography (TLC)-Gas liquid chromatography (GLC) ï High performance liquid chromatography (HPLC). Electrophoresis: Principles-Factors affecting the migration of substances- Supporting media in electrophoresis- Gel electrophoresis-Poly acrylamidegel electrophoresis (PAGE)-Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SOS-PAGE).

Module-V: Optical & Diffraction Techniques. Circular Dichroism and optical rotator dispersion-: Plane, circular and elliptical polarization of light- Absorption by oriented molecules ï Dichroic ratio of proteins and nucleic acids- Circular dichroism (CD) ï optical rotator dispersion (ORD)-Relation between CD and ORD- Application of ORD in conformation and interactions of bimolecular. Crystallization of proteins-preparation of heavy metal derivatives- Patterson synthesis- isomorphism replacement methods-structure factors of Centro-symmetric and non-centrosymmetric crystals- General remarks on Protein-Structure determination from X-ray diffraction data-Neutron diffraction- , Electron diffraction- ,Synchrotron diffraction, Application in Bimolecular structural studies

TEXT AND REFERENCE BOOKS:

1. The Cell: A Molecular Approach, Geoffrey M. Cooper, A S M Press, 2013.
2. Biophysics, VasanthaPattabhi, N. Gautham, Narosa Publishing, 2009

Course Outcomes:

CO1	Explain models of biological systems and models dealing with statistical mechanics and transport phenomena
CO2	Solve qualitative and quantitative problems, using appropriate statistical mechanics and computing techniques
CO3	Perform experiments which involve making correct and appropriate use of a range of scientific equipment, keeping an accurate record of experimental work and analyzing results and reaching non-trivial conclusions from them
CO4	Communicate at an advanced level the results of both theoretical and experimental work in various forms including written reports, oral presentations and poster presentations.
CO5	Collaborate effectively with team members for scientific investigations and for the process of learning.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	2	3	1
CO2	3	3	1	2	3	1
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2.2	2.6	2.8	2.2

Course: M.Sc. (4^{th} Semester) (ELECTIVE-III-3)
Subject: CRYSTALLOGRAPHY

Course Objectives: To understand the general principles of crystal and molecular structures and structure-property relationship, and to obtain the basic knowledge of X-ray diffraction analysis and phase transition problems.

Module-I

Symmetry of crystals, crystal projection and point groups, space groups. Production of X-Ray,X-Ray generator, absorption of X-Rays and principle of filter. Scattering of X-Ray by an electron, an atom and a unit cell, Structure factor calculations. Diffraction of X-Rays, Laue and Bragg equation, X-Ray powder diffraction, determination of lattice parameters by Debye-Scherrer method

Module-II

X-Ray diffract meter, X-Ray line profile analysis, broadening of diffraction line, size and strain broadening, Scherrer equation, Chemical analysis by X-ray Diffraction and X-ray fluorescence, Qualitative Analysis- Hanawalt method

Module-III

Quantitative Analysis-External Standard method, Direct Comparison method, Internal Standard method, Energy Dispersive X-ray(EDX), Wavelength Dispersive. Particle induced X-ray emission (PIXE) and their applications; Introduction to medical X-ray and X-ray techniques (radiography, radiotherapy, CT scanning)

Module-IV

Reciprocal lattice, sphere of reflection, Oscillation and Wiesenberger photograph and their interpretation. Introduction to small Angle X-ray Scattering (SAXS) and its applications, Residual stress and its determination by X-ray diffraction, Elementary idea of Neutron and Electron diffraction.

Module-V

Fourier series representation of electron density in crystals, projection of electron density in two dimensions. Phase problem and its solutions, trial and error method, Patterson function, Heavy atom method, Isomorphous replacement method, direct methods, Use of Harker-Kasper inequalities, Refinement- differential synthesis and method of least squares.

