DEPARTMENT OF PHYSICS
GURRU JAMBHESHWAR UNVIERSITY OF SC. & TECH., HISAR

Scheme & Syllabi for M.Sc. (Physics) Session 2016-17 on words
ACADEMIC CURRICULUM

Total Credits : 100

Teaching Scheme				**Contact Hours Per Week**		**Exam. Duration (Hrs.)**		**Marks**	
								Ext.	**Int.**
Sr. No.	SUBJECT CODE	COURSE TITLE	Credits	Theory	Practical (Per Group)	Theory	Practical	**70**	**30**
1st semester									
1. P-I	PHL 501	Mathematical Physics	4	4	-	3	-	**70**	**30**
2. P-II	PHL 502	Classical Mechanics	4	4	-	3	-	**70**	**30**
3. P-III	PHL 503	Quantum Mechanics-I	4	4	-	3	-	**70**	**30**
4. P-IV	PHL 504	Electronics	4	4	-	3	-	**70**	**30**
5.	PHP 505A	Laboratory Work (General Physics Lab.)	4	-	8	-	6	**70**	**30**
6	PHP 505B	Laboratory Work (Electronics Lab-I)	4	-	8	-	6	**70**	**30**
		Sub Total=	**24**						
2nd semester									
1. P-V	PHL 506	Solid State Physics	4	4	-	3	-	**70**	**30**
2. P-VI	PHL 507	Atomic and Molecular Physics	4	4	-	3	-	**70**	**30**
3. P-VII	PHL 508	Statistical Mechanics	4	4	-	3	-	**70**	**30**
4. P-VIII	PHL 509	Physics of Lasers	4	4	-	3	-	**70**	**30**
5.	PHP 510A	Laboratory work(Laser Physics Lab)	4	-	8	-	6	**70**	**30**
6	PHP 510B	Laboratory work (Electronics Lab.)	4	-	8	-	6	**70**	**30**
		Sub Total=	**24**						
3rd semester									
1. P-IX	PHL 511	Quantum Mechanics-II	4	4	-	3	-	**70**	**30**
2. P-X	PHL 512	Electrodynamics and Plasma Physics	4	4	-	3	-	**70**	**30**
3. P-XI	PHL 513	Nuclear and Particle Physics	4	4	-	3	-	**70**	**30**
4. P-XII	PHL 514	Computational Methods & Programming	4	4	-	3	-	**70**	**30**
5.	PHP 515A	Laboratory work (Advance Physics Lab.)	4	-		-	6	**70**	**30**
6	PHP 515B	Laboratory work (Computational Physics Lab.)	4					**70**	**30**
7 8	PHL-500*	Open Elective Physics for everyday life	4					**70**	**30**
		Sub Total=	**28**						
4th semester									
1.P-XIII	PHL 516(i)***	Physics of Nano Materials	4	4	-	3	-	**70**	**30**
2.P-XIV	PHL 516(iii)*** **OR**	Condensed Matter Physics: Materials Science	4	4	-	3	-	**70**	**30**

	PHL-516(v)***	Radiation Physics							
3. P-XV	PHL 517(i)***	Optoelectronics	4	4	- -	3	- -	**70**	**30**
4.P-XVI	PHL 517(ii)***	Fiber Optics and Optical Communication	4	4		3 - -	- -	**70**	**30**
5.		Laboratory Work	4		8		6	**70**	**30**
	PHP519A or	Radiationr Physics Lab.							
	PHP519B or	Meterial Science Lab.							
	PHP519C	Fibre or optics & Opto Electronics Lab							
6.	PHP-520****	Project Work	4					**70**	**30**
		Sub Total=	**24**						

Important Notes:

(i) A student will be required to opt for four programme elective/ special papers out of the following three groups of specializations. A student may opt for two papers in any two of these groups. These (Special/ Elective) papers will be offered in the beginning of the IV Semester depending upon the availability of staff in the field of specialization(s).

Programme Elective/Special Papers (Group-I)

PHL 516 (i) Physics of Nano Materials
PHL 516 (ii) Experimental Techniques
PHL 516 (iii) Condensed Matter Physics : Materials Science
PHL 516 (iv) Electronic Devices and Smart Materials
PHL516 (v) Radiation Physics

Programme Elective/Special Papers (Group-II)

PHL 517 (i) Optoelectronics
PHL 517 (ii) Fiber Optics and Optical Communication
PHL 517 (iii) Non Linear Optics
PHL 517 (iv) Applied Optics

Programme Elective/Special Papers (Group-III)

PHL 518 (i) Computational Technique and Computer Simulation
PHL 518 (ii) Advance Quantum Mechanics
PHL 518 (iii) Theoretical Nuclear Physics
PHL 518 (iv) Environmental Physics

(i)* A work of 4 credit to opted by the students as per elective course from other departments.

(ii)** PHL-500 Elective Paper: Physics for everyday life is be offered to the students of other department.

(iii)*** From the session 2016-2017 onwards the papers to be offered have been tentatively identified in the above table of Curriculum. Changes if any, will be conveyed to the concerned quarter as and when made.

(iv)**** The evaluation of project report & presentation will be done internally by a group of 3-4 teachers and will be submitted along with the sessional marks.

(v) Each unit has been uniformly distributed for about 15 hours and full papers is for about 60 hours.

PAPER-I (PHL-501)
Mathematical physics

M.Marks: 70
CREDITS: 4
Time: 3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives
This course has been formulated to introduce students to some important topics of mathematical physics which are relevant to other papers of M. Sc. Physics course. It includes matrices, group theory, special functions, functions of a complex variable and calculus of residues and integral transforms.

Course Outcome
After completing this course, students would be able to deal with mathematics that appears in other papers such as Classical Mechanics, Quantum Mechanics, Nuclear Physics, Condensed Matter Physics, etc.

Unit I
Matrices: Orthogonal, Unitary and Hermitian Matrices with examples, Independent elements of orthogonal and unitary matrices of order 2, Matrix diagonalization, eigen values and eigenvectors; Fundamentals of Group theory: Definition of a group and illustrative examples, Group-multiplication table, Rearrangement theorem, cyclic groups, subgroups and cosets, permutation groups, conjugate elements and class structure, normal divisors and factor groups, isomorphy and homomorphy, class multiplication.

Unit II
Groups representation by matrices, reducible and irreducible representations, the great orthogonality theorem and its geometric interpretation, character of a representation, construction of character table with illustrative examples of symmetry groups of equilateral triangle, rectangle and square. Decomposition of reducible representations, the regular representation. The elements of the group of Schrodinger equation.

Unit III
Bessel Functions: $J_n(x)$ as solution of Bessel differential equation, Second solution of Bessel's equation using Wronskian, Generating function, Recurrence relations, Integral representation; Legendre Polynomials: $P_n(x)$ as solution of Legendre differential equation, Second solution of Legendre's equation using Wronskian, Generating function, Recurrence relations and special properties, Rodrigues, formula, Orthogonality of $P_n(x)$; associated Legendre polynomials and their orthogonality; Hermite and Laguerre's Polynomials: generating function & recurrence relations only.

Unit IV
Functions of complex variable, Cauchy-Riemann conditions, Cauchy's integral theorem, Cauchy's integral formula: Singularities; Cauchy's residue theorem, singular points and evaluation of residues, Jordan's Lemma; Evaluation of real definite integrals; Fourier transform (FT): Introduction, FT of derivatives; Laplace transform (LT): Introduction, partial fraction expansion, LT of derivatives.

Reference Books:

1. Group Theory and Quantum Mechanics by Michael Tinkham.
2. Mathematical Methods for Physicists (6^{th} edition) by G.B. Arfken & H. J. Weber

Paper II (PHL-502)
Classical Mechanics

M.Marks: 70
CREDITS: 4
Time: 3 Hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives
The objective of this course on Classical Mechanics is to train the students of M. Sc. class in the Lagrangian and Hamiltonian formalisms.

Course Outcome
After going through this course on classical mechanics students will be able to apply Lagrangian and Hamiltonian formalisms to solve real world problems.

Unit I
Constraints & their classification, generalized coordinates, D'Alembert's principle and Lagrange's equations, simple applications of the Lagrangian formulation, Hamilton's principle, Derivation of Lagrange's equations from Hamilton's principle, conservation theorems and symmetry properties. Two –body central force problem: Reduction to the equivalent one-body problem, the equations of motion and first integrals, the equivalent 1-D problem and classification of orbits.

Unit II
The virial theorem, the differential equation for the orbit and integrable power-law potentials, the Kepler problem, scattering in a central force field. Legendre transformations and the Hamilton equations of motion, cyclic coordinates and Routh's procedure, the physical significance of the Hamiltonian, Derivation of Hamilton's equations from a variational principle, the principle of Least Action.

