Central University of Tamil Nadu

Thiruvarur - 610 005

Syllabus for

Integrated M. Sc. (Physics)

Program – Starting 2016

To be implemented from 2016 – 17 Batch onwards

Department of Physics

Curriculum for the five year IMSC - Physics program starting from admission year 2016-2017
Central University of Tamil Nadu, Thiruvarur - 610 005.

SEMESTER	CORE COURSES (Credits)	Ability Enhancement Compulsory Courses-AECC (Credits)	Skill Enhancement Courses –SEC (Credits)	Discipline Specific Electives – DSE (Credits)	Total Credits
I	Parent Dept. a (5) Mechanics Physics Laboratory – I	English (3) Environmental Science (2)			20
	Other Dept. 1a (5) Chemistry –I				
	Other Dept. 2a (5) Mathematics – I				
II	Parent Dept. b (5) Waves, Oscillations, Sound and Optics Physics Laboratory – II	English (3) Media & Information Literacy (2)			20
	Other Dept. 1b (5) Chemistry –II				
	Other Dept. 2b (5) Mathematics – II				
III	Parent Dept. c (5) Heat and Thermodynamics Physics Laboratory – III	Language (3) Disaster Management (2)			20
	Other Dept. 1c (5) Chemistry –III				
	Other Dept. 2c (5) Mathematics – III				
	Parent Dept. d (5) Electricity and Magnetism Physics Laboratory – IV				20

IV	Other Dept. 1d (5) Chemistry –IV Other Dept. 2d (5) Mathematics – IV	Language (3) Anti-Corruption (2)			
(Min – Max Credits)	(124-132)		(4-8)	(36-48)	(116)
V	Mathematical Physics-I (4) Classical Mechanics (4) Modern Physics & Relativity (4) Modern Physics Laboratory (2)		Machine Shop (2)	Numerical Methods and Computer programming (4) Computational Laboratory-I (2)	14+2+6 = 22
VI	Mathematical Physics-II (4) Quantum Mechanics-I (4) Electro Magnetic Theory (4) Condensed Matter Physics- I (4) Condensed Matter Physics Lab (2)			Elective Paper (4)	18+0+4 = 22
VII	Quantum Mechanics II (4) Atomic & Molecular Physics (4) Statistical Mechanics (4) Atomic Physics and Optics Lab (2)			Electronics (4) Electronics Lab (2) Elective Paper (4)	14+0+10 = 24
VIII	Modern Optics (4) Nuclear and Particle Physics (4)			Laser Physics (4) Laser Physics Laboratory (2) Experimental Methods and Design (4) Experimental Techniques Lab (2)	8+0+12 = 20

IX	Condensed Matter Physics- II (4)		Advanced Physics Laboratory (2)	Computational Physics (4) Computational Laboratory-II (2) Elective Paper (4)	4+2+10 = 16
X	Project and Thesis (12)				= 12
Grand Total (Credits)	130	20	4	42	196

(Those in red are core papers)
The university has implemented CBCS from the academic year 2015-2016. The norms of CBCS state that the general pattern should be as follows:

A student should earn a minimum of 196 credits over the 5 year period. The credits should be as per the following breakup:

Core Courses – 124-132

Ability Enhancement Compulsory Course – 20 (non-Negotiable) – English, 2nd Language, Gandhian Thought, Environmental Science etc

Skill Enhancement Course – 4-8 like Machine shop, computer/soft skills etc

Department Specific elective – 36-48 – electives offered by the department for the students of the

department. General Elective – Over and above 196 credits. – Electives offered by other department.

IMSC Physics – Syllabus

Mechanics

Sub Code: PHY111
Semestter: I

Course Objectives:

- The primary aim of this course is to provide the comprehensive understanding of fundamental aspects of mechanics including the kinematics and dynamics. This course covers the general motion of particle in uniform fields, different co-ordinate systems, Newton's laws of motion in non-inertial frames, pendulums, theory of gravitation, systems of particles, energy, momentum, conservations laws, rigid body dynamics, collisions, frictions, and particle motion in central forces.

Course Outcomes:

Upon successful completion of this course , student should be able to:

- Understand the core principles of mechanics and have a knowledge on their applications
- Apply the different co-ordinate systems (Cartesian, cylindrical and spherical coordinate systems) to describe the motion of particle.
- Calculate the moment of inertia of a different bodies using the parallel and perpendicular axis theorem
- Determine the gravitation field and potential due to circular ring, spherical shell and solid sphere etc
- Solve the problems involving translation and rotation of a rigid body by applying principles of kinetics, work-energy theorem and impulse momentum.
- Describe th motion in central forces and Keplers laws of orbits

UNIT-1

Frames of reference, Inertial and non-inertial frames, Galilean transformation, Newton's laws of motion, Integration of Newton's law with various kinds of forces, Motion in uniform field, Components of velocity and acceleration in Cartesian, polar and cylindrical coordinate systems, system of particles, Centre of mass and its equation of motion, Conservation of – energy and linear momentum, Impulse and Linear momentum, Elastic and inelastic collision, direct and oblique collision of two smooth surfaces, Work, power and energy; conservation of mechanical energy.

UNIT-2

Angular velocity and angular momentum, conservation of angular momentum, Centripetal acceleration due to rotation, banking of curves, Rotational motion, Rolling, Moment of inertia, Calculation of moment inertia of systems of different geometrical shapes, parallel and perpendicular axis theorems, Radius of gyration, Pendulums, Gravitation and. gravitational potential due to spherical shell and sphere.

UNIT-3

Motion in a general central force field and the special case of inverse-square force field, Central force problem: Kepler problem, inverse square law force, geosynchronous orbits, weightlessness, global positioning system (GPS), scattering in central force field, Rutherford formula, Virial theorem.

UNIT-4

Elasticity, strain and stress, Young's modulus, Hook's law, Bulk modulus. Inter relations of elastic constants for an isotropic solid; torsional rigidity; bending moments and shearing forces; cantilever; Elasticity Energy in a strained body, Torsion of a rod, Torsional oscillation, Word done in stretching and twisting a wire, Searles method – determination of rigidity modulus and moment of intertia, Bending of beam, Beam of I section, Cantilever and depression of a cantilever.

UNIT 5

Fluid statics, Pressure and density, Buoyancy, Archimede's principle, Introduction to surface tension, Derivation and applications of Hydrostatic equation Free surface energy, excess pressure – application to spherical, cylindrical drops and bubbles, variation of surface tensiton with temperature – Jaegar's method, Fluid flow, stream lines and tubes of flow, Equation of continuity; Euler's equation for liquid flow, Bernoulli s theorem -applications, Fluid friction and coefficient of viscosity. Poiseuilles equation for incompressible fluids; Stokes law; terminal velocity,effect of temperature on viscosity; Reynolds number.

Books recommended:

1. Theoretical Mechanics - M. R. Spiegel, (Schaum's Outline Series) (McGraw-Hill).
2. Mechanics - K. R. Symon (Addison-Wesley).
3. Introduction to Classical Mechanics - R. G. Takwale and P. S. Puranik (Tata McGrawHill).
4. R. P. Feynman, Lectures on Physics (vol-1), Narosa Publishing, 2008.
5. An Introduction to Mechanics – D. Kleppner and R.J. Kolenkow (Tata McGraw-Hill)
6. H. Goldstein, *Classical Mechanics*, Addison Wesley, Pearson Education, 2007.
7. R. D. Gregory, *Classical Mechanics*, Cambridge University Press, 2006.
8. N. C. Rana and P. S. Joag, Classical Mechanics, Tata-McGraw-Hill, 1991.
9. Sears and Zemansky, University Physics.(1987)
10. Newman & Searle : General Properties of Matter
11. Mathur D.S. : Elements of Properties of Matter
12. The General Properties of Matter - F. H. Newman and V. H. L. Searle (Radha Publ. House).
13. Mechanics and General Properties of Matter – D. P. Roychaudhuri and S. N. Maiti(Book Syndicate).