TEXT AND REFERENCE BOOKS:

1. B. D.Cullity-ElementsofX-raydiffraction, Addison-WesleyPublishingCompany.
2. S. K. Chatterjee-X-ray diffraction-its theory and applications, Prentice Hall, India.
3. B. E. Warren-X-ray diffraction, Addison-Wesley Publishing Company.
4. A. R. Verma and O. N. Srivastava- X-ray Crystallography, New Age International Publisher.
5.H. P. Klug and L. E. Alexander-X-ray Diffraction procedures, John Wiley & Sons.
6. J. A. Nielson and D. McMorrow- Elements of Modern X-ray physics, John Wiley & Sons (2001)
7. G.V. Pavlinsky, Fundamentals of X-ray Physics, Cambridge International Sci. Pub(2008)
8. A. K. Singh, Advanced X-ray Techniques in Research and Industry-,Capital Publishing Company.
9. N. Kasai, M. Kakudo, X-ray diffraction by macromolecules, Springer (2005)

Course Outcome:

The following skills are expected at the end of this course:

1. Ability to describe fundamental crystallographic concepts,
2. Ability to extract the relevant information from a crystallographic paper,
3. Ability to find specific tools for solution of a given crystallographic problem

Course Outcomes:

CO1	To understand the general principles of crystal structure of a material
CO2	To have some idea about structure-property relationship
CO3	To understand X-ray diffraction and its analysis in crystallography.
CO4	To understand the concept of phase problems.
CO5	To understand and use of x-ray diffraction techniques for various application.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	3	2	3	2	2
CO3	3	3	3	3	3	2
CO4	3	3	2	2	3	3
CO5	3	2	2	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	3	3	2

Course: M.Sc. (4th Semester) (ELECTIVE-III-4)

Subject: LASER PHYSICS

Course Objectives:

1. To understand the basic concepts and phenomenology of lasing technique
2. To study the set up of various laser systems and absorption mechanisms
3. To analyse the dynamics of laser processes and spectroscopy

Module-I: Fundamentals and different levels of Lasers:

Review of Introduction to the Lasers, Population inversion, Transient population inversions, Processes that inhibit inversions, Saturation intensity, Laser Pumping: Two-, Three-level laser systems, Three-level laser with the intermediate level as the upper laser level, Three-level laser with the upper laser level as the highest level, Four-level laser system, Resonators, Vibrational modes of a resonator(8 Lectures)

Module-II: Various types of Lasers:

Solid (Ruby), Liquid (europium), Gas (He-Ne), ion (Argon-ion), Semiconductor, Excimer lasers, Dye and Chemical lasers (HCl), Metal vapor laser (He-Cd), Ground state absorption in Dye lasers, Triplet absorption in Dye lasers, Excited state absorption in excimer and solid state lasers, Absorption in semiconductor lasers (8 Lectures)

Module-III: Einstein Coefficients and Light Amplification

Einstein coefficients, Absorption and emission cross sections, Light Amplification, The threshold condition, Line broadening mechanisms (Natural, Collision, and Doppler) (8 Lectures)

Module-IV: Dynamics of Laser Processes:

Production of a giant pulse ï Q switching, Mechanical and electro-optical shutters, Giant pulse dynamics, Laser amplifiers, Ultra-short light pulses, Distributed feedback lasers, Gamma ray laser (7 Lectures)

Module-V: Laser Spectroscopy

Rayleigh and Raman scattering, Stimulated Raman Effect, Hyper-Raman effect: Classical and Quantum treatment, Coherent anti-stokes Raman scattering (CARS), Spin-flip Raman laser, Free-electron laser (FEL), Photo-acoustic Raman Spectroscopy (PARS) (9 Lectures)

TEXT AND REFERENCE BOOKS:

1. W. T. Silfvast, Laser Fundamentals, Cambridge University Press, 1996
2. B. B. Laud, Lasers and Non-linear Optics, New-Age International Ltd, 2004
3. O. Svelto, Principles of Laser, Plenum, 1998.
4. K. Thyagarajan and A.K. Ghatak, Lasers: Fundamentals and Applications, Springer 1981.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Capable of handling tensor applications in electrodynamics in therelativisitic formalism.
CO2	A depth in handling dynamics of charged particles under various field configurations
CO3	Conversant with classical dispersion theory
CO4	Able to tackle radiation problems for various time varying charge and current distributions
CO5	Acquainted with the rudiments of the field theoretic formulation of electrodynamics

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Course: M.Sc. (4^{th} Semester) (ELECTIVE-III-5)
Subject: SOFT CONDENSED MATTER PHYSICS

Course Objectives: The main objectives of the course are:

1. To introduce the concepts of soft matter physics
2. To discuss the polymerization mechanism
3. To study the electronic properties of various alkali halides
4. To understand the magnetic relaxation and resonance phenomenon

Module-I: Liquid Crystals
Thermotropic, lyotropic, polymer based, Nematic, Smectic, cholesteric, Ferroelectric liquid crystals, Blue phase LCs, chemical structure of LCs, Building blocks of liquid crystals, structure-property relationship of liquid crystals, General structural features of mesogens, Effect of structure on mesophase thermal stability, Homologous series.