Unit III
The equations of canonical transformation, examples of canonical transformations, Poisson brackets, special cases of Poisson brackets, Poisson theorem, Poisson bracket and Canonical transformation, Jacobi's identity and its derivation. Lagrange brackets and its properties, the relationship between Poisson and Lagrange brackets and its derivation, the angular momenta and Poisson bracket.

Unit IV
Liouville's theorem, Theory of small oscillations: Formulation of the problem, the eigenvalue equation and the principle axis transformation, frequencies of free vibrations and normal coordinates, free vibrations of a linear triatomic molecule. The Hamilton- Jacobi equation for Hamilton's principal function, the harmonic oscillator problem as an example of the Hamiton-Jacobi method, Hamilton's characteristic function & its properties. Action-angle variables for completely separable system, the Kepler's problem in action-angle variables.

Reference Books:

1. Classical Mechanics (3rd ed.,2002) by H.Goldstein, C. Poole and J. Safko, Pearson Edition
2. Classical Mechanics of particles and rigid bodies by K. C. Gupta

Paper III (PHL-503)
Quantum Mechanics-I

M.Marks: 70
CREDITS : 4
Time: 3hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

The primary objective of this course is to develop familiarity with the physical concepts and facility with the mathematical methods of quantum mechanics. A secondary, but still very important objective is to cultivate your skills at formulating and solving physics problems.

This course will introduce Schrodinger Equations, Heisenberg Uncertainty Principle, Dirac's bra-ket formulation of quantum mechanics and make students familiar with various approximation methods applied to atomic, nuclear and solid-state physics and to scattering, which include: Time-independent perturbation theory and variational method.

Course Outcomes

After the course students should be able to understand the general concepts and principles of quantum mechanics: the Schrödinger equation, the wave function and its physical interpretation, stationary and non-stationary states, time evolution and expectation values.

They can independently solve the Schrödinger equation for simple one-dimensional systems -- the ones explicitly taught, as well as similar new ones. The solution can be used to compute probabilities, expectation values, uncertainties and time evolution.

Unit-I

The Schrodinger equation: Time dependent and time independent forms, Probability current density, expectation values, Ehrenfest's theorem, Gaussian wave packet and its spreading. Exact statement and proof of the uncertainty principle, Time independent equation, eigenvalues and eigenfunctions, Degeneracy and orthogonality. Applications of Schrodinger equation for 1 d Box, Tunneling problem & Linear Harmonic Oscillator.

Unit-II

Operator formalism in quantum mechanics, Hermitian operators and their properties, Vector representation of States-Bra and Ket algebra, relationship between kets and wave functions, Linear harmonic oscillator problem, coherent states, annihilation and creation operators, Matrix representation of an operator, Unitary transformation.

Unit-III

The angular momentum operators and their representation in spherical polar coordinates, solution of Schrodinger equation for spherically symmetric potentials, spherical harmonics, Hydrogen atom, Angular momentum matrices and Pauli spin matrices.

Unit-IV

Time independent perturbation theory: Nondegenerate case, first and second order perturbations, Degenerate case, removal of degeneracy in second order. First order Stark effect in hydrogen, The Variational Method: expectation value of the energy, application to excited states, ground state of helium.

Text and Reference Books :

L.I.Schiff	Quantum Mechanics
B.Craseman and J.D. Powell	Quantum Mechanics
Ghatak & Loknathan	Quantum Mechanics
Satya Prakash	Advanced Quantum Mechanics
Cohen Tannoudji	Quantum Mechanics

Paper IV (PHL-504)
Electronics

M.Marks: 70
CREDITS: 4
Time: 3 Hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

The objective of this course is to introduce students about important electronic devices being used in vital practical applications. It includes Field effect transistors, Operational Amplifiers, Oscillators etc. In addition the topics of various number systems and their arithmetic, basic logic gates and simplification techniques for Boolean Expressions will enable the students to enter into the fascinating world of digital electronics.

Course Outcomes

After completion of this course, students will be able to understand the basics of FETs, Op-Amp and their characteristics along with applications in various electronic devices The students will be able to design different types of oscillators. Combinational and sequential digital systems will be used to understand the applications in day to day life,

Unit I

The Junction Field Effect Transistor: Basic structure & Operation, pinch off voltage, single ended geometry of JFET, volt – ampere characteristic, Transfer Characteristics. FET parameters, Biasing of the FET and setting of Q point using load line. MOSFET: Enhancement MOSFET, Threshold Voltage, Depletion MOSFET, Biasing of MOSFET, comparison of p & n channel FETs, FET small signal model, JFET low frequency common source and common drain amplifiers, FET application as Voltage Variable Resistor (VVR)

Unit II

Differential Amplifier: Circuit configuration, dual input balanced output different amplifier, D.C. & A.C. analysis, Inverting and Non-inverting inputs, CMRR, Differential Amplifier using constant current bias, current mirror, level translator. Operational Amplifier: Block diagram, ideal electrical characteristics, equivalent circuit, transfer characteristics, Open loop OP-AMP configuration: Differential, inverting & non-inverting amplifier, OP-AMP with negative feedback (a) Voltage series feedback: Effect of feedback on closed loop voltage gain, Input resistance, output resistance, band width, output offset voltage. Voltage follower; (b) Voltage shunt feedback: Effect of feedback on closed loop voltage gain, Input resistance, output resistance, band width, output offset voltage.

Unit III

OP-AMP Applications: DC and AC amplifier (with offset null circuitry and external offset voltage compensating networks), summing, scaling, averaging (Non-inverting, Inverting and differential configuration), Integrator, Differentiator, Electronic analog computation, comparator. Oscillators: principles, Types, frequency stability, Phase shift oscillator, Wein-bridge oscillator, Square wave, Triangular wave and pulse generator

Unit IV

Digital operation of system: Introduction to OR, AND & NOT gates Ex-OR gate, De Morgan’s Laws, NOR & NAND DTL Logic, Binary adder, Digital Comparator, Decoder/Demultiplixer, Data selector/Multiplixer-Encoder, ROM and its applications. Flip-Flops: R-S, J-K, Master slave, T & D type flip flop, shift Register, Synchronous & Asynchronous Counter.

Text and Reference Books:

Ramakanth A. Gayakwad: OP-Amps & Linear integrated Circuits, Second Edition, 1991
J. Millman et al: Integrated Electronics, 2nd Edition

PAPER-I (PHL-506)
SOLID STATE PHYSICS

Marks: 70
CREDITS: 4
Time: 3 hours

Paper setter is to set nine questions in all, Question no 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting at least one from each Unit and a compulsory question.

Course Objective
The course is introductory but elaborate in nature which gives idea of solid state physics with theoretical touch using quantum mechanics. Students get introduced to all solid state phenomena with good theoretical background.

Course Outcome
The course will equip the student with ample knowledge of solid state physics. This will enable them to pick up material science and condensed matter physics in their advanced courses in MSC and research.

UNIT-I
Crystalline solids, Unit cell, Primitive lattice and Bravais lattice. Concepts of Direct and reciprocal lattice. Closed packed structures. Symmetry concepts ,point groups and space groups, Schoenfleis notation symmetry axes, Diad, triad , terad axes and notations, Stereographic projections, Brillioun zones and weigner seitz cell concepts. Crystal structure determination by Powder, Laue and Rotating crystal experiments. Concepts of crystal structure factor.

UNIT-II
Elementary excitations in solids, Lattice vibration, phonon concept, Effective mass of electron, Vibration of monoatomic and diatomic lattice, Acoustical and optical modes. quantization of elastic waves Dispersion relation for phonons, Density of states concepts. Dispersion relations, Free electron Fermi gas: energy levels and density of orbitals, Fermi Dirac distribution, free electron gas in 3 dimensions, Electrons in periodic lattice, Bloch theorem, band theory, tight binding approximation, Fermi level and surfaces.

UNIT –III
Magnetic properties, cyclotron resonance, Magneto resistance, de Hass van Allen effect, quantum Hall effect, orbital magnetic moment, diamagnetism an: langevin theory of Diamagnetism, Quantum theory of magnetic susceptibility, paramagnetism: van Vleck theory and Pauli theory of paramagnetism , ferromagnetism: wiess theory, ferromagnetic domains, Heisenberg model, Bloch walls and energy of Bloch wall, Ferri and ferro magnetic order, concept of magnons

UNIT-IV
Basics of superconductivity, cooper pairs, BSC theory, critical temperature current density, and Meissner effect, London equations, Type I and Type II superconductors, Introduction to High Temperature superconductors.