Supplementary Reading:

1. L. D. Landau and E. M. Lifshitz, Course of Theoretical Physics- Mechanics, (vol.-1), 3rd Ed., Pergamon Press.

2. D. Morin, Introduction to Classical mechanics (with problems & solutions), Cambridge University Press, 2008.
3. T. W. B. Kibble and F. H. Berkshire, Classical Mechanics, 5th Ed., Imperial College Press, 2004.
4. Srinivasa Rao K N, "Classical Mechanics, University press, ", Ist Edition, 2003.
5. Biswas S N, "Classical Mechanics", Books and Allied Ltd., Kolkatta, 1998.
6. Fowles Cassiday (2004). Analytical Mechanics. 7th Edition. Thomson Brooks/Cole.
7. Y. R. Waghmare (1990) Classical Mechanics. Prentice Hall of India, New Delhi.
8. John R. Taylor (2005). Classical Mechanics. University Science Books.

Physics Laboratory –I (Mechanics Lab):

Sub Code: PHY112
Semester: I

Preliminary experiments
(a) Vernier calipers
(b) Screw gauge
(c) Physical Balance.
(d) Travelling Microscope

Core experiments
1. Young's modulus – cantilever bending
2. Young's modulus –Koenig's Method
3. Torsional Pendulum
4. Verification of Hooke's law
5. Projectile motion
6. Conservation of momentum
7. Conservation of energy
8. Archimedes principle
9. Centripetal force
10. Measurement of surface tension using capillary rise method.

Waves, Oscillations, Sound and Optics

Sub Code: PHY121

Semester: II

Course Objectives:
- Introduction to the physics oscillations, waves and geometrical optics.

Course Outcomes:
- The student, at the end of the course, is supposed to have learnt the basics of oscillations – free, damped and forced and about transverse waves and longitudinal waves in solids and fluids. The student is also supposed to have learnt the basics of geometrical optics, reflection, refraction, dispersion and about specific experiments in optics and spectroscopy

1. **Vibrations:** Simple harmonic motion, Angular simple harmonic oscillator, Damped harmonic oscillator, relaxation time, Forced oscillations and Resonance; Condition for resonance- sharpness of resonance - coupled harmonic oscillators.

2. **Waves:** Transverse vibrations in stretched strings, Wave equation in the linear approximation - Speed, Energy of transverse vibrations, Linear equation of plane progressive wave motion in one dimension; wave propagation - group velocity and phase velocity; Traveling waves, Superposition principle, Wave speed, Power and intensity in wave motion, Interference of sound waves, Stationary waves.

3**. Sound**: Waves on strings and surfaces, Propagation and speed of longitudinal waves, Vibrating systems and sources of sound - musical sound and noise, characteristics of musical sound: Loudness, noise, quality and intensity. Beats. The Doppler effect - derivation of expression for Doppler shift in frequency - Shock waves, Velocity of sound and its measurement, Factors affecting the speed of sound. Audible, ultrasonic and infrasonic waves. Ultrasonic-Introduction, production, Applications.

4. **Geometrical Optics:** Nature and propagation of light, Reflection, Refraction, Fermat's principle, Images, Plane mirrors, Spherical mirrors, Spherical refracting surfaces, Lenses, Defects of images, Spherical and Chromatic aberrations, Achromatism of two thin lenses separated by a distance. Dispersion produced by a thin prism - Dispersive power - Cauchy's formula.

5. **Wave Optics:** Spectrometer - measuring refractive index - Optical instruments (Microscopes and Telescopes), Velocity of light and its measurement. Simple account of Wave theory, Newton's ring, Air Wedge, Colour on thin films.

References:

1. David Halliday, Robert Resnick and Jearl Walker (2004) Fundamentals of Physics. 7th edition. John Wiley & Sons. 8th Ed. (2008).
2. Vibrations and waves, A.P. French, Second Edition (1971), Norton & Company, Newyork
3. Berkeley Physics Course - Vol. 3: Waves and Oscillations (Crawford)
4. Optics, Ajoy Ghatak, Fourth Edition (2009), Tata McGraw Hill
5. Fundamentals of Optics: K. G. Mazumdar

Suggested Reading:

1. F. W. Sears, M. W. Zemansky, and H D Young, University Physics, Addison Wesley (1976)
2. Fundamentals of Optics : Jenkins and White
3. Geometrical and Physical Optics : P. K. Chakraborty
4. Optics : B. K. Mathur
5. Optics : A. N Matveev

Physics Laboratory – II (Waves, Oscillations, Sound and Optics Lab)

Sub Code: PHY122
Semester: II

1. Simple pendulum and Compound pendulum
2. Resonance air column and water column
3. Newton's rings
4. Sonometer
5. Focal length 'f' of lenses
6. Angle of prism and minimum deviation of solid prism
7. Diffraction using grating.
8. Air wedge.
9. Angle of prism and minimum deviation of liquid prism

Heat and Thermodynamics

Sub Code: PHY211
Semester: III

Course Objectives:

- This course discusses on thermometry: thermal equilibrium; temperature scale; specific heats; constant volume thermometer; resistance thermometer; Law of heat and work: all laws of heat and thermodynamics; isothermal and adiabatic transformations. principle of increasing entropy; Transfer of heat: mode of heat transfer; Lee's dic method; Dulong-Petit's law; specific heat of gases; Phase transformation: Maxwell's equations; kinetic theory of gases; liquefaction of gases; Van der Waals state equations; Clausius and Clapreyon heat equations; Heat engines and refrigerators: Carnot engine; cycle; Carnot cycle in P-V and T-S diagram; internal combustion; Diesel and steam engine.

Course Outcomes:

- Students are exploited knowledge about heat and energy, thermodynamic state, transformation process. Latent heat, specific heat, thermal condivity, Gibbs free energy, enthalpy, Van der Waals application, real gas conversion into ideal gases, working process of heat engines etc.

1.**Thermometry:** Thermal equilibrium and notion of temperature; Zeroth law of thermodynamics; Thermometers and temperature scales: Celsius and Fahrenheit scales; Linear, surface and volume expansions; Absorption of heat by solids and liquids ; specific heat; Molar specific heat of solids; Constant volume gas thermometer; Platinum resistance thermometer; Callender & Griffith's bridge – Thermistor; Ideal gas temperature scale.

2. **Law of Heat and work**: Equivalence of heat and work; Internal energy function; First law of thermodynamics; Second law of thermodynamics: Kelvin-Planck and Claussius statements; Reversible and irreversible transformations. Entropic formulation of second law: reversibility, irreversibility and the principle of the increase of entropy. Carnot engine and refrigerator: Carnot cycle, efficiency, Coefficient of performance, Carnot cycle in P-V and T-

S planes; Thermodynamic temperature scale; Different heat engine cycles: Internal combustion engine, Diesel engine and steam engine. Third law of thermodynamics.

3.**Transfer of heat:** Conduction, convection and radiation; Definition of thermal conductivity, thermal conductivity of bad conductor -Lee's disc method; Black body radiation; Wien's law, Rayleigh-Jean's law and Planck's law ;Stefen's law ; Specific heat capacity of solids - Dulong & Petit's law ; Specific heat capacity of liquid; method of mixtures; Cooling correction - Specific heat of capacity of gases - C_p and C_v by Regnault's and Callender and Barne's methods

4. Phase transition: Exact and inexact differentials ; Relations among partial derivatives of entropy and of Internal energy : Maxwell's relations ; Legendre transformation ; Helmholtz free energy , enthalpy and Gibbs free energy; Kinetic theory of gases; Meyer's relation ; Change of phase, Latent heat, discontinuous and continuous phase transition, regelation, triple point; Examples of phase transitions. Real gases: Liquefaction of gases; critical point, thermodynamic surfaces, Clausius Clapreyon heat equation; Van der Waals gas: equation of state, critical temperature, critical pressure and critical volume; The Virial Expansion.