Module-II: Theory of Liquid Crystals
Introduction, The pair interaction potential, Mean field approximation, symmetry, structure and order parameters, Phase diagrams, The molecular potential, The possibility of second order transitions, Electro-optic phenomenon, Field induced birefringence, Twisted nematic effect, Guest-host effect

Module-III: Polymers
Basic concepts and definitions, Classification of polymers: Natural vs synthetic, Polymer structure: Linear, branched, Amorphous or crystalline, Homopolymer or copolymer, Molecular forces and chemical bonding in polymers, Polymerization mechanism.

Module-IV: Electronic Properties of Alkali Halides
Optical and thermal electronic excitation in ionic crystals, The upper filled band and the conduction band in ionic crystals, The ultraviolet spectrum of the alkali halides; excitons, The influence of lattice defects on the electronic levels, The transformation of F centers into F' centers apd vice versa, The photoe1ectric effect in alkali halides, The Hall effect and electron mobility, Color centers resulting from excess halogen, Color centers produced by irradiation with X-rays

Module-V: Magnetic Relaxation and Resonance Phenomena
Paramagnetic relaxation: Description, Relaxation mechanisms, Spin-lattice, spin-spin relaxation, Nuclear magnetic resonance: Nuclear magnetic moments, condition for resonance absorption, Bloch equation and complex susceptibility, The influence of molecular motion on the relaxation times

TEXT AND REFERENCE BOOKS:

1. Introduction to Liquid Crystals Ed. By E.B. Priestley, Plenum Press
2. Polymer Science and Technology, R. O. Edewele, CRC Press
3. Solid State Physics by A.J.Dekker, Macmillan & Co Ltd.
4. Liquid Crystals, S. Chandrasekhar, Cambridge university press
5. Text book of polymer science, 3rd Edition, F. W. Billmeyer Jr., John Wiley & Sons.

Course Outcomes:

CO1	The concepts of soft matter physics help in new way of addressing the physical systems.
CO2	The knowledge of polymerization mechanism helps in developing macromolecules.
CO3	The electronic properties of various alkali halides help in developing commercially significant products.
CO4	The concept of magnetic relaxation and resonance phenomenon offers deeper understanding of atomic and nuclear properties of matter.
CO5	To refine the link between both based on other branches of physics.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	2	2	1
CO2	2	3	3	2	2	1
CO3	2	3	3	2	2	1
CO4	2	3	3	2	2	1
CO5	2	3	3	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2	3	3	2	2	1

Course: M.Sc. (4^{th} Semester)

Subject: ADVANCED EXPERIMENTS LAB

LIST OF EXPERIMENTS:

1. FTIR Study of a given sample
2. To measure the frequency dependence of dielectric constant of a ferroelectric material ($BaTiO_3$) using an óImpedance meterô
3. To find the band gap of a wide band gap semiconductor film by measuring its absorbance of light using UV-visible spectrophotometer
4. Principle and operation of Raman spectrometer
5. Solution of Linear algebraic equation: Gauss Jordan elimination, Singular Value Decomposition, Sparse linear system, Cholskey decomposition, QR decomposition.
6. Interpolation/extrapolation: Polynomial interpolation and extrapolation, cubic spline, interpolation in two more dimension.
7. Simulation of Bell state using Quantum computation method

Pool of Subjects for Open Elective (For Other Department Students)
1. Elementary Biophysics 2. Medical Physics 3. Radiation Safety 4. Renewable energy and energy harvesting

Course: M.Sc. (3rd Semester) (OPEN ELECTIVE-1)

Subject: ELEMENTARY BIOPHYSICS

Module-I: FOUNDATIONS OF BIOPHYSICS:
Biophysics as an interdisciplinary science ,aim. and scope of biophysics. Chemical and physical forces between atoms and molecules: Atomic and molecular forces. Inter-atomic molecular bonds: Ionic, covalent and Vander Waals bonds, coordinate bonds and hydrophobic interaction. Mechanism of bond formation based on electronic orbital's. Formation of molecular orbital's, Sigma and Pi bonds, Hybridization. Examples of bond formation between C-C, C-N and carbon and other atoms.