Text and Reference Books:

1. Verma and Srivastava, crystallography for solid state physics
2. Azaroff Introduction to solids
3. Omar Elementary Solid state Physics
4. Aschroft and Mermin Solid state Physics
5. Kittel C, Solid State physics
6. P. M. Chaikin and T. C. Lubensky ,*Principles of Condensed Matter Physics*, Cambridge University Press
7. Hans and Liith: condensded matter physics
8. M Tinkham: Introduction to superconductivity
9. O Medelung : Introduction to sold state theory , Springer verlag

Paper VI (PHL-507)
Atomic & Molecular Physics

M.Marks: 70
CREDITS: 4
Time: 3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

In this course, students will learn important concepts of atomic and molecular physics. IR, Raman and electronic band spectra of diatomic molecules will be studied. In addition this NMR and ESR techniques will be introduced.

Course Outcome

The expected outcome is that student is familiar with different types of atomic and diatomic models and their spectra. Student will also be familiar with NMR and ESR techniques

Unit I
Spectrum of He-atom and Heisenberg resonance, Physical interpretation of quantum numbers, Pauli principle and the building-up principle, Terms for equivalent & non-equivalent electron atom, Space Quantization: Stern-Gerlach experiment, Normal & anomalous Zeeman effect, Stark Effect, Paschen-Back effect, Intensities of spectral lines, General selection rule, Hyperfine structure of spectral lines: Isotope effect and effect of Nuclear spin.

Unit II
The diatomic molecule as a Rigid Rotator and a Harmonic Oscillator: Energy levels, IR and Raman spectra; The diatomic molecule as Nonrigid Rotator and an Anharmonic Oscillator: Energy levels, IR and Raman spectra; The diatomic molecule as the Vibrating Rotator: Energy levels, IR and Raman spectra; Intensities in Rotation-Vibration spectra; Symmetry properties of the Rotational levels: Influence of nuclear spin. Isotope effect.

Unit III
Electronic energy and Total energy: Resolution of the total eigenfunction, Resolution of Total energy; Vibrational structural of Electronic transitions: Progression and Sequences; Rotational structure of Electronic bands: Band-head formation, Fortrat parabola; Intensity distribution in the Vibrational structure: The Franck-Condon principle-Absorption and Emission (Condon parabola).

Unit IV
NMR: Basic principles, Classical and quantum mechanical description, Bloch equations, Spin-spin and spin-lattice relaxation times, chemical shift and coupling constant, Experimental methods, single coil and double coil methods, High resolution methods; ESR: Basic principle, ESR spectrometer, nuclear interaction and hyperfine structure, relaxation effects, g-factor, Characteristics, Free radical studies and biological applications.

Text and Reference Books:
Atomic spectra & atomic structure by G. Hertzberg;
Introduction to Atomic spectra by H.E White;
Spectra of diatomic molecules by G. Herzberg.

Paper VII (PHL-508)
Statistical Mechanics

M.Marks : 70
CREDITS : 4
Time: 3 Hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

The objective of this course is to introduce the student to today's understanding of statistical physics and statistical mechanics. The microcanonical, canonical, and grand canonical ensembles will be considered and some other ensembles will be noted. Both classical and quantum systems will be investigated. Then, Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics will be discussed and applied to different fields.

Course Outcomes

On successful completion of the course, students should be able to: 1. discuss the various classical ensembles and quantum ensembles 2. solve the statistical mechanics problems using ensemble theory 3. explain the connection between classical statistical mechanics and quantum statistical mechanics 4. explain the concept of density matrix

Unit-I

Foundations of statistical mechanics, specification of states of a system, concept of phase space and ensemble contact between statistics and thermodynamics, equipartition theorem, classical ideal gas, entropy of mixing and Gibb's paradox.

Unit-II

Microcanonical ensemble, phase space, trajectories and density of states, Liouville's theorem, Boltzmann H Theorm. Canonical and grand canonical ensembles, partition function. Calculation of statistical quantities, Energy and density fluctuations.

Unit-III

Density matrix, statistics of ensembles, statistics of undistinguishable particles, Maxwell – Boltzmann, Fermi-Dirac and Bose – Einstein statistics, properties of ideal Bose – Einstein and Fermi-Dirac gases, Bose Einstein condensation, Laser cooling of atom as an example of Bose Condensate. Planck's radiation formula (Black body Radiation)

Unit-IV

Virial equation of state, Ising model, mean – field theories of the Ising model in one dimension and Exact solution in one dimension. Landam theory of phase transition.

Text and Reference Books:

F. Reif	Statistical and Thermal
K.Huang	Statistical Mechanics
R.K.Patharia	Statistical Mechanics
ESR Gopal	Statistical Mechanics
Gupta & Kumar	Statistical Mechanics
Eugene Stanley	Critical Phenomena & Phase Transitions

Paper VIII (PHL-509)
Physics of Lasers

M.Marks: 70
CREDITS :4
Time: 3hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

The main aims of this course are to develop a working knowledge and conceptual understanding of important topics in contemporary laser physics at a quantitative level. A key objective is to enable the student to undertake quantitative problem-solving relating to the design, performance and applications of lasers through thereby acquiring an ability to put such knowledge into practice by way of numerical calculations.

Course Outcomes

Students who complete the course will learn about the physics of lasers and their applications. This course develops a conceptual understanding of the classical approach to laser physics, and a perspective of areas of applicability. Students approach an ability to both analyze quantitatively and to design such lasers. This emphasis on understanding of such important aspects of laser active media as line width determining processes, dispersive/gain properties, spatial and frequency hole-burning, the principles and design of laser resonators, particularly stable cavities.

UNIT-I

Spontaneous & Stimulated Emission, Stimulated absorption, Relationship of Einstein's coefficient, Ideas of Light amplification by an atomic system.
Cavity radiations and modes (one, two and three dimensions), Important properties of Laser, Spatial and temporal coherence (Experimental evidence).

UNIT-II

Origin of Line shape function, Broadening of spectral line: Homogeneous (natural and collisional) and Inhomogeneous (Doppler) broadening mechanisms, Threshold condition for oscillation, Laser oscillation and amplification in a homogeneous broadened transition and its Gain saturation.

UNIT-III

Laser oscillation and amplification in an inhomogeneous system, Multi-mode oscillation, Spatial hole burning (Lamb dip), Efficiency of laser (various factors), Population inversion & rate equations for three and four level laser systems. Variation of Laser power around threshold. Optimum output coupling.

UNIT-IV

Gaussian beam and its properties Physical description of Lowest order modes, Preliminary considerations of optical resonator, Energy stored in optical resonaters, Different types of resonaters. Different types of losses in optical resonaters (Diffration losses, coating losses, tramsmission losses).

Text and Reference Books :

Laser Electronics, J.T.Verdeyen, Prentice Hall (1995)
Lasers & Electro-Optics : Fundamental & Engineering C.C.Davis, Cambridge (1996)
Lasers Fundamentals By W.T. Silfvast, Cambridge (1996)
Principles of Lasers, O.Svetto, Plenum (1989)
Laser Physics, L.V.Tarasov, Mir (1983)
Quantum Electronics, A.Yavir, John Wiley (1992)
Laser: Theory & Applications, A. Ghatak & Tayagrajan, Macmillan India
Introduction to Laser Physics, K. Shimoda, Springer (1986)
Lasers & non-Linear Optics, B.B.Laud

Paper IX (PHL-511)

Quantum Mechanics-II

M.Marks: 70
CREDITS :4
Time: 3hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

The course on advanced quantum mechanics deals with exactly solvable problems. Perturbation theory is applied to light-matter interaction and transport problems such as scattering and tunneling, Green's function approach is introduced to understand open quantum systems. To make understand the idea of Spin and statistics. The Dirac operator formalism is developed and used for perturbation theory. The course will conclude with a discussion of the Klein-Gordon and Dirac equations, and the recent interest in Majorana Fermions.

Course Outcomes

After introducing the tools and ideas, the students gain familiarity and intuition by learning to handle the real life problems .The search for exact solutions lead to the study of genuinely many-particle excitations of the quantum field such as polarons, excitons, polaritons, and Cooper pairs.

The course is made to understand What exactly is spin? Why do particles of integer spin behave one way while particles of half odd integer spin behave in another?

UNIT-I

WKB Approximation: The WKB method for one-dimensional problems, Application to barrier penetration, The WKB method for three dimensional problems.

Time-dependent perturbation theory: harmonic perturbation; Fermi's golden rule, adiabatic and sudden approximations.