5. **Statistical Physics**: Macroscopic and microscopic variables; Configuration space, Concept of Phase space; Maximum entropy principle; Statistics of particles - Maxwell-Boltzmann, Bose-Einstein and Fermi Dirac Statistics (qualitative).

References:

1. Heat and thermodynamics - Zemansky and Ditman (Mc Graw Hill).
2. F. W. Sears, and G. L. Salinger, Thermodynamics, Kinetic theory, and Statistical Thermodynamics, (Narosa , 1986)
3. An introduction to Thermal Physics, D.V. Schroeder, (Pearson, 2008)

Suggested Reading:

1. Introduction to Statistical Physics, K. Huang, (Taylor and Francis, 2001).
2. Fundamental Thermodynamics, G. Weinreich (Addison-Wesley, 1968).
3. D. Kondelpudi, and I. Prigogine, Modern Thermodynamics: from Heat Engines to Dissipative Structures, John Wiley (1998).
4. Thermodynamics – F. Fermi.
5. A Treatise on Heat - Saha and Sribastava (The Indian Press Ltd).
6.Thermal Physics – S. Garg, R. M. Bansal, C. K. Ghosh (Tata Mc Graw Hill).
7. Heat and Thermodynamics – H. P. Roy and A. B. Gupta.
8. J S Dugdale, Entropy and its physical meaning, Taylor and Fancis (1996)
9. Fundamentals of Physics, 6th Edition, by D.Halliday, R.Resnick and J.Walker, Wiley, NY, 2001.
10. Thermal Physis, C. Kittel and H. Kroemer , (W. H. Freeman , 1980)

Physics Laboratory – III (Heat and Thermodynamics Lab)

Sub Code: PHY212
Semester: III

Preliminary experiments::
An introduction to the subject - will not be included in the finalExam

1. Temperature of mixing - mix hot and cold water - note their initial and final temperature - try and predict the final temperature
2. Galton's board
3. Thermometry - Measuring temperature using different thermometers such as (a) alcohol (b) mercury (c) IR (contact less) (d) digital (e) min-max (f) dry-wet (for humidity)
4. Place a cube of ice on three different black colored boards - one made of metal, one of wood and one of plastic - qualitative concepts of specific heats and thermal conductivity

Core Experiments:
1. Newton's law of cooling
2. Thermal conductivity of a good conductor - Searle's method
3. Thermal conductivity of a bad conductor - Lee's method
4. Specific heat by method of mixtures
5. Verification of Stefan-Boltzmann law
6. Latent heat of steam/ice
7. Verification of Boyle's law
8. Seeback effect and thermocouple
9. Mechanical equivalent of heat

ELECTRICITY AND MAGNETISM

Sub Code: PHY221
Semester: IV

Course Objectives:
- This paper aims to give the students a working knowledge of electricity and magnetism. It is assumed that the student has had a one-term course on differential and integral calculus. No previous knowledge of vectors, multiple integrals, differential equations, or complex numbers is assumed. Starting from vector analysis focuses on various electrostatic and magnetostatic laws, current electricity, alternating current and finally ends with basic Maxwell equations.

Course Outcomes:
- After successful completion of this course, student should be able to:
- Discuss the basic vector theory (div, curl, del, stokes and green's theorem)
- Explain the fundamental laws in electricity and magnetism such as coulomb's law, ampere law, biot-savart law, Fleming's left and right hand rule etc.
- Discuss the different types electrical measuring instruments (wheatstone's bridge, and anderson's bridge, galvanometer and wattmeter).
- Explain the interesting topic of hysteresis cycle on ferromagnetic materials.
- Know how the resonance are happened in series and parallel LCR circuits and working of transformers

UNIT 1
Introductory vector analysis: div, grad, curl; Stokes' and Green's theorems. Electrostatics: Inverse square law, Problems related to coulombs law-Cavendish proof, Electric field and intensity, Electric field of a point charge, multiple point charges, dipole, line of charge;

Electric field of rings, discs, planes and spheres- Electrostatic potential- relation between electric field and potential, potential due to a point charge, infinitely charged long wire, uniformly charged disc- equipotential surfaces, electric multipoles- potential and field due to a point dipole.

UNIT 2

Electrostatic energy of charge configurations, energy of a charged sphere. Conductors in an electrostatic field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor, capacitors and their types, capacitors in series and parralel combinations, capacitance of an isolated conductor. Method of Images and its application to plane infinite sheet of charge and charged sphere.

UNIT 3

Magnetism: Magnetic field, magnetic shell, magnetized sphere, forces and couples between magnets, B&H lines of force of a bar magnet, Terrestrial dip circle, magnetic condition of the earth, Biot-Savarats law, magnetic field due to a straight, circular conductor and solenoid, Self and mutual indication, calculation of inductance, measurement of L & M. measurement of permeability and susceptibility, basic ideas of para-, ferro – and diamagnetism cycle of magnetization, hysteresis, energy loss due to hysteresis,

UNIT 4

Current Electricity: Steady current, standard cells, secondary cells, Helmholtz Gibb's equation; Force between currents, Ampere's theorem and of its applications; Resistors and Ohm's law, Kirchoff' laws, conservation theorems and their applications; electrical measuring instruments: Wheatstone bridge, Anderson's Bridge, moving coil galvanometers, ballistic galvanometer, Ammeters and Voltmeters, Wattmeter.

UNIT 5

Alternating currents: A.C. generators- polyphase circuits- with star and delta connections, rotating magneitc field and induction motor, principle of working and uses of transformers. Chokes, resonance and resonant circuits, power in A.C. circuits. Resonance circuits – RC, LC and RLC circuits. Phasor representation and Q factor. Impedance of series and parallel resonant circuits. Maxwells's equations in vacuum and media, derivation of wave equation and its plana wave solutions. Basic ideas of reflectance, absorbance, transmittance, and polarization of electric magnetic waves.

References:

1. David Halliday, Robert Resnick and Jearl Walker (2004) Fundamentals of Physics. 7th edition. John Wiley & Sons. 8th Ed. (2008)
2. Tewari K K, "Electricity and Magnetism", S.Chand and Co., 1994.
3. Sears, Zemansky and Young, University Physics, Narosa Publishing House, Delhi.

Suggested Reading:

1. Brijlal and Subramaniam, "Electricity and Magnetism", Ratan Prahasan Mardis Educational and University Publishers, Delhi, 1990.
2. David Griffiths, Introduction to electrodynamics, Pearson Education
3. H.C.Verma, Concepts of Physics, Bharathi Bhavan
4..Mahajan and Rangwalla, Electricity and Magnetism, Mcgraw Hill
5. Martin A Plonus, "Applied Electromagnetics", McGraw Hill International Edition, 1998.
6. Bennett A, "Electricity and Modern Physics", ELBS, 1972.
7. Jacob Millman and Christos C Halkias, "Electronic Devices and Circuits", Tata McGraw

Hill Edition, 1991.
8. Ashutosh Pramanik, "Electromagnetism- Theory and Applications", Prentice Hall of India Pvt. Ltd., 2003.

Physics Laboratory – IV (Electricity and Magnetism Lab)

Sub Code: PHY222
Semester: IV

Preliminary experiments:
1. Mapping of electrical field lines for different charges and charge configurations.
2. Mapping of magnetic field lines using a bar magnet and compass/iron filings
3. Lenz's Law – take two identical copper pipes – drop a steel ball and a magnet – magnet will take much longer to fall
4. Shielding of Magnetic fields by different materials using a rare earth magnet and gauss meter

Core experiments:
1.. Verification of Kirchoff's laws
2. Resonance in LCR Circuits and Transient response of resonant circuit
3. Conversion of Voltmeter to Ammeter. And ammeter to Voltmeter
4. Hysteresis curve
5. Measurement of Average Resistance of a Wire by Carey-Foster Method and hence to determine the Value of Unknown Resistance
6. Charging and Discharging a Capacitor
7. Determination of the Moment of a Bar Magnet and the Horizontal Component of Earth's Magnetic Field by Magnetometers
8. Comparison of EMF of cells using by potentiometer.
9. Determination earth magnetic field using by tangent galvanometer and determination of reduction factor of given tangent galvanometer.
10. Kelvin double bridge

Mathematical Physics I

Sub Code: PHY311
Semester: V

Course Objectives:
- This course is an introduction to the basic concepts of mathematical physics at the undergraduate level. This course is intended to introduce the students to the applications of mathematical methods in physics. Starting from the basics of vector algebra, the course focuses on matrices, linear algebra, and complex analysis. The course ends up with the study of different methods for solving differential equations.