Module-II: PHYSICAL METHODS OF INVESTIGATION OF MACROMOLECULES:
Biological macromolecules, General classification, Physical methods of determining size and shape of molecules. Separation methods: Diffusion, Sedimentation and osmosis. Viscosity and surface tension measurements.

Module-III: INSTRUMENTAL METHODS OF ANALYSIS OF BIOLOGICAL SYSTEMS:
Light scattering by .macromolecules. Optical activity, Absorption spectroscopy and spectrophotometry Calorimetry, IR and Raman spectroscopy for study of biomolecules.NMR spectroscopy for studying interactions and identification of biomoecules. X-ray diffraction and microscopy for studying living matter (general treatment).

Module-IV: ISOTOPES AND RADIOACTIVITY:
Radioactive decay laws, production of radioisotopes (radio nuclides),allocation of radioactive traces, isotopic tracer method. Assay using radioactive substances, Labeling and detection methods using fluorescent molecules (a few examples).

Module-V: RADIATION BIOPHYSICS:
Radiation sources, Interaction of rad1tion with matter (general discussion), energy transfer process, measurement of radiation, Dosimetry, Biological effects of radiation, effect of radiation on living systems, radiation protection and radiation therapy.

TEXT AND REFERENCE BOOKS:

l. Essential of Biophysics - P. Narayanan, 2ndEdn., New Age International Publications. 2008.
2. Aspects of Biophysics – William Hughes, John Wiley and Sons, 1979
3. Biochemistry of Nucleic acids – Adams et al. Chapmann and Hall, 1992
4. Biophysics – VasanthaPattabi and N.Goutham, Narosa Publishing House, New Delhi. 2002.
5. Biophysics – Cotterill

Course Outcomes:

CO1	Explain models of biological systems and models dealing with statistical mechanics and transport phenomena
CO2	Solve qualitative and quantitative problems, using appropriate statistical mechanics and computing techniques
CO3	Perform experiments which involve making correct and appropriate use of a range of scientific equipment, keeping an accurate record of experimental work and analysing results and reaching non-trivial conclusions from them
CO4	Communicate at an advanced level the results of both theoretical and experimental work in various forms including written reports, oral presentations and poster presentations.
CO5	Collaborate effectively with team members for scientific investigations and for the process of learning.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	2	3	1
CO2	3	3	1	2	3	1
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2.2	2.6	2.8	2.2

Course: M.Sc. (3rd Semester) (OPEN ELECTIVE-2)
Subject: Medical Physics

Module-I

Basic Anatomical Terminology: Standard Anatomical Position, Planes.Familiarity with terms like- Superior, Inferior, Anterior, Posterior, Medial, Lateral, Proximal and Distal. **Mechanics of the body:** Skeleton, forces, and body stability. Muscles and dynamics of body movement.Physics of Locomotors Systems: joints and movements, Stability and Equilibrium. **Energy household of the body:** Energy balance in the body, Energy consumption of the body, Heat losses of the body, Thermal Regulation.

Pressure system of body: Physics of breathing, Physics of cardiovascular system.(8 Lectures)

Module-II

Acoustics of the body: Nature and characteristics of sound, Production of speech, Physics of the ear, Diagnostics with sound and ultrasound. **Optical system of the body:** Physics of the eye. **Electrical system of the body:** Physics of the nervous system, Electrical signals and information transfer. (8 Lectures)

Module-III

X-RAYS: Electromagnetic spectrum, production of x-rays, x-ray spectra, Brehmsstrahlung, Characteristic x-ray. **X-ray tubes & types**: Coolidge tube, x-ray tube design, tube cooling stationary mode, Rotating anode x-ray tube, Tube rating, quality and intensity of x-ray. X-ray generator circuits, half wave and full wave rectification, filament circuit, kilo voltage circuit.Single and three phase electric supply.Power ratings.Types of X-Ray Generator, high frequency generator, exposure timers and switches, HT cables. (8 Lectures)

Module-IV

RADIATION PHYSICS: Radiation units exposure, absorbed dose, units: rad, gray, relative biological effectiveness, effective dose- Rem & Sievert, inverse square law.Interaction of radiation with matter Compton & photoelectric effect, linear attenuation coefficient. **Radiation Detectors**: ionization (Thimble chamber, condenser chamber), chamber. Geiger Muller counter, Scintillation counters and Solid State detectors, TFT. (8 Lectures)