UNIT-II

Basic concept of scattering, Scattering amplitude, differential and total scattering cross sections, scattering by spherically symmetric potentials, partial waves and phase shifts, scattering by a perfectly right sphere and by square well potential. Born approximation and its application to scattering of electrons by atom. Neumann equation and its solution, Neumann series and Bessel function.

UNIT-III

Identical particles : Symmetric and antisymmetric wave functions, distinguishability of identical particles, the exclusion principle, the connection with statistical mechanics, collisions of identical particles, Spin angular momentum : connection between spin and statistics, spin matrices and eigenfunctions. Spin functions for a many electron system. Atomic levels of Helium atoms as an example of two electron system.

UNIT-IV

Semiclassical theory of radiation: Transition probability for absorption and induced emission, Electric dipole and forbidden transitions, selection rules.

Relativistic quantum mechanics : The Klein – Gordon equation, the Dirac equation, probability current density, plane wave solutions.

Text and Reference Books :

L.I.Schiff	Quantum Mechanics , McGraw-Hill
S.Gasiorowicz	Quantum Physics , Wiley
B.Craseman and J.D. Powell	Quantum Mechanics, Addison Wesley

Paper-X (PHL-512)
Electrodynamics and Plasma Physics

M.Marks: 70
CREDITS: 4
Time: 3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

The main objective of this course is to understand of theoretical fundamentals of Electrodynamics and physics of plasma i.e. electromagnetic fields the one side and the interaction of charges and currents with field on other side.
This includes solutions of the free wave equations, solutions with stationary sources and solutions to the equations with time dependent charge and current distributions. This also emphasis on the study of the radiation phenomena and basic concepts of plasma.

Course Outcomes

The intention of this part of the lectures is to analyze the fundamentals of electrodynamics on the basis of Maxwell's equations. The idea is to examine solutions of Maxwell's equations under different types of conditions. Ability to analyze electromagnetic problems and to apply mathematical methods for solving.

Unit 1 : Energy stored in an electric and magnetic fields. Maxwell's equations, power flow in an electromagnetic field and pointing theorem. Electromagnetic waves in a homogeneous medium-solution for free space conditions. Uniform plane waves, the wave equations for a conducting medium, Sinusoidal time variations, Maxwell's equations using phasor notation. Wave propagation in a loss less medium, wave propagation in a conducting medium, wave propagation in a good dielectric.Lorentz Invariance in Maxwell's Equations

Unit 2: Polarization : Linear, elliptical and circular Polarization, Direction cosines.Reflection and refraction of plane waves: Reflection by a perfect conductor – normal and oblique incidence. Reflection by a perfect dielectric – normal and oblique incidence. Power loss in a plane conductor.Dispersion and Scattering; Coherent and Incoherent Scattered Light, Polarization of Scattered Light, Dispersion in Solids, Liquids and gases.

Unit 3: Wave Equation for Vector and Scalar Potential and Solution Retarded Potential and Lienard – Wicehert Potential, Electric and Magnetic fields due to a Uniformly Moving Charge and An Accelerated Charge, ,Bremsstrahlung, Synchrotron Radiation and Cerenkov Radiation, Reaction Force of Radiation.

Unit 4: Elementary Concepts: Plasma Oscillations, Debye Shielding, Plasma Parameters, Magnetoplasma, Plasma Confinement. Waves Guides: Rectangular, Parallel Plane & Dielectric Slab Wave guide, Concept of Cut off frequency, Lippman Fringes, TE, TM & TEM modes.

Text and Reference Books:

Panofsky and Phillips	Classical Electricity and Magnetism
Bittencourt	Plasma Physics
Chen	Plasma Physics
Jackson	Classical Electrodynamics
Griffiths	Electromagnetic Theory
Jordan & Balme	Electromagnetic Waves
B.B. Laud	Electromagnetic New Age Publication

Paper XI(PHL-513)
Nuclear & Particle Physics

M.Marks : 70
CREDITS : 4
Time: 3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

The objectives of this course are to: introduce students to the fundamental principles and concepts governing nuclear and particle physics and have a working knowledge of their application to real-life problems

Course Outcomes

After taking the course, students should be able to explain central concepts, laws and models in nuclear and particle physics, interpret basic experiments & can use basic laws and relations to solve simple problems

Unit-I

Nuclear Interaction and Nuclear Reaction: Two Nucleon Problem, Exchange forces, Meson theory of nuclear forces, nucleon-nucleon scattering, Effective range theory, Spin dependence of nuclear forces, Charge independence and charge symmetry of nuclear forces.
Direct and compound nuclear reaction mechanism, Cross-section in terms of partial wave amplitude.

Unit-II

Nuclear Models: Liquid drop model, Bohr-Wheeler theory of fission, Experiment evidence for shell effect, Magic numbers, Shell model, Spin-orbit coupling, Angular momenta and parities of nuclear ground states, Qualitative discussion and estimates of transitions rates, Magnetic moments and Schmidt lines.

Unit-III

Nuclear Decays: Beta decay, Fermi theory of beta decay, Shape of the beta spectrum, Total decay rate, Angular momentum and parity selection rules, Detection and properties of neutrino, Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules, Internal conversion, Nuclear isomerism, Interaction of charged particle with matter, (qualitative idea).

Unit-IV

Elementary Particle Physics: Type of interaction between elementary particle – Hadrons and leptons, Symmetry and conservation laws, Elementary ideas of CP and CPT invariance, Classification of hadrons, SU (2)-SU (3) multiples (qualitative only), Quark model, Gell-Mann-Okubo formula for octet and decuplet hadrons-Charm, bottom and top quarks.

Text and Reference Books :

1. Kenneth S. Krane, Introductory Nuclear Physics, Wiley, New York, 1988
2. Atomic and Nuclear Physics, S.N.Ghoshal , Vol. 2., S.Chand publication
3. Introduction to high Energy Physics, P.H. Perkins, Addison-Wesley, London, 1982.
4. Introduction to Elementary Particles, D. Griffiths, Harper and Row, New York, 1987.
5. Introductory nuclear physics, Y.R. Waghmare, Oxford – IBH, Bombay, 1981.
6. Nuclear Physics, Kapaln, 2nd addition, Narosa, Madras, 1989.
7. Introduction to Nuclear Physics, F.A. Enge, Addison-Wesley, 1975
8. Nucleon interaction, G.E. Brown and A.D. Jackson, North-Holland, Amsterdam, 1976.
9. Atomic Nucleus, R.D.Evans Me Graw Hill, New York, 1955
10. R.R.Roy and B.P.Nigam, Nuclear Physics, Wiley-Eastern Ltd., 1983

PAPER-I (PHL-514)
Computational Physics and Programming

M.Marks: 70
CREDITS: 4
Time: 3 hours

Paper setter is to set nine questions in all, Question no 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting at least one from each Unit and a compulsory question.

Course Objective
The course is elaborate and thorough which gives idea about all type of numerical methods and FORTRAN programming used in higher (PhD) work of any university.

Course Outcome
The course will equip the student with FORTRAN programming and will enable then to write FORTRAN codes in their higher studies. This will equip them to do theoretical analysis if their research work is experimental too.

UNIT-I
Elementary information about digital computer principles, compilers, Interpreters and operating systems, FORTRAN Programming codes and Commands, Flow charts, Integer and Floating point , arithmetic expressions , built in functions, executable and non executable statements , assignments, control and input-output elements, subroutines and functions, Operation with files.

UNIT –II
Solution of Simultaneous linear equations, Gaussian elimination , Gauss Jordan methods, Iterative and Jacobi's method
Eigen values and eigen vectors of Matrices, Power method and Matrix Inversion

UNIT-III
Finite differences, Newtons forward and Backward formulas, Central differences, Stirlings interpolation, Root finding techniques like Bisection, Newton Raphson method, Polynomial Interpolation and Extrapolation Cubic spline fitting
Numerical solution of ordinary differential equations, , Introduction to Euler method, Runga Kutta method, Predicto Corrector method

UNIT-IV
Numerical differentiation Integration, Newtons Cotes formula, Simpson's rule, Gauss Quadrature.
Monte Carlo simulation, Random Variables and Generators, Monte Carlo evaluation of Integrals, Hit and Miss method,

Text and References

B S Grewal, Numererical methods and Programming
C Xavier, FORTRAn && and Programming
Sasthry : Introduction to numerical methods
Kalavathy: FORTRAN programming and Numerical methods
Vetterming Numerical Recipes
Teukolsky Press and Framney
Binder & Herman Monte Carlo Simulation

Paper VII (PHL-500)

Physics for everyday life

M.Marks: 70
CREDITS :4
Time: 3hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

To provide an introduction to popular concepts of Physics in day to day life.To provide intellectual resources for constructive critical analysis of physics in sports, light in life, communication and information technology, Renewable energy sources.