Course Outcomes:
- At the end of this course, students will develop knowledge of mathematical physics and its applications and get expertise in mathematical techniques that are required in physics. Students will also be able to enhance problem solving skills and solve differential equations that are common in physical sciences.

1. Ordinary and partial Differential Equations: Linear ordinary differential equations – Elementary methods – Linear second order differential equations with variable coefficients – Frobenius method-wronskian-physical example. Method of forming partial differential equations – Solution by direct integration – Method of separation of variables – Partial differential equations in physics problems – Wave equation – Equation of vibrating string – One dimensional heat flow – Two dimensional heat flow – Laplace equation.

2. Vector Analysis: Gradient, Divergence, Curl and ∇^2 operators in curvilinear coordinates. Divergence theorem, Stokes theorem. Green's theorem. Linear Vector Spaces : Definition vector space, Subspace, basis, Linear dependence, Inner product Space, complete set, Hilbert space, Schwarz inequality, Gram Schmidt orthogonalization process.

3. Operators: Linear and nonlinear Operators, Eigen values: degenerate and non degenerate, Eigen functions: adjoint, Hermitian and unitary operators, similarity transformation, differential, integal and matrix representation of operators and its applications.

4. Tensors: Contravariant and Covariant tensors – Addition – Subtraction – Outer and inner products – Contraction – Metric tensor – matrix representation of tensors- Hooke's law stress— strain Piezoelectricity and dielectric susceptibility – Moment of inertia tensor. Tensor applications in mechanics.

5. Complex Analysis: Functions of complex variable, derivative and Cauchy-Riemann differential equations, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, Cauchy's residue theorem, singular points of an analytic function, evaluation of residues, evaluation of definite integrals.

References:

1. Butkov E, Mathematical Physics, (Addison Wesley, New York, 1973).
2. Arfken G and Weber H J, "Mathematical Methods for Physicists", (Academic Press, SanDiego, 2001).
3. Kreyszig E, "Advanced Engineering Mathematics", 8th Edition. (Wiley, New York, 1999).

Suggested Reading:

1. D.C. Kay, Tensor Calculus , Schaums Outlines, McGraw-Hill..
2. Pipes L.A. & Harvil, Applied Mathematics for Engineers and Physicists, McGraw-Hill Book Co., New York, 1980.
3. Grewal B.S., Higher Engineering Mathematics, Khanna Publishers, New Delhi, 1998.
4. M.K.Venkatraman, Advanced Mathematics for Engineers & Scientists, National Publishing Co., Madras, 1994.
5. Gupta, B.D., Mathematical Physics 3rd Edition, Vikas Publishing House Pvt Ltd, New Delhi, 2004
6. A Papoulis and S U Pillai, Probability, Random Variables and Stochastic Processes, McGraw Hills (2002)
7. Walpole,E, Myers,R.M, Myers,S.L and Ye,K, "Probability & Statistics for Engineers and Scientists", Pearson Education, 2002.
8. Sathya Prakash, "Mathematical Physics", Sultan Chand & Sons, 2000.
9. Ghatak A.K , Goyal I C and S.H.Chua, "Mathematical Physics", Macmillan India, New Delhi, 2002.
10. Linear Algebra: A Geometric approach, S. Kumaresan (PHI learning 2000).

CLASSICAL MECHANICS

Sub Code: PHY312
Semester: V

Course Objectives:
The course has the following major objectives:

- Gain deeper understanding of classical mechanics: Consolidate the understanding of fundamental concepts in mechanics such as force, energy, momentum etc. more rigorously as needed for further studies in physics, engineering and technology.
- Advance skills and capability for formulating and solving problems: Expand and exercise the students' physical intuition and thinking process through the understanding of the theory and application of this knowledge of classical mechanics to the solution of practical problems. Learn and apply advanced mathematical techniques and methods of use to physicists in solving problems. The lectures are supplemented with a number of problem solving sessions and take-home assignments to enable enhanced learning.

Course Outcomes:

- The study of classical mechanics which does fulfill the new requirements. At the end of this course students will be able to demonstrate the competency in solving the dynamical equations using the Lagrangian and Hamiltonian formulations. They will be able to develop problem solving skills.

Unit-I : Langrangian Formulation
System of particles, Newtonian mechanics, Non-inertial frame, constraints and degrees of freedom – generalized coordinates- conservation of linear and angular momenta- D'Alemberts principle of virtual work- Lagrange's equation of motion – applications of Lagrange's equation of motion –applications of Lagrange equations of motion; single particle in space-Atwood's machine-bead sliding in rotating wire, generalized momenta, Routh's procedure, symmetry properties and conservations theorems.

Unit-II : Hamilton Principle
Calculus of variation – Liouville theorem-Hamilton's principle – derivation of Lagrange's equation from Hamilton's principle – Hamilton's principle for nonholonomic system-variational principle – Legendre transformation and Hamilton's equations of motion –cyclic coordinates and conservation theorem – Hamilton's equations from variational principle – principle of least action – Solving the Harmonic Oscillator problem using canonical transforms- Canonical transformations- angular momentum using Poisson brackets-Generating functions –Examples – Poisson brackets and its properties

Unit-III : Small Oscillations
Small oscillations of dynamical systems, equilibria and derivations, frequencies of free vibrations and normal coordinates and normal modes; motion of masses connected by springs –vibrations of linear triatomic molecule.

Unit –IV : Kinematics of Rigid Body

Independent coordinates of rigid body – orthogonal transformation – properties of transformation matrix – Euler angle and Euler's theorem – infinitesimal rotation –rate of change of vector – Coriolis force – angular momentum and kinetic energy of motion about a point – moment of inertia tensor – Euler's equations of motion – torque free motion of a rigid body –heavy symmetrical top.

Unit-V : **Hamilton –Jacobi Theory**

Hamilton–Jacobi equation for Hamilton's Principle function- Example; Harmonic oscillator problem- Hamilton's characteristic function – Action – angle variable in systems of degree of freedom- application of angle of action to Kepler problem and simple harmonic oscillator.

Referemces:

1. Classical Mechanics by H. Goldstein, Addison Wesley, Pearson Education, 2007.
2. Theoretical Mechanics by M.R. Spiegel, Schaum's Outline Series, McGraw- Hill Press, 1987.
3. Introduction to classical mechanics (with problems & Solutions) by D. Morin, Cambridge University Press, 2008.
4. Mechanics by Keith R. Simon, Addison-Wesley, 2nd Ed. 1971.
5. Classical Mechanics by K. N. Srinivasa Rao, Universities Press (India) Pvt. Ltd, 2003.

Suggested Reading:

1. Classical Mechanics by N.C. Rana and P.S. Joag, Tata-McGraw-Hill, 1991.
2. Introduction to classical Mechanics by R.G. Takwale and P.S. Puranik, Tata McGraw-Hill, 1979.
3. LCourse of Theoretical Physics-Mechanics by D. Landau and E.M. Lifshitz,, (Vol-1), 3^{rd}Ed..,Pregmen Press. 1969.
4. Classical Mechanics by T.W.B. Kibble and F.H. Berkshire, 5^{th} Ed., Imperial College Press, 2004.

Modern Physics and Relativity

Sub Code: PHY313
Semester: V

Course Objectives:

- Study of atomic physics and specific developments which led to the birth of quantum mechanics – quantum theory. The course also introduces the subject of the special theory of relativity.