Module-V

MEDICAL IMAGING PHYSICS: Evolution of Medical Imaging, X-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. Radiography: Filters, grids, cassette, X-ray film, film processing, fluoroscopy. **Computed tomography scanner**- principle and function, display,generations, mammography.Thyroid uptake system and Gamma camera (Only Principle, function and display). (8 Lectures)

TEXT AND REFERENCE BOOKS:

1. Medical Physics, J.R. Cameron and J.G.Skofronick, Wiley (1978)
2. Basic Radiological Physics Dr. K. Thayalan - Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi (2003)
3. Christensenôs Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
4. Physics of the human body, Irving P. Herman, Springer (2007).
5.Physics of Radiation Therapy : F M Khan - Williams and Wilkins, 3rd edition (2003)
6. The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
7. Handbook of Physics in Diagnostic Imaging: R.S.Livingstone: B.I. Publication Pvt Ltd.
8. The Physics of Radiology-H E Johns and Cunningham.

Course Outcomes:

CO1	Acquaint with the basic anatomical terminology to identify and describe locations of major organs and analyze their mechanism in terms of physics.
CO2	Explain the physics of eye, ear and nervous system of the body.
CO3	Understand the all aspects of X-ray production and the working principles of X-ray generators.
CO4	Gain the knowledge of radiation quantities, units and the interaction of radiation with matter. Also, acquaint with different kinds of radiation detectors and their working mechanisms.
CO5	Familiar with different medical imaging techniques like X-ray imaging, NMR, MRI, Ultrasound, Computed tomography scanner and their applications.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	2	3	1
CO2	3	3	1	2	3	1
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2.2	2.6	2.8	2.2

Course: M.Sc. (3^{rd}Semester) (OPEN ELECTIVE-3)

Subject: Radiation Safety

The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics

Module-I:

Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission. (8 Lectures)

Module-II:

Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, **Interaction of Photons** - Photo- electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, **Interaction of Charged Particles:** Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung),**Interaction of Neutrons**- Collision, slowing down and Moderation. (9 Lectures)

Module-III:

Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). **Radiation detection:** Basic concept and working principle of *gas detectors* (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), *Scintillation Detectors* **(**Inorganic and Organic Scintillators), *Solid States Detectors* and *Neutron Detectors, Thermo luminescent Dosimetry.* (9 Lectures)

Module-IV:

Radiation safety management: *Biological effects of ionizing radiation*, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management. (7 Lectures)

Module-V:

Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. *Industrial Uses:* Tracing, Gauging, Material Modification, Sterization, Food preservation. (7 Lectures)

TEXT AND REFERENCE BOOKS:

1. W.E. Burcham and M. Jobes ï Nuclear and Particle Physics ï Longman (1995)
2. G.F.Knoll, Radiation detection and measurements
3. Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
4. W.J. Meredith and J.B. Massey, ñFundamental Physics of Radiologyò. John Wright and Sons, UK, 1989.
5. J.R. Greening, ñFundamentals of Radiation Dosimetryò, Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
6.Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001
7.A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
8.NCRP, ICRP, ICRU, IAEA, AERB Publications.
9.W.R. Hendee, ñMedical Radiation Physicsò, Year Book ï Medical Publishers Inc. London, 1981

Course Outcomes:

CO1	Learn the basics of atomic and nuclear physics including the nuclear reactions to understand the production of radioisotopes useful in various practical applications.
CO2	Acquaint with different types of radiations and their interaction with matter.
CO3	Acquire the knowledge of radiation measurements, quantities and units; and know the different types of radiation detectors.
CO4	Understand the principles involved in radiation monitoring and protection; and also get familiar with the nuclear waste and, itôs safe handling and disposal.
CO5	Familiar with the application of nuclear techniques in medical science, archeology, art and industry.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	2	2
CO5	3	3	2	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2.8	3	2.8	2.8

Course: M.Sc. (3rd Semester) (OPEN ELECTIVE-4)
Subject: RENEWABLE ENERGY AND ENERGY HARVESTING

The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible

Module-I:

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

Module-II:

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

Module-III:

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

Module-IV:

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.
Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

Module-V:

Geothermal Energy: Geothermal Resources, Geothermal Technologies.
Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

TEXT AND REFERENCE BOOKS:

1.Non-conventional energy sources - G.D Rai - Khanna Publishers, NewDelhi
2. Solar energy - M P Agarwal - S Chand and Co.Ltd.
3.Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing CompanyLtd.
4.Godfrey Boyle, ñRenewable Energy, Power for a sustainable futureò, 2004, Oxford University Press, in association with The OpenUniversity.
5.Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook,2009
6.J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich(USA).
7.http://en.wikipedia.org/wiki/Renewable_energy

Course Outcomes:

CO1	Understand the types of energy , energy storage and energy conversion systems.
CO2	Understand availability of solar radiation, solar geometry, instrument used for measuring solar radiation
CO3	Recognize the selection and design criteria of pumps and turbines
CO4	Have a basic knowledge of Ocean energy resources and technologies including Tidal energy, Wave power devices, Ocean currents and Salinity gradient devices.
CO5	Recognize hydrological facts and differentiate micro, mini and small hydro systems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	3
CO2	3	3	2	3	2	3
CO3	3	3	2	2	3	3
CO4	3	3	3	2	3	2
CO5	3	3	2	3	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	3	2	3	3

Audit:

Sl. No.	Subject
1	English for Research Paper Writing
2	Disaster Management
3	Sanskrit For Technical Knowledge
4	Value Education
5	Constitution of India
6	Pedagogy Studies
7	Stress Management By Yoga
8	Personality Development through Life Enlightenment Skills

Course: M.Sc. (1st and 2nd Semester)

AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

Syllabus:

Units	CONTENTS	Hours
1	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	4
2	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	4
3	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	4
4	key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,	4
5	skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	4
6	useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	4

References:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highmanǿs book .
4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

AUDIT 1 and 2: DISASTER MANAGEMENT

Syllabus

Units	CONTENTS	Hours
1	**Introduction** Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.	4
2	**Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	4
3	**Disaster Prone Areas In India** Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	4
4 5 6	**Disaster Preparedness And Management** Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness. **Risk Assessment** Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, Peopleös Participation In Risk Assessment. Strategies for Survival. **Disaster Mitigation** Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India	4

References:

1. R. Nishith, Singh AK, ' Disaster Management in India: Perspectives, issues and strategies New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.),ö Disaster Mitigation Experiences And Reflectionsö, Prentice Hall of India, New Delhi.
3. Goel S. L., Disaster Administration And Management Text And Case Studiesö,Deep &Deep Publication Pvt. Ltd., New Delhi.

AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

Syllabus

Unit	**Content**	**Hours**
1	• Alphabets in Sanskrit, • Past/Present/Future Tense, • Simple Sentences	8
2	• Order • Introduction of roots • Technical information about Sanskrit Literature	8
3	• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics	8

References:

1. Abhyaspustakamóï Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. Teach Yourself SanskritóPrathama Deeksha-VempatiKutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. Indiaós Glorious Scientific TraditionóSuresh Soni, Ocean books (P) Ltd., New Delhi.

Course Output

Students will be able to

1. Understanding basic Sanskrit language.
2. Ancient Sanskrit literature about science & technology can be understood.
3. Being a logical language will help to develop logic in students.

AUDIT 1 and 2: VALUE EDUCATION

Syllabus

Unit	*Content*	*Hours*
1	• Values and self-development ï Social values and individual attitudes. Work ethics, Indian vision of humanism. • Moral and non- moral valuation. Standards and principles. • Value judgements	4
2	• Importance of cultivation of values. • Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. • Honesty, Humanity. Power of faith, National Unity. • Patriotism.Love for nature ,Discipline	6
3	• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. • Punctuality, Love and Kindness. • Avoid fault Thinking. • Free from anger, Dignity of labour. • Universal brotherhood and religious tolerance. • True friendship.	6
4	• Happiness Vs suffering, love for truth. • Aware of self-destructive habits. • Association and Cooperation. •Doing best for saving nature • Character and Competence ï Holy books vs Blind faith. • Self-management and Good health. • Science of reincarnation. • Equality, Nonviolence ,Humility, Role of Women. • All religions and same message. • Mind your Mind, Self-control. • Honesty, Studying effectively	

References:

1 Chakroborty, S.K. ' Values and Ethics for organizations Theory and practice ,
OxfordUniversity Press, New Delhi

Course outcomes

Students will be able to
1.Knowledge of self-development
2.Learn the importance of Human values3.Developing the overall personality