Course Outcomes

After going through the course, students will be able to know the physics behind various activities around us.

Unit-I

Physics in sports: Swimming - Forces acting on a floating body, Forces acting on a swimmer moving through the water, Dolphin kick. Golf- the Golf Swing, Aerodynamics of Ball flight. Gymnastics- The still rings, Trampoline. Pole Vaulting. Running-Forces generated during running, Path travelled by runners and center of mass, Arm swinging.

Unit-II

Light in Life: Laser in Medicine-Skin and eyes, cosmetic surgery, Optical coherent tomography for eyes, Photo dynamic therapy & other treatments.

Unit-III

Communication & Information Technology-Optical fiber communication: Sources and Detectors, Satellite Communications: Satellite Orbits, Geostationary orbits, Applications of satellite Communication, Telephones, Television, Digital Communication, Radio Broadcasting, Military.

Unit-IV

Renewable Energy: Wind Power, Hydropower, Solar energy, Geothermal energy, Bio energy, Commercialization: Economic Trends, industry & policy trends.

Programme Elective/Special Papers (Group-I)

PHL 516 (i) Physics of Nano Materials
PHL 516 (ii) Experimental Techniques
PHL 516 (iii) Condensed Matter Physics : Materials Science
PHL 516 (iv) Electronic Devices and Smart Materials
PHL516 (v) Radiation Physics

Programme Elective/Special Papers (Group-II)

PHL 517 (i) Optoelectronics
PHL 517 (ii) Fiber Optics and Optical Communication
PHL 517 (iii) Non Linear Optics
PHL 517 (iv) Applied Optics

Programme Elective/Special Papers (Group-III)

PHL 518 (i) Computational Technique and Computer Simulation
PHL 518 (ii) Advance Quantum Mechanics
PHL 518 (iii) Theoretical Nuclear Physics
PHL 518 (iv) Environmental Physics

Paper XIII (PHL-516(i))
Physics of Nano Materials
(Special Paper I : Condensed Matter Physics, Group-I)

M.Marks: 70
CREDITS :4
Time: 3hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives
The course gives an overview of NanoScience &Technology including basics of sensors, quantum dots, Lithography. Fabrication and characterization of nanomaterials is the important component.

Course Outcomes
The course is made to understand the need of nanotechnology. Various fabrication and cauterization techniques for nanomaterials will help the students for seeking jobs in future industry.

UNIT-I
An overview of Nano Science & Technology:
Types of Nanomaterials (1D ,2D & 3D Nanomaterials), Different allotropes of Carbon (CNT, Fullerene, & Graphene), Applications of Nanotechnology in different areas. Optical luminescence of nanoparticles, size dependent properties of Quantum Dots.

UNIT-II
Simple Basics of : Sensors, Semiconductor Quantum dots and Quantum wires, Nanotweezers & Nanomanuplation, Nanocomposits. Basics of: Dip Pen Lithography, Electron beam lithography, Ion beam lithography, Photo lithography, X-ray based lithography, MEMS, NEMS.

UNIT-III
Fabrication Techniques: Top down & Bottom Up approach, Vacuum system,(Working of Rotary Pump & Diffusion pump, Measurement of Vacuum by Pirani & Penning Gauge and working principle) Physical Vapour Deposition(PVD)Viz; Arc discharge, Sputtering, Thermal evaporation Technique, pulsed Laser Deposition. Chemical vapor deposition (CVD) , Plasma enhanced CVD, Sol- gel, Spin Coating, Dip Coating, Ball Milling.

UNIT-IV
Characterization Techniques : Scanning Probe Microscope (SPM), Electron Microscope (SEM, TEM), X-ray Diffraction (XRD, EDX), Determination of Particle size by XRD, Increase in
width of XRD Peaks of nanoparticles. Atomic Force Microscopy (AFM),UV-Vis-NIR Spectrophotometer, Raman Spectrophotometer.

Text and Reference Books:
GAn-Moog Chow, Nanotechnology Molecularly ,
Kenneth E.Gonsalves Designed materials American Chemical Society
D. Bimerg Quantum dot heterostructures John Wiley & Sons, 1998
M. Grundmann and N.N.Ledenstoy
B.C. Crandall Nano technology: Molecular MIT Press, 1996;Speculations on global abundance
John H. Davies Physics of low dimensional Cambridge Univ. Press, 1997 ;Semiconductors
K.P. Jain Physics of semiconductor nano Narosa 1997
Structures ;Harvey C. Hoch, Nano fabrication and bio system: Cambridge Univ. Press, 1996
Harold G. CRaichead and Integrating materials science
Lynn Jelinski engineering science and biology . Ed. .H.Fendler Nano Particles and nano structured John Wiley & Sons 1998

PHL-516(ii)
EXPERIMENTAL TECHNIQUES
(Special Paper: Condensed Matter Physics, Group-I)

M.Marks: 70
CREDITS :4
Time: 3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives
This course has been formulated to introduce students to some important techniques for the characterization of different types of materials.

Course Outcome
After completing this course, students would be able to deal with the characterization of glasses, ceramics, nano-materials and thin films.

Unit I
Optical Methods of Structure determination, optical microscopy, scanning electron microscopy (SEM), internal reflection spectroscopy, X-ray fluorescence.

Unit II
Detailed study of spectroscopic techniques: NMR, ESR, Photoacoustic Spectroscopy. Electron Microprobe analysis.

Unit III
Surface Analytical Techniques: Electron spectroscopies – Auger, XPS (ESCA), UV-photoemission and inverse photoemission, Electronic Structure determination using Synchrotron radiation sources. X-ray absorption techniques EXAFS,NEXAFS. Thermal Desorption Spectrometry, SIMS (secondary ion mass spectroscopy), RBS (Rutherford Backscattering Spectroscopy). Low energy electron diffraction.

Unit IV
Scanning Probe Techniques: (STM) Scanning Tunneling Microscopy, (AFM) Atomic Force Microscopy) STS (Scanning Tunneling Spectroscopy.)

Text and Reference Books:

R. Ueda and J.B.Mullin	Crystal Growth and Characterisation
Woodruff and Delchar	Experimental Techniques of Surface Science
Ibach and Luth	Solid State Physics
Ibach	Solid Surfaces
Prutton	Solid Surfaces
Zangwill	Physics at Surfaces.

Paper XIV (PHL-516(iii))
Condensed Matter Physics: Materials Science
(Special Paper II: Condensed Matter Physics, Group-I)

M.Marks: 70
Credits: 4
Time: 3hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

Course Objectives: To make students aware of different types of materials in their bulk and thin film forms and their properties

Course Outcomes

Course Outcome: Students will become aware of various thin film deposition and characterization techniques, Properties of dielectric and ceramic materials in advance applications.

UNIT-I

Defects in Materials : point defects, line defects (dislocations), surface defects (grain boundaries), volume defects (voids), impact of defects on properties of materials, defect creation and annihilation, stress fields, Elastic energy of dislocations, Burger vector, slip and glide, motions of dislocations, Crystal Growing techniques including artificial crystals and gems.

UNIT-II

Thin film deposition techniques: Physical vacuum deposition, e-beam, MBE, sputtering, laser ablation, Plasma assisted deposition, Chemical deposition techniques – CVD, MOCVD, electrochemical deposition, Sol-gel technique, Thin film Characterization: Thickness measurements (Stylus, quartz crystal, microbalance etc.), Electrical conductivity, optical parameters, roughness, stress and hardness measurement.

UNIT-III

Electronic Properties of alkali halides: Optical and thermal electronic excitation, upper filled and the conduction band, Excitons-hole interaction, influence of lattice defects on electronic levels, non-stoichiometric crystal containing excess metal, Colour centers: F, M, R centers. Transformation of F centers into F'.

UNIT-IV

Dielectric Materials: Polarization and dielectric constant, Clausius and Mossotti relation, Debye theory for polar dielectrics, Dielectric Loss, Classification of dielectric materials: Piezo-electric, Pyro-electric and Ferroelectric, applications of dielectric materials, Optical Kerr effects

Text and Reference Books:

Azaroff	X-ray Crystallography
Weertman & Weertman	Elementary Dislocation Theory
Dekker	Solid State Physics
Kittel	Solid State Physics
Heavens	Thin Films
Chopra	Physics of Thin Films

PHL-516(iv)
ELECTRONIC DEVICES & SMART MATERIALS
(Special Paper: Condensed Matter Physics, Group-I)

M.Marks: 70
CREDITS :4
Time: 3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives
This course has been formulated to introduce students to some important electronic devices and smart materials having wide range of applications.

Course Outcome
After completing this course, students would be able to understand the concept of solar energy, microwave devices, superionic conductors and spintronics.