Course Outcomes:

- The student, at the end of the course, is supposed to have learnt how quantum theory completes the understanding of the experiments in atomic physics.

Unit 1: Pre-Relativity/Quantum Physics – Brief history of Physics up to 1800 – special mention of scientific ideas from India - wave and corpuscular theories of light – Young's Double slit experiment – unification of ideas of electricity and magnetism – Maxwell's equations – Aether hypothesis and Michelson-Morley Experiment.

Unit 2: Special theory of Relativity: Einstein's Principles and postulates of relativity and concept of space-time, length contraction, time dilation and Doppler effect, velocity addition formula, four vector notation, relativistic dynamics- variation of mass with velocity. Energy momentum and mass energy relations. energy–momentum four-vector for a particle, relativistic invariance of physical laws- Twin paradox, relativity of mass, Einstein's mass-energy equivalence, massless particles.

Unit 3: Reference system, Inertial and Non-inertial frames, Galilean invariance and conservation laws - Newtonian Relativity Principle, Velocity of light, Michelson-Morley experiment – Search for ether – Lorentz transformations- Introduction - Newton's law of Gravitation and its limitations - Gravitational mass and inertial mass Principle of Equivalence. Applications of Relativity: Relativistic Effects and Paradoxes - Minkowski Diagrams; Relativistic Momentum, Energy, and Mass- Relativistic Particle Collisions; Relativity and Electricity: Coulomb's Law, Magnetic Fields

Unit 4: Failure of Classical Physics – Photoelectric effect, Positive rays and their analysis. Cathode rays, e/m Thompsons method, Rutherford's experiment and model of atom and its limitations. Millikan's method, Mass of the electron, Atomic structure, Bohr's theory and evidences in favour of and against the theory, Stark effect, Normal Zeeman effect, Stern-Gerlach experiment, Concept of spin, Pauli's exclusion principle, Franck–Hertz experiment, Fine structure of spectral lines, D lines of sodium . X-rays, Properties, Braggs law, Compton's effect

Unit 5: Elementary properties of nucleus, Nuclear structure – binding energy – radioactivity – nuclear fission and fusion – four fundamental forces in nature – basic ideas of elementary particles – particles and anti-particles - idea of standard model – discovery of Higgs boson and gravity waves.

References:

1. Beiser A. : Perspectives of Modern Physics
2. Mani H.S. and Mehta G.K. : Introduction to Modern Physics
3. 1000 Solved Problems in Modern Physics, Ahmad.A.Kamal, Springer.

Suggested Reading:

1. Feynmann R.P. Et al : The Feymann Lectures in Physics, B.I. Publication
2. Khandelwal D.P. : Optics and Atomic Physics, Himalaya Publishing
3. Hertzberg G. : Atomic Spectra and Atomic Structure
4. Hertzberg G. : Molecular spectra and Molecular Structure
5. Introduction to Atomic Spectra : H. E. White (McGraw Hill).
6. Atomic and Molecular Spectroscopy: Dunford.
7. R. Eisberg and R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley, India Pvt. Ltd., 2006.
8. Atoms and molecules by M. Weissbluth
9. Atomic Physics by J. B. Rajam

10. Christopher J. Foot – Atomic Physics, Oxford Master series, 2005
11. G.K.Woodgate, Elementray Atomic Structure, Second Edition Clarendon Press, Oxford.
12. T.A. Littlefield - Atomic and Molecular Physics.
13. P. Atkins, J. D. Paula, Atkins' Physical Chemistry, Oxford University Press, (Indian Edition), 8th Edition, 2008.
14. Quantum theory of Atomic Structure Vol I by Slater
15. Quantum theory of molecules and Solids by Slater

Modern Physics Laboratory

Sub Code: PHY314
Semester: V

List of Experiments:
1. Millikan's Oil Drop Method
2. Rydberg Constant
3. Balmer – Emission Spectra
4. Frank – Hertz Experiment
5. Zeeman Effect
6. e/m by Thomson method
7. Electron spin Resonance
8. Planck's Constant
9. Own experiments.

Numerical Methods and Computer Programming

Sub Code: PHY351
Semester: V

Course Objectives:

- This course mainly covers the FORTRAN and C Programming languages. At the initial level, students learn the very simple programs. After getting some knowledge in both languages, the students are encouraged to use the tools to solve the problems based on Numerical Methods.
- The students are given equal weightage for evaluation on all the three languages (C, Modern Fortran and Python) so that the students spent adequate time in grasping the programming concepts and code. The most important objective of this course is that the students can implement the code after practicing programming in C or Fortran in solving mathematical equations and problems which are very common in physics

Course Outcomes:

- At the end of this course, students will write the programs on their own and solve numerical problems in physics.

Numerical Analysis

Unit 1: Approximations and round off errors: Significant digits, true/absolute and truncation errors, Taylor Series – Taylor polynomial error formula. Determination of roots of polynomials and transcendental equations: Bisection methods, Newton-Raphson method, Secant method and Bairstow's method. Solutions of linear simultaneous linear algebraic equations by Gauss Elimination and Gauss- Siedel iteration methods.

Unit 2: Curve fitting- linear and nonlinear regression analysis. Backward, Forward and Central difference relations and their uses in Numerical differentiation and integration, Application of difference relations in the solution of partial differential equations. Numerical solution of ordinary differential equations by Euler, Modified Euler, Runge-Kutta and Predictor-Corrector method.

Unit 3: Numerical integration: midpoint rule, trapezeoidal method, Simpson's method, Newton-Cotes method, Gaussian rules. Least squares approximation, fitting data to a straight line, fitting data to linear combinations of functions.

Computer Programming

The emphasis should be more on programming techniques rather than the language itself. Languages such as MODERN FORTRAN/C/Python may be used.

Unit 4: Arithmetic expressions, Concepts of variables, expressions and statements, program statements and function calls from the library (printf for example) data types - int, char, float etc. expressions, arithmetic operations, relational and logic operations. Assignment statements, extension of assignment to the operations. Statements, conditional execution using if, else. Optionally switch and break statements may be mentioned.

Unit 5: Branching of a program – branch, loop, conditional loops. Concepts of loops, example of loops in C using for, while and do-while, continue. One dimensional arrays and example of iterative programs using arrays, 2-d arrays. Use in matrix computations. Concept of Sub-programming, functions. Example of functions. Argument passing mainly for the simple variables. Pointers, relationship between arrays and pointers. Argument passing using pointers. Array of pointers, Passing arrays as arguments.

References:

1. Venkatraman, M. K., "Numerical Methods in Science and Engineering", National Publishing Company, Madras, 1996.
2. S.S.Sastry, "Introductory Methods of Numerical Analysis", Prentice Hall of India, New Delhi, 1992
3. Grewal, B.S. and Grewal,J.S., " Numerical methods in Engineering and Science", 6th Edition, Khanna Publishers, New Delhi, 2004.
4. Sankara Rao, K. "Numerical methods for Scientists and Engineers', 3rd Edition, Prentice Hall of India Private Ltd., New Delhi, 2007.
5. "Modern Fortran Explained", by Michael Metcalf , John Reed, and Malcolm Cohen, Oxford University Press, 2011.
6. "Guide to Fortran 2008 Programming" by Walter S. Brainerd (Springer 2015).
7. Introductory Methods of Numerical Analysis 4th Ed. By S.S. Sastry (PHI Learning Pvt. Ltd., 2006)
8. Numerical Mathematical Analysis by James D. Scarborough (sisth Edition), Oxford & IBH Publishing

9. Elementary Numerical Analysis By Kendall E. Atkinson (Wiley, 1985)
10. Numerical Methods for Scientists and Engineers By Richard Wesley Hamming (Courier Dover Publications, 1986)
11. Schaum's Outline of Programming with C++, McGraw-Hill; 2nd Edition
12. Numerical Recipes in C++: The Art of Scientific Computing , Cambridge University Press; 2nd

Suggested Reading:

1. Bracewell,R.N, “The Fourier Transform and its applications”, McGraw Hill International Edition, 2000
2. Steven C Chapra and Raymond P Canale, “Numerical Methods for Engineers with Software and Programming Applications”, Tata McGraw Hill, 2004.
3. Curtis F Gerald and Patrick O Wheatly, “Applied Numerical Analysis”, Pearson Education, 2002.
4. Chapra, S. C and Canale, R. P. “Numerical Methods for Engineers”, 5th Edition, Tata McGraw-Hill, New Delhi, 2007.
5. Gerald, C. F. and Wheatley, P. O., “Applied Numerical Analysis”, 6th Edition, Pearson Education Asia, New Delhi, 2006.
6. Brian Bradie, “A friendly introduction to Numerical analysis”, Pearson Education Asia, New Delhi, 2007.
7. Numerical methods by Balaguruswami - TMH.
8. Numerical methods by Mathews – Pearson.
9. Computational Methods in Physics and Engineering: Wong.
10. Computer Oriented Numerical Methods: Rajaraman.
11. Fortran 77 Elements of programming style William M. Fuori, Stephen Graham, Louis Gioid and Michael. Fuori CBS Publishers.
12. Understanding Fortran 77, Michale Boillot Juico publishing House.

Computational Laboratory I (Fortran,C etc)

Sub Code: PHY352
Semester: V

List of Experiments:
1. Find maximum, minimum & range of a given set of numbers
2. Add, multiply and find inverse of a given (3x3) matrix
3. Arrange the given set of 10 numbers in increasing or decreasing order, calculate the mean
4. Solve the given three simultaneous equations by elimination method.
5. Find the roots of a given quadratic equation
6. Fit a straight line or a parabolic curve to a given set a data
7. Find values of (a) sin x, (b) cos x, (c) ex considering their series expansion
8. Solve first order, homogeneous, linear differential equation.

Machine Shop

Sub Code: PHY371
Semester: V

Machine Drawing and Machine Shop

Part A: Machine Drawing

1. Lines and Lettering
2. Scales and paper sizes
3. Title blocks

4. Basic instruments used

a) T-square
b) Set-square
c) Parallel rules
d) Drafting Machine

5. Axonometric projections

a) Dimetric projection
b) Isometric projection

6. Orthographic projection

a) First angle projection
b) Third angle projection

7. Introduction to CAD

Part B: Machine Shop

1. Introduction to machine tools
2. Safety aspects in machine shop
3. Milling
4. Turning
5. Shaping
6. Filing
7. Keyway/slot/groove making
8. Surface/slot milling

Mathematics Physics II

Sub Code: PHY321
Semester: VI

Course Objectives:

- This course is an introduction to the basic concepts of mathematical physics at the undergraduate level. This course is intended to introduce the students to the applications of mathematical methods in physics. Starting from the basics of integral transforms, the course focuses on special functions, group theory, tensors, and ends with the study of basics of probability theory. This course is an introduction to the basic concepts of mathematical physics at the undergraduate level. This course is intended to introduce the students to the applications of mathematical methods in physics. Starting from the basics of integral transforms, the course focuses on special functions, group theory, tensors, and ends with the study of basics of probability theory.

Course Outcomes:

- At the end of this course, students will develop knowledge of mathematical physics and its applications and get expertise in mathematical techniques that are required in physics and material science. Students will also get requisite mathematical skills in solving physics problems at an advanced level

1. Fourier series: Fourier series, Fourier integral theorem, Fourier transform, Parseval's identity – related problems, convolution theorem, transform of derivates, Complex form of Fourier series, Fourier transforms of simple function occurring in physical applications - Dirac delta function- properties.

2. Laplace Transforms: Laplace transform of elementary functions – Inverse Laplace transforms – Methods of finding Inverse Laplace transforms – Heaviside expansion formula – Solutions of simple differential equations

3. Special Functions: Gamma function with real argument: Definition and properties. Evaluation of gamma function with half-integral arguments. Beta function. Relation between –error function - Legendre Hermite, Laguerre function – Generating function, Recurrence relations and their differential equations - Orthogonality of eigenfunctions - Bessels's function of first kind , Spherical Bessel function, Associated Legendre function, Spherical harmonics.

4. Group Theory: Definition of group - symmetry elements - homomorphisms ; isomorphism; Subgroups and cyclic groups; Cosets; Abelian groups; Cayley's theorem ; Reducible and irreducible representation – Character table; Orthogonality theorem.

5. Probability: Elementary probability theory, random variables, binomial, Poisson and normal distributions, Variance, standard deviation, statistical error. Conditional probability: Bayes theorem and its application.

References:

1. A Papoulis and S U Pillai, Probability, Random Variables and Stochastic Processes, McGraw Hills (2002)
2. Butkov E. Mathematical Physics, (Addison Wesley, New York, 1973).
3. Arfken G and Weber H J, "Mathematical Methods for Physicists", (Academic Press, SanDiego, 2001).

Suggested Reading:

1. F. W. Byron and R. W. Fuller, 'Mathematics of Classical and Quantum Physics', (Dover books, 1970).
2. Kryswicky, Mathematics for Physicist Demystified.
3. Kreyszig E, "Advanced Engineering Mathematics", 8th Edition. Wiley, New York, 1999.
4. Cotton F A, "Chemical Applications of Group Theory", Addison Wiley, 1970.
5. Pipes L.A. & Harvil, Applied Mathematics for Engineers and Physicists, McGraw-Hill Book Co., New York, 1980.
6. Grewal B.S., Higher Engineering Mathematics, Khanna Publishers, New Delhi, 1998.
7. M.K.Venkatraman, Advanced Mathematics for Engineers & Scientists, National Publishing Co., Madras, 1994.
8. Gupta, B.D., Mathematical Physics 3rd Edition, Vikas Publishing House Pvt Ltd, New Delhi, 2004
9. Walpole,E, Myers,R.M, Myers,S.L and Ye,K, "Probability & Statistics for Engineers and Scientists", Pearson Education, 2002.
10. Sathya Prakash, "Mathematical Physics", Sultan Chand & Sons, 2000.
11. Ghatak A.K , Goyal I C and S.H.Chua, "Mathematical Physics", Macmillan India, New Delhi, 2002.
12. Joshi A W, "Elements of Group Theory for Physicists", 4th Edition, New Age international, New Delhi, 1997.

Quantum Mechanics-I

Sub Code: PHY322
Semester: VI

Course Objectives:

- Discuss with students that what they know about the Classical Physics and introduce Quantum Physics
- Correct the flaws made by the students and clear all possible doubts asked by the students. Change the method of teaching based on their ability.
- Ask the students to solve few problems using different quantum postulates and let them face the difficulties.
- Explaining the concept and clear the doubts and difficulties faced by the students.

Course Outcomes:

- Help the students for deeper understanding of the already known topics in Classical Physics and then Quantum Physics.
- Create an interest in advanced topics in forth coming semesters.
- Helpful to improve the independent thinking and creativity of the student.

1. **Introduction:** The Classical Framework - A quick review of the central notions of the Classical Framework of Physics. Historical perspective and origin of quantum theory: Blackbody radiation, Specific heat of solids, photoelectric effect. Uuncertainty principle, Fourier Transforms, Dirac-delta function, Principle of Complementary and Correspondence principle.

2. **Wave mechanics:** Wave Particle duality, Debroglie hypothesis of matter waves – Experiments of Davisson and Germar and of G.P.Thomson – Wave packets - Phase velocity, Group velocity, motion and spread of wave packets. Postulates of Quantum Mechanics - Wave function and its statistical interpretation - Normalization - Operators, eigen values and vectors - Orthogonality of Eigen function, Hilbertz space, Completeness condition, Dirac notation, Expectation value- observables and their averages, Formulation of time dependent and independent Schrodinger wave equation, Wave function collapse, Philosophy of Measurements.