AUDIT 1 and 2: CONSTITUTION OF INDIA

Syllabus

Units	Content	Hours
1	**History of Making of the Indian Constitution:** • History • Drafting Committee, (Composition & Working)	4
2	• **Philosophy of the Indian Constitution:** • Preamble Salient Features	4
3	**Contours of Constitutional Rights &Duties:** • Fundamental Rights • Right to Equality • Right to Freedom • Right against Exploitation Right to Freedom of Religion • Cultural and Educational Rights • Right to Constitutional Remedies • Directive Principles of State Policy • Fundamental Duties	4
4	**Organs of Governance:**	4
	• Parliament • Composition • Qualifications and Disqualifications • Powers and Functions • Executive • President • Governor • Council of Ministers • Judiciary, Appointment and Transfer of Judges, Qualifications • Powers and Functions	
5	**Local Administration:** • Districtĝs Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of ElectedRepresentative, CEO • of Municipal Corporation. • Pachayati raj: Introduction, PRI: ZilaPachayat. • Elected officials and their roles, CEO ZilaPachayat: Position androle. • Block level: Organizational Hierarchy (Different departments), • Village level: Role of Elected and Appointed officials, • Importance of grass root democracy	4
6	**Election Commission:** • Election Commission: Role and Functioning. • Chief Election Commissioner and Election Commissioners. • State Election Commission: Role and Functioning. • Institute and Bodies for the welfare of SC/ST/OBC and women.	4

References:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

AUDIT 1 and 2: PEDAGOGY STUDIES

Syllabus:

Units	Content	Hours
1	• **Introduction and Methodology:**	4
	• Aims and rationale, Policy background, Conceptual framework and terminology • Theories of learning, Curriculum, Teacher education. • Conceptual framework, Research questions. • Overview of methodology and Searching.	
2	• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. • Curriculum, Teacher education.	2
3	• Evidence on the effectiveness of pedagogical practices • Methodology for the in depth stage: quality assessment of includedstudies. • How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effectivepedagogy? • Theory of change. • Strength and nature of the body of evidence for effectivepedagogical practices. • Pedagogic theory and pedagogical approaches. • Teachersć attitudes and beliefs and Pedagogic strategies.	4
4	• Professional development: alignment with classroom practices and follow-up support • Peer support • Support from the head teacher and the community. • Curriculum and assessment • Barriers to learning: limited resources and large class sizes	4
5	• **Research gaps and future directions** • Research design • Contexts • Pedagogy • Teacher education • Curriculum and assessment • Dissemination and research impact.	2

References:
1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272ï 282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education.Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, Ųlearning to readócampaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

Syllabus

Unit	Content	Hours
1	• Definitions of Eight parts of yog. (Ashtanga)	8
2	• Yam and Niyam. Do`s and Donót́s in life. i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	8
3	• Asan and Pranayam i) Various yog poses and their benefits for mind & body ii)Regularization of breathing techniques and its effects-Types of pranayam	8

Suggested reading

1. Yogic Asanas for Group Tarining-Part-Ió:Janardan Swami Yogabhyasi Mandal, Nagpur
2. Rajayoga or conquering the Internal Natureó by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

Syllabus

Unit	Content	Hours
1	Neetisatakam-Holistic development of personality • Verses- 19,20,21,22 (wisdom) • Verses- 29,31,32 (pride & heroism) • Verses- 26,28,63,65 (virtue) • Verses- 52,53,59 (dontós) • Verses- 71,73,75,78 (doós)	8
2	• Approach to day to day work and duties.	8
	• Shrimad BhagwadGeeta : Chapter 2-Verses 41, 47,48, • Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35, • Chapter 18-Verses 45, 46, 48.	
3	• Statements of basic knowledge. • Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68 • Chapter 12 -Verses 13, 14, 15, 16,17, 18 • Personality of Role model. Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42, • Chapter 4-Verses 18, 38,39 • Chapter18 ï Verses 37,38,63	8

References:

1. Srimad Bhagavad Gitaó by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata

2. Bhartrihariós Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

Course Outcomes

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achievethe highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**2**	**1**	**3**	**2**	**2**
CO2	**2**	**2**	**1**	**3**	**2**	**2**
CO3	**2**	**2**	**1**	**3**	**2**	**2**
CO4	**2**	**2**	**1**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	2	2	1	3	2	2