Unit I
Solar Energy: Fundamental of photovoltaic energy conversion Physics and Materials Properties, Basic test in Photovataic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.
Types of Solar Cells, p n junction solar cell, Transport Equation, Current Density, open circuit voltage and short circuit current, Brief descriptions of single srystal silocon and amorphous silicon solar cells, elementary ideas of advances solar cells e.g. Tandem Solar Cells. Solid Liquid Junction Solar Cells, Nature of Semiconductor, Electrolyte junction, Principles of Photoelectrochemical Solar cells.

Unit II
Microwave Devices: Tunnel diode – Principle of Operation, Microwave characteristics, Transfer Electronic devices, Gun Effect Diodes, Avalenche Transist Time Devises: impact Diode-Physical structure, Principle of operation, Power put out & efficiency. Parametric devices-Physical structure, Non-Linear reactance, parametric amplifier & applications.

Unit III
Superionic Conductors: Introduction, Types of ionic solids, Superionic materials. Classification of superionic materials: Alkali metal ion conductors, silver ion conductors. Copper ion conductors proton conductors, B – alumina, composite electrolytes, ion conducting glasses and polymers. Basic concepts: jump mechanisms, ionic conductivity and diffusion coefficient. Defect concentration in pure crystals and doped crystals, impurity – vacancy association. Application of superionic conductors on solid state batteries, fuel cells, electrochromic display devices, gas sensors.

Unit IV
Engineering Magnetic Materials: Magnetising processes. Hysteresis loops and energy product. Magnetic anisotropies. Soft magnetic materials: Iron and steel, permalloys, metallic glasses, ferrites. Hard magnetic materials: Alnico, hard ferrites, rare earth compounds, bonded magnets. Materials for antenna, inductor and transformer cores. Materials for permanent magnets. Magnetic recording fundamentals. Particulate and thin film recording media. Recording heads: ferrite heads, metal – in –gap heads, thin film heads and magnetoresistive heads. Fundamentals of magneto – opto recording. Magneto – optic recording media and heads. Introduction to magnetic bubbles.

Text and Reference Books:
Nanophase materials: Sythesis, Properties and applications – R.V. Siegel and G.C. Hadjipanayis, Kluwer Publishers, 1994
High Temp. Superconductors – E.S.R. Gopal & S.V. Subramanyam (Wiley Eastern Ltd., 1989)
Studies of High Tc superconductors Vol. 1 -6 –A.V. Narlikar, Nova Science Publishers USA, 1990
Physics of High Tc superconductors – J.C. Philips, Academic Press, 1989

Superionic Solids, Principles and Application – S. Chandra, North Holland, 1981
Encyclopaedia of Applied Physics G.L. Trig Vol. 9, G.L. Trigg, V.CH Publishers, 1994
Materials science and Technology – A comprehensive Treatment – Vol. 3a and 3B, R.W. Cahn,
P. Hassen and E.J.Kraurer, VCH Publishers, Germany, 1992
Electron Microscopy in the study of Materials, P.J. Grundy and G.A.Jones, Edward Arnold Publishers, 1976
Thin Film Fundamentals, A. Gosswami, New Age International, 1996

Paper - XIV (PHL- 516V)
Radiation Physics

M. Marks: 70
CREDITS :4
Time: 3hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives:

Course Objectives: To make students aware of interaction of radiations with matter and different phenomenon associated. How the energy and dose of nuclear radiations affects cells of living beings. The main objective of this course will also be to make students aware of radiation measurement.

Course Outcomes:

Course Outcome: Students will become aware of different phenomenon associated with interaction of radiations with matter and radiations energy and dose measurement, units different types of radiation detectors with principal of working. Students will also be aware of radiological risk and their assessment.

Unit I

Radiation Physics: Atomic structure, Isotopes, Isotones, Isobars, Radioactivity, Modes of radioactive disintegration, Nature and properties of nuclear radiations, Radioactive decay, Half life time, and Neutron sources.
Interaction of Radiation with Matter: Modes of interaction: ionization, excitation, elastic and inelastic scattering, Bremsstrahlung, Cerenkov radiation, concepts of specific ionization, mean free path; Interaction of Light Charged Particles with matter; Interaction of Heavy Charged Particles with matter; Interaction of Electromagnetic Radiations with matter: Photoelectric effect, Compton Scattering, and Pair production; Attenuation of Gamma Radiation: Linear and mass attenuation coefficient; Interaction of Neutrons with matter: elastic scattering, inelastic scattering, capture, and fission.

Unit II

Radiation quantities and units: Activity, KERMA, Exposure, Dose, Equivalent Dose, Effective Dose, Annual Limit on Intake (ALI), and Derived Air Concentration (DAC).
Radiation Detectors and Monitors: Principles of radiation detection; Gas filled radiation detectors: ionization chambers, proportion counters, GM counters, and Spark counter. Scintillation (organic/inorganic) counter; Solid State Detector: Crystal detector, Semi conductor

Detectors (Junction type detector, Lithium drift Germanium detector, and HPGe), Thermo – Luminescent Dosimeters (TLD), Chemical detectors (Photographic Emulsions Films), Radiation Monitoring Instruments and Calibration check of radiation monitoring equipment.

Unit III

Biological Effects of Ionizing Radiation: Introduction, Cell Biology: Structure and function of living cell, cell division-mitosis, meiosis and differentiation, central dogma of molecular biology, genetic codes-DNA, RNA and Proteins; Effect of Radiation on Cell: inhibition of cell division, chromosome aberrations, genes mutation, and cell death; Biological effects of Radiation on Human: Somatic Effects (Early effect) and Stochastic effect (Late effect).

Operational Limits: Principles of Radiological Protection: Justification of Practice, Optimization of Practice, and Dose Limitations; Internal Exposure, Dose Limit for (i) Radiation Workers (ii) Public, Occupational Exposure of Women, Apprentices and Students

Unit IV

Radiation Hazard Evaluation and Control: Radiation Hazard: Internal Hazards and External Hazards; Evaluation and Control of Radiation Hazard, Radiation Shield, Monitoring of External Radiation, Control of Internal Hazard: (i) Containment of Source (ii) Control of Environment (iii) Contamination (iv) Air Contamination Monitoring (v) Personal Contamination Monitoring (vi) Decontamination Procedures; Radiation Emergency and Preparedness.

Production of Radioisotopes and Labelled Compounds: Introduction, Separation of Isotopes, Production of labeled compounds, Specific Activity of labeled compounds, Storage, Quality, and Purity of Radio-labelled compounds.

References:

1. Introduction to Radiological Physics and Radiation Dosimetry, by Frank H. Attix, John Wiley & Sons, 1986.

2. Radiation Detection and Measurement 4th Edition by Glenn F. Knoll

3. Physics and Engineering of Radiation Detection By Syed Ahmed, Laurentian University, Ontario, Canada

4. Measurement and Detection of Radiation, Fourth Edition
Nicholas Tsoulfanidis, Nicholas Tsoulfanidis, Sheldon Landsberger

Paper XV (PHL-517(i))

Opto-Electronics
(Special Paper III: Optics & Spectroscopy, Group-II)

M.Marks: 70
CREDITS: 4
Time: 3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

The objective of this course is to introduce various pumping processes used in different laser systems, basics of different nonlinear effects, introduction to nonlinear optics and advantages of Lasers in spectroscopy

Course Outcomes

After going through this course, students will be able to understand the excitation mechanisms of different Lasers, applied aspects of nonlinear effects in Q-switching and mode-locking. Students will learn various nonlinear optical phenomena: Optical mixing, OPA, OPO and optical bistability. Various laser spectroscopic techniques will also be learnt

Unit I
Pumping Processes: Optical pumping, conversion efficiency; Electrical pumping and Physical description of discharge; Excitation by Resonant energy transfer; Physical description, Excitation mechanism, Applications and Structure of He-Ne, Ruby, Nd:YAG, Dye and CO_2 lasers.

Unit II
Electro-optic effect: Pockels and Kerr effects; Pockel effect in KDP crystal: Longitudinal and transverse configuration; Elementary idea of magneto-optic effect and acousto-optic effect, Design of Q switched laser (theory), Theory of mode locking, Methods for Q-Switching and mode locking.

Unit III
Introduction to nonlinear optics: Harmonic generation; Steady state and transient nonlinear optical effects (Brief idea); Maxwell's equation in nonlinear optical medium, Three wave mixing phenomenon (using slowly varying amplitude approximation): Second harmonic generation and Phase matching condition, Index Ellipsoid; Optical Mixing; Optical Parametric generation of Light (OPA and OPO); Intensity dependent refractive index (Self focusing of light); Four wave mixing phenomenon: Brillioun scattering, Optical phase conjugation, Optical bistability: Absorptive and Refractive bistability.