3. **Time development of Wave functions:** Stationary states, Ehrenfest theorem, Constants of motion, probability current and conservation of probability. Uncertainty relation and its derivation, commutators and simultaneous measurements of canonically conjugate observable, minimum uncertainty product, Momentum eigen function. The angular momentum commutators and their significance.

4. Application of Schroedinger wave equation: Particle in a box - for particles in a one dimensional potential well – Box normalization - Penetration of rectangular potential barrier in one dimension: derivation of reflection and transmission coefficients. Linear Harmonic Oscillator (LHO) - Solution of the equation of LHO: Hermite differential equation approach and number operator approach, zero point energy, Parity of wave function. Quantum mechanical theory of hydrogen atom.

5. Quantum Mechanics pictures: Three pictures of Quantum mechanics: Schrödinger picture, Interaction picture and Heisenberg picture.

References:

1. P. M. Mathews and Venkatesan, A Text Book of Quantum Mechanics, Tata McGraw Hill, 2010.
2. D. J. Griffith, Introduction to Quantum Mechanics, Pearson Education, 2007.
3. Liboff, Introdunctory Quntum Mechanics, Narosa Publishing House.
4. Quantum Mechanics – Zettli

Suggested Reading:

1. A. Beiser, Perspective of Modern Physics / Concept of Modern Physics, McGraw-Hill, 2005.
2. R. P. Feynman, Lectures on Physics (vol.III), Narosa Publishing, 2008.
3. L. Landau and E. M. Lifshitz, Course in theoretical physics vol.3-Quantum Mechanics (non-relativistic), 3rd Ed.
4. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education, 2005.
5. Amit Goswami, "Quantum Mechanics", WCB Publishers, 1992.
6. Aruldhas G, “Quantum Mechanics”, Printice-Hall of India Pvt. Ltd. 2002
7. R. Eisberg and R. Resnick, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles,* Wiley India Pvt. Ltd., 2006.
8. C. Cohen-Tannoudji, *Quantum Mechanics (vol.2),* John Willey & sons, 2005.
9. Basic Quantum Mechanics , J. M. Cassels.

10. Quantum Mechanics, S. P. Singh.
11. Quantum Mechanics – J. L. Powell and B. Crasemonn, (Oxford, Delhi).
12. Quantum Mechanics – F. Schwabl (Narosa).
13. Quantum Mechanics – A. K. Ghatak and S. Lokenathan (Macmillan, Delhi).
14. Introductory Quantum Mechanics - S. N. Ghoshal (Calcutta Book House).

ELECTROMAGNETIC THEORY

Sub Code: PHY323
Semester: VI

Course Objectives:

- This course is intended to introduce the basics of electromagnetic theory at a level that is between a first course on electricity and magnetism and an advanced course on electromagnetic theory.

Course Outcomes:

- Understanding and solving problems related to electrostatics, magnetostatics, electric and magnetic fields and also simple applications such as optical fibers and waveguides

Electrostatics:
Gauss's law - applications of Gauss's law – spherical and cylindrical symmetric charge distributions, potential energy of a continuous charge distributions, electrostatic boundary conditions, Laplace and Poisson's equations, Neumann and Dirichlet boundary conditions, boundary value problems, Uniqueness theorem, Method of images, Multipole expansion of potential energy, electric dipole – potential energy and electric field of a dipole.

Magnetostatics:
Magnetic field, Magnetic forces – Lorentz Force law, cyclotron motion, cycloid motion, magnetic forces on current carrying wires, surface and volume current density, Biot Savart Law, Divergence and Curl of magnetic field, Ampere's law of magnetostatics, magnetic field of infinite plane current, circular current loop, solenoid and toroid, Vector potential, Vector potential of a straight current, spinning spherical shell, and spinning charged sphere. magneto-statics boundary conditions, multipole expansion of the vector potential, magnetic moment, Larmor precession.

Electrodynamics:
Ohm's law, Joule heating law, electromotive force, flux rule for motional emf, electromagnetic induction, Faraday's law, induced electric field, energy in magnetic fields, Maxwell's displacement current, Ampere's law and Maxwell's correction, boundary conditions of electric and magnetic fields, Conservation laws – Continuity equation and Poynting's theorem, Vector and scalar potentials, Gauge transformations.

Electromagnetic Waves:

Wave equation – Electromagnetic waves in vacuum and matter, monochromatic plane waves – energy and momentum, plane waves and their propagation – reflection and transmission, total internal reflection and Snell's law, Fresnel's equations, waves in conductors – skin depth, reflection at a conducting surface, absorption and dispersion, frequency dependence of permittivity, Cauchy's formula, Green function for the wave equation, waves from accelerated charges, electric dipole radiation.

Wave Guides:
Waveguides, resonant cavities and optical fibers, cylindrical cavities and waveguides, TE,TM and TEM modes, cutoff wavelength in a rectangular waveguide; Q factor of a cylindrical resonant cavity; Introduction to optical fibers – single mode and multimode; numerical aperture and angle of acceptance. Step index and graded index fibers, attenuation in fibers, couplers and connectors, fiber optic communications.

References:

1. D J Griffiths, Introduction electrodynamics Addison Wesley.
2. Tai L. Chow, Introduction to electromagnetic theory: A modern perspective, Jones & Bartlett Learning, 2006
3. Joseph A. Edminister, Mahmood Nahvi, Schaum's outline of Electromagnetics, 4th Edition
4. J. Franklin, Classical Electromagnetism, Second Edition (2017), Dover Publications.
5. Andrew Zangwill, Modern Electrodynamics, First Edition (2013), Cambridge University Press.

Suggested Reading:

1. J D Jackson, Classical Electrodynamics Wiley.
2. Landau and Lifshitz, Electrodynamics of continuous media PErgamon Press.
3. Daniel Fleisch, A student's guide to Maxwell's Equations Cmbridge.
4. W Hyat and J Buck, Engineering electromagnetics Mc Graw Hill.
5. Mathew N.O. Sadiku, Principles of Electromagnetics, Fourth Edition, Oxford

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Condensed Matter Physics- I

Sub Code: PHY324
Semester: VI

Course Objectives:

- Understand the fundamental physics behind different materials with various properties we commonly see in the world around us and attempt to classify and name things based on their structure and properties relation.
- Gain knowledge on what gives materials their properties and what are the different models to explain these properties.

Course Outcomes:

- Students will be able to
- Relate crystal structure and degree of ordering to atom binding and packing,
- Explain the thermal properties in solids iii)classify condensed matter upon its electrical and transport properties,
- Apply the obtained concepts to challenges in condensed matter physics.
- Be able to understand the interplay between classical and quantum mechanical phenomena

UNIT 1: Crystal structure: Lattice, Basis, Translational vectors, Primitive unit cell, Symmetry operations, Bravais lattices, SC, BCC and FCC structures, Packing fraction, Miller indices, Lattice planes and directions, Reciprocal lattice; Bragg's law and Bragg's Diffraction condition in direct and reciprocal lattice, Ewald's construction, Debye Scherer method, Analysis of cubic structure by powder method, Crystal Binding and Lattice dynamics.

UNIT 2: Ionic cohesive energy – Covalent – Metallic Vander Waals and hydrogen bonded crystals – Vibrational modes – one, two and three dimensional lattices – Thermal conductivity – Elastic constants – Phonon dispersion relation – Localised modes, cohesive energy. Lattice Vibrations: Vibration modes of continuous medium; concept of Phonons; Lattice specific heat; Classical theory, Einstein's theory and Debye's theory of specific heat.

UNIT 3: Free Electron Theory: Classical free electron theory (Drude model) and its draw back; Quantum theory of free electrons: Schrodinger's wave equations and its applications in particle in box; Physical significance of wave function; Fermi energy, Fermi level, Fermi-Dirac distribution function and effect of temperature; Hall Effect, Origin of energy gap, Energy bands in Solids, Distinction between metal, semiconductor and insulator

UNIT 4: Semiconductors and Dielectrics: Introduction to Metal, Semiconductors and insulator; Types of semiconductors: intrinsic and extrinsic semiconductors; junction devices (diode, transistors, LED,). Dielectrics: Concepts of dielectrics, Dipole moment; Basic concepts and types of polarization, A.C. effects, Ferro-electricity, Piezo electricity, Ferro and piezo electric materials.