Unit IV
Advantages of lasers in spectroscopy, High sensitivity methods of absorption spectroscopy; frequency modulation, Intracavity absorption (using single mode operation), Fluorescence excitation spectroscopy, photo-acoustic spectroscopy (PAS), laser induced fluorescence (LIF), Laser Raman Spectroscopy: Basic considerations of linear, Non-linear and stimulated Raman Spectroscopy.

Text and Reference Books:
Laser Electronics, J.T. Verdeyen, Prentice Hall (1995)
Lasers & Electro-Optics: Fundamental & Engineering C.C.Davis, Cambridge (1996)
Lasers Fundamentals by W.T. Silfvast, Cambridge (1996)

Principles of Lasers, O. Svelto, Plenum (1989)
Nonlinear Optical By R.W. Boyd, (2008)
Laser Physics, L.V.Tarasov, Mir (1983)
Quantum Electronics, A Yavir, John Wiley (1992)
Laser: Theory & applications, A. Ghatak & Tayagrajan, Macmillan India

Paper XVI (PHL-517(ii))

Fiber Optics and Optical Communication

(Special Paper IV: Optics & Spectroscopy, Group-II)

M.Marks: 70
CREDITS: 4
Time: 3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

The course on Fiber Optics and optical communication deals with Semiconductor Physics as it acts as the optical source in Optical communication. To make understand the idea of various types of Detectors and noise associated with detectors for improving signal to noise ratio. Optical Fiber as transmission medium, dispersion in waveguides, Attenuation are the key features of the contents

Course Outcomes

After introducing the idea of Light propagation through Optical waveguide, Optical sources and detectors, the student will be able to understand the concept of design of Optical communication system considering the time budget and power budget. Understanding the concept of fiber laser is important to the requirement beyond conventional lasers.

UNIT-I

Optical Sources & Detectors: General description, Laser structure, Excitation Mechanism of the Semiconductor Laser Diode and light emitting Diode, Radiative recombination in semiconductor materials, Semiconductor density of states, Occupation probability, Optical absorption and Gain, Heterostructure laser, Quantum well lasers, Modulation rates in semiconductor lasers.

Noise in Optical detectors: S/N ratio for optical power and signal currents, Background radiation, Johnson (Thermal noise), Dark current shot noise, 1/f noise, Combined effect of all the noise sources.

UNIT-II

Transmission Medium-Fiber Optics: Principle of fiber optics: Ray optics and wave propagation in infinite slab waveguide, Electromagnetic analysis of the planer waveguide, The longitudinal wavevector, Fiber types: step index and graded index fiber structures, Wave Equations for Step index Fiber, Optical modes and their properties, Number of guided modes in a waveguide, Mode field diameter, Numerical Aperture and propagation modes.

UNIT-III

Dispersion in waveguides: Material dispersion, Modal Dispersion, and waveguide Dispersion and their simultaneous effects. The ray picture of Propagation in a graded Index material: The Eikonal equation, dispersion reduction with a graded index profile and the modal picture.WKB approximation of graded index fiber, Wave equations for Step index circular waveguides, Spatial Modes in Step-index waveguides: TE/TM modes, Hybrid modes and Linearly Polarized modes, Power flow in Step-index fibers.

UNIT-IV

Attenuation and Nonlinear Effects in Waveguides:

Optical fiber Attenuation as a function of wavelength.

Intrinsic absorption losses, Mechanical losses, Nonlinear effects in dielectrics, Stimulated Raman Scattering, Stimulated Brillouin scattering, Self Phase modulation and Optical Solitons. The Optical -Fiber laser.

Source to fiber power launching: Source outputs pattern, Power coupling calculation, Equilibrium NA, Lansing scheme for coupling improvement: Non-imaging microsphere. Design issues in a fiber optics communication Link: Power budget, Time budget, Optical repeaters and amplifiers.

Text and Reference Books:

Fundamental of Opto-electronics by C.R.Pollock,
Irwin (1995)
Essentials of Optoelectronics, Alan Rogers,
(Chapman & Hall), 1997
Optical Fiber Communication by G.Keiser, 2nd ed.
Mc GRaw Hill
Optical communication, M. Mukunda Rao,
Universities Press (2000)
Optical Communication, Components & Systems,
J.H. Franz & V.k. jain, Narosa (2001)

Optical Communication, Components & Systems,
J.H. Franz & V.k. jain, Narosa (2001)

Optical Communication System, W.K.Pratt. (1968)

PHL-517(iii)
NON LINEAR OPTICS
(Special Paper: Optics & Spectroscopy, Group-II)

M.Marks: 70
CREDITS :4
Time:3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives
This course has been formulated to introduce students about the basics of nonlinear optics that includes optical mixing, Second and higher order harmonic generation.

Course Outcome
After completing this course, students would be able to understand the concept of nonlinear optics particularly four wave mixing, Raman and Brillouin scattering, optical solitons.

Unit I
Introduction to nonlinear optics. Maxwell's eqs. in nonlinear medium, an harmonic oscillator, nonlinear polarization & susceptibilities. Steady-state & transient nonlinear optical effects, slowly varying envelope approximation.

Unit II
Three wave mixing phenomena, sum & difference frequency generation, phase matching conditions, parametric amplification and oscillation single resonant parametric oscillator, Second Harmonic Generation, second harmonic generation conversion efficiency.

Unit III
Four wave mixing phenomena degenerate four wave mixing, Cascaded nonlinearities in & second-order media stimulated Raman & Brillouin scattering short pulse generation. Two photon absorption Optical phase conjugation (OPC), of photorefractive effect and their applications, Optical logic group velocity dispersion.

Unit IV
Self focusing phenomena and its applications, optical soliton, Interaction between ideal two level atom and coherent field (semi classical approach), induced dipole moment, brief idea about transient coherent effects. Selection criteria of nonlinear optical materials optical breakdown.

Text and Reference Books:

The Principle of Nonlinear Optics, Y.R.Shen, John Wiley, 1984.
Quantum Electronics, A. Yariv, J. Wiley, 1989.
Nonlinear Optics: Basic Concepts, D.L. Mills, Narosa, 1991.
Laser & Electro Optics: Fundamentals & Engineering, C.C.Davis, 1996.
Fundamentals of Photonics, Saleh & Teich, J. Wiley, 1992.

PHL-517(iv)
APPLIED OPTICS
(Special Paper: Optics & Spectroscopy, Group-II)

M. Marks: 70
CREDITS :4
Time:3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

This course has been formulated to introduce students about the basics of fraunhofer and fresnel diffractions, Spatial frequency filtering, Holography etc.

Course Outcome

After completing this course, students would be able to understand the concept of Diffraction, Fourier transforming properties of lens, Electro and magneto optic effects.

UNIT - I

Diffraction: Integral theorem of helmholtz & Kirchhoff diffraction formula (Sommerfeld radiation condition, Kirchhoffs boundary conditions, ubiquity factor). Fresnel-Kirchhoff approximate formula, Approximations for fraunhofer and fresnel diffractions, fraunhofer diffraction by circular apertures, fresnel diffraction by a square aperture. A thin lens as a phase transformation.

UNIT - II

Fourier Transforming properties of lenses (object placed against the lens, object placed in front of the lens, object placed behind the lens). and its applications. Frequency response of a coherent imaging system (impulse response function, coherent transfer function), frequency response of incoherent imaging system(optical transfer function & its relation to CTF, modulation transfer functions.

UNIT - III

Crystal structure of important anisotropic materials; index ellipsold, pockel & Kerr effects, Pockel effect in KDP crystal (longitudinal & transverse configurations), general consideration of modulated design. Magneto-optic effect in diamagnetic media.

UNIT - IV

The strain optic tensor, Raman-Nath & Bragg regimes of diffraction. Theory of Raman-Nath diffraction., diffraction. Introduction to Holography, the wavefront-reconstruction problem (recording of amplitude & phase), classification of holograms, hologram as a diffraction grating & zone plate, fresnel Hologram & fourier transform holograms. Application of holography.

Text and Reference Books:

Introduction to Fourier Optics, J.W. Goodman, Mg. Hill.
Engineering Optics, K. Jizuka, Springer, 1987
Contemporary Optics, Ghatak &Thyagrajan, Macmillan, 1981
Modern Optics, R. Gaenther, J. Wiley, 1990
Optical Electronics, Ghatak & Thyagrajan, Cambridge, 1991
Quantum Electronics, A Yariv, john Wiley, 1989
Laser & Electro Optics: Fundamentals & Engineering C.C.Davis 1986.
Optical Electronics, A TAriv, J. Wiley.

PHL-518(i)
COMPUTER TECHNIQUES AND COMPUTER SIMULATION
(Special Paper: Theoretical Physics, Group-III)

M. Marks: 70
CREDITS :4
Time:3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

This course has been formulated to introduce students about the computation of various types of functions, Programming language C++ and unit operating systems.

Course Outcome

After completing this course, students would be able to solve Multidimensional integration by Runge-Kutta method,Methods for solving Elliptic, Hyperbolic & Parabolic PDE, MC simulation to generate Paramagnetic to Ferromagnetic phase diagram, etc.

UNIT I

Differentiation & Integration: Differential equation (PDE&ODE) Composite Integration methods, Romberg Integration double Integration, Multi-step Methods for solving Initial Value ODE, Stability Analysis of multi-step methods, Ferrite element method for solving boundary value ODE, Multidimensional integration by MC method Runge-Kutta method for order first degree ODE, Methods for solving Elliptic, Hyperbolic & Parabolic PDE & its application to Physical problems.

UNIT II

Computations of Function: Bassel function, Legendre function, Lagrange Function, Hermite Function, Hypergeometric function, Gamma function Beta Function. Application to Physical & chemical Problems.

UNIT III

Simulation & Algorithm: Molecular Dynamics with application to elementary problems, chaotic motion of dynamical systems, Many particle system, MC simulation to generate Paramagnetic to Ferromagnetic phase diagram, Kawasaki & Glauber Kinetics, Introduction to Density functional theory based simulation.

UNIT IV

Programming Language C/c^{++} : Tutorial Introduction on C, I/o variables & expressions, Arrays, Functions, Operators, Control statements, Functions & Program structure Pointers, Library Function, Syntax, File management in C, the preprocessor.

UNIX Operating systems: Introduction, login, password electronic mail & on-line help, using of editions, File & directories, Manipulation of files directories, Concepts of shell, Information processing (Grep, find & shell Scripts) File management Commands & others (WC, sort lp, chmod), programming using unix command.

Text and Reference Books:

Sastry	Introduction Methods of Numerical Analysis	
Rajaraman	Numerical Analysis	
Rajaraman	Fortran Programming	
Vetterming	Numerical Recipes	Teukolsky Press and Framney
Binder & Herman	Monte Carlo Simulation	

PHL-518(ii)
ADVANCED QUANTUM MECHANICS
(Special Paper: Theoretical Physics, Group-III)

M. Marks: 70
CREDITS :4
Time:3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives
This course has been formulated to make understand the students the concepts of Quantum mechanics using Dirac notation, even the Schrodinger Eqn. through Dirac formulation, non relativistic quantum mechanics.

Course Outcome
After completing this course, students would be able to realise the various phenomenon interms of quantum mechanics like formulation of energy levels, concept of negative energy quantisation through Maxwell's Eqns.

UNIT I
Relativistic Quantum mechanics: Dirac equation, Free particle solution of Dirac equation, Covariant from of Dirac equation, γ (gamma) matrices and their anticommutation relations, Dirac equation in the presence of an electromagnetic field, central field, spin angular momentum, spin orbit interaction energy, energy levels of the hydrogen atom, negative energy states and explanation in terms of Dirac's hole theory.

UNIT II
Elements of field quantization: Coordinates of the field, classical lagrangian equation, classical Hamiltonian equation, Quantization of the field, Quantization of the nonrelativistic Schrodinger field using commutation relations, lagrangian and Hamiltonian density, The creation, destruction and number operators, Quantization of the non relativistic
Schrodinger field using anti commutation relations.

UNIT III
Quantization of the relativistic wave equations. Quantization of Klein Gordon equation and the complex Klein Gordon equation, Dirac Eq, Lagrangian and Hamiltonian equation, quantum equations, The N representation, negative energy states and positrons, Anticommutation relation at different times

UNIT IV
Quantum Electrodynamies: Maxwell's equations, Lorentz condition and Gauge transformations, quantization of maxwell's equations, transversality condition

Text and Reference Books:

Quantum mechanics, by L.I. Schiff, Mc Graw Hill
Quantum field theory, F. Mandl and G. Shaw

PHL-518(iii)
THEORETICAL NUCLEAR PHYSICS
(Special Paper: Theoretical Physics, Group-III)

M. Marks: 70
CREDITS :4
Time:3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

UNIT I

Single Particle Models: Spherical single particle orbits, Harmonic oscillator single particle Hamilton and wavefunctions, The spin orbit coupling, Pairing and extreme single particle model, Predictions of ion magnetic and quadrupole moments, Configuration mixing, the deformed shell model of Nilson.

UNIT II

Collective Models: The signature of collectivity of states, The quadrupole moments, The electromagnetic transitions, The electric dipole transitions, Electric quadrupole transitions, Harmonic vibrations of the nuclear surface, Quantum mechanics of the rotor, The space fixed and the body fixed co-ordinate systems, The rotation-vibration model.

UNIT III

The Interacting Boson Model: The description of nuclear collective motion in terms of bosons, Operators and definitions, The lie algebra U(6), The most general IBM Hamiltonian, The U9%0 limit and vibrational spectra.

UNIT IV

Formulation of special relativity in Minkowski space, four vector covariant forms, s, t and u variables (Mandelstam variables) and their importance in scattering problems.
SU(3), Classification of hadrons and quark model, Gell-Mann Okubo mass formula and its application to mass spectra of particles, Concept of colour quantum number, Basic features of quantum chromodynamics and comparison with quantum electrodynamics (only qualitatively)

Text and Reference Books:

Theory of Nuclear Structure by M.K.Pal (Affiliated East-West)
Nuclear models by J.M.Eisenberg and Walter Greiner (North Holland)
Simple models of Complex nuclei by Igal TAlmi (Harward Academic Publishers)
N.P.by R.R.Roy and B.P. Nigam (Wiley Eastern)
Elementary Particles by I.S. Hughes (Cambridge University Press)
Elementary Particle Physics by S.Gasiorwics (John Wiley Sons)

PHL-518(iv)
ENVIRONMENTAL PHYSICS
(Special Paper: Theoretical Physics, Group-III)

M. Marks: 70
CREDITS :4
Time:3 hours

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives
This course has been formulated to introduce students about the basics of fraunhofer and fresnel diffractions, Spatial frequency filtering, Holography etc.

Course Outcome
After completing this course, students would be able to understand the concept of Diffraction, Fourier transforming properties of lens, Electro and magneto optic effects.

UNIT I
Essentials of Environmental Physics: Structure and thermodynamics of the atmosphere. Composition of air. Greenhouse effect and enhanced Greenhouse effect. Transport of matter, energy and momentum in nature. Stratification and stability of atmosphere. Law of motion, hydrostatic equilibrium. General circulation of the tropics. Elements of weather and climate of India.

UNIT II
Solar and Terrestrial radiation: Physics of radiation. Interaction of light with matter. Rayleigh and Mie scattering. Laws of radiation (Kirchoffs law, Planck's law, Wien's displacement law, etc.). Solar and terrestrial spectra. UV radiation problem. IR absorption energy balance of the earth atmosphere system.

UNIT III
Environmental Pollution and Degradation: Elementry fluid dynamics. Diffusion. Turbulence and turbulent diffusion. Factors governing air, water and noise pollution. Air and water quality standards. Waste disposal. Heat island effect. Land and see breeze. Puffs and pulume. Gaseous and particulate matters. Wet and dry deposition. Stability and vertical motion of air. Horizontal motion of air and water. Pressure gradient forces. Viscous forces. Inertia forces. Reynolds number.

UNIT IV
Environmental change, and Remote Sensing and Global and Regional Climate: Energy sources and combustion processes. Renewable sources of energy. Solar energy, wind energy, bio-energy, hydropower, fuel cells, nuclear energy. Forestry and bio-energy. Energy balance-a zero-dimensional Greenhouse model. Global climate models.

Text and Reference Books
Egbert Boeker & Rienk Van Groundelle: Environmental Physics (John Wiley).
J.T.Hougtyion: The Physics of Atmosphere (Cambridge University Press, 1977).
J.T. widell and J. Weir: Renewable Energy Resources (Elbs, 1988).
Sol Wieder: An Introduction of Solar Energy for scientists and Engineers (John Wiley 1982).
R.N. Keshavamurthy and M. Shankar Rao: The Physics of Monsoons (Allied Publishers 1992).
K.L.Kumar: Engineering Fluid Mechanics (S.Chand, 1994).
Landau & lifshitz: Fluid Mechanics, Pergamon Press (2000).