UNIT 5: Magnetism & Superconductivity: Electron spin and magnetic moment; Origin of magnetism; Types of Magnetism: Dia-, para-, ferro-, ferri-, and antiferromagnetism; Langevin theory of Dia- and paramagnetism, Curie's law; Magnetic domains & hysteresis, Magnetic materials, Magnetic storage devices, Memory materials. Introduction, effect of magnetic field, Meissner effect, Isotope effect, Penetration depth (London Equations).

References:

1. N. W. Aschcroft and N. D. Mermin, Solid state physics, Holt, Rineheart and Winston, New York (1976)
2. L. V. Azaroff, Introduction to solids, Tata McGraw Hill (2008),
3. C. Kittel, Introduction to solid state physics. John Wiley (2003) Seventh Edition.
4. Condensed Matter Physics, Michael P. Marder (John Wiley, 2015)

Suggested Reading:

1. A. J. Dekker, Solid state physics, MacMillan (1981).
2. Ali Omer, Elementary solid state physics, Pearson Education (1999),

Condensed Matter Physics Lab

Sub Code: PHY325
Semester: VI

List of Experiments:

1) High frequency permittivity of solids.
2) X-ray Diffraction.
3) Hall Effect.
4) Determination of band gap of a solid/ semiconductor.

5) Solar cell I-V Characteristics (internal).
6) Solar cell I-V Characteristics (External).
7) Thermal Diffusivity of Brass.
8) Thermal and Electrical Conductivity of Copper
9) Solar thermal.
10) Guoys Balance experiment t find the determination of magnetic susceptibility of solids.

Quantum Mechanics-II

Sub Code: PHY411
Semester: VII

Course Objectives:

- This is a second course on Quantum Mechanics. The purpose of the course is to introduce the mathematical foundations of many quantum phenomena. The course focuses on perturbations, identical particles, scattering and Dirac's relativistic equation.

Course Outcomes:

- By the end of this course, students could able to understand the splitting of energy levels of atoms and the transition between the states with rigorous mathematics under an external perturbation. They will also learn about the interaction of radiation with matter quantum mechanically and understand absorption, stimulated emission and spontaneous emission of radiation.

1. Approximation methods for stationary systems : Time – independent perturbation theory : (a) Non–degenerate and (b) Degenerate perturbation theory, application to Zeeman effect, fine structure, helium atom and anharmonic oscillator, Isotopic shift and Stark effect, WKB approximation, Variational method and their applications.

2. **Time-dependent perturbation theory:**, Time-dependent perturbation theory, Transition to a continuum of final states – Fermi's Golden rule. First order correction – Semiclassical radiation theory, interaction between electromagnetic wave and atoms – transition probabilities - radiation field quantization, polarizability of a system, Photo-electric effect, Einstein's coefficients – selection rules for harmonic oscillator and hydrogen atom., Adiabatic and sudden approximations, Spontaneous emission, absorption, induced emission, dipole transitions, selection rules.

3. **Symmetries:** Construction of wave functions for a system of identical particles. Bosons and Fermions; symmetric and anti-symmetric wave functions; Pauli principle. Symmetry-Galilean invariance; Translation and Rotation operation; Parity and time reversal; Wave function for time, space translation and rotation; Eigen value and Eigen function of angular momentum; Addition of angular momentum, Clebsh-Gordan coefficient.

4. **Scattering:** Non-relativistic scattering, solution of scattering problem by the method of partial wave analysis, optical theorem, Scattering Amplitude - Expression in terms of Green's Function - Born approximation and its validity for scattering problems, Interaction with

classical radiation fields; Rayleigh scattering - Scattering theory- Scattaring cross section, Phase Shifts - Scattering by coulomb and Yukawa Potential.

5. **Relativistic Quantum Mechanics:** Dirac equation: Motivation for Dirac equation, Properties of Dirac matrices, positive and negative energy states, Plane wave solution of Dirac equation. Spin of Dirac particle - Spin wave function of Dirac particle and Magnetic moment.
Introduction to Quantum Field Theory, Second Quantization of Schrodinger Equation.

References:

1. Mathews P M and Venkatesan K, "A Text book of Quantum Mechanics", Tata Mc Graw- Hill, New Delhi. 1976.
2. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education, 2005.
3. Liboff, Introdunctory Quntum Mechanics, Narosa Publishing House.
4. Quantum Mechanics – Zettli

Suggested Reading:

1. R. P. Feynman Lectures on Physics (vol.III), Narosa Publishing, 2008.
2. L. Landau & E. M. Lifshitz, Course in theoretical physics vol.3-Quantum Mechanics (non-relativistic), 3rd Ed.
3. Arthur Beiser, "Concepts of Modern Physics", Tata McGraw-Hill Publishing Company Limited, 2005.
4. Aruldhas G, "Quantum Mechanics", Printice-Hall of India Pvt. Ltd.,, 2002
5. Atkins P W and Friedman R S, "Molecular Quantum Mechanics", Oxford University Press, 1997.
6. Amit Goswami, "Quantum Mechanics", WCB Publishers, 1992.
7. Merzbacher E, Quantum Machanics, John Willey & Sons.
8. Jinkham, Group theory and Quantum Mechanics, Tata McGraw Hill.
9. Powell & Graseman, Quantum Mechanics, Narosa Publishing House
10. Parling, Introduction to Quantum Mechanics, McGraw Hill, 1995
11. Park, Introduction to Quantum Mechanics, Tata McGraw Hill 1995
12. Jownsend, A Modern approach to quantum Mechanics, Tata McGraw Hill.
13. L. Schiff, Quantum Mechanics, McGraw Hill International
14. Gathak & Loknathan, Introduction to Quantum Mechanics-Narosa Publishing House.
15. C. Cohen-Tannoudji, *Quantum Mechanics (vol.2),* John Willey & sons, 2005.
16. D. J. Griffith, *Introduction to Quantum Mechanics*, Pearson Education, 2007.
17. S. Flugge, Practical Quantum Mechanics
18. M. P. Khanna, Quantum Mechanics
19. G. Baym, Lectures on Quantum Mechanics
20. Dirac P.A.M. The principle of Quantum Mechanics, Oxford University,
21. Quantum Mechanics - G.R.Chatwal & S.C.Anand.

Atomic and Molecular Physics

Sub Code: PHY412
Semester: VII

Course Objectives:

- This core course is about the understanding basics of atomic and molecular physics. This course covers mainly atomic structure and the interaction between atoms and fields, electronic transitions, atomic spectra, excited states, hydrogenic and multi-electron atoms, binding of atoms into molecules, atoms in electric and magnetic fields, fine and hyperfine structure, molecular structure. Rotation-, vibration- and electronic spectra

Course Outcomes:

- At the end of this course, the students will be in a position to understand the basics of atomic and molecular physics.

UNIT 1
Molecular Binding: Vander Waals, ionic bonding and valence bond, Review of group theory for spectroscopy: symmetry elements and operations, matrix representations, introduction to spectroscopic term symbols; classification of molecules, introduction to character table of point group, reducible and irreducible representation for C_{2v} and C_{3v}. Fourier transforms in spectroscopy- need for FT, basic ideas, basic instrumentation.

UNIT 2
Pure rotational energy levels and spectra (Rigid and non-rigid), Isotopic effect. Symmetric top, asymmetric top and spherical molecules- energy levels Rotational spectra and its selection rules. Idea of symmetry elements and point groups for simple molecules, such as H_2O, NH_3 etc.. Selection rules.

UNIT 3
Angular momenta and magnetic moment in atoms and their interactions, Spin-orbit interaction in one valence electron. Fine structure of spectral line: Fine structure of hydrogen lines and its corrections; Fine structure of structure of single and many electron atoms using LS and j-j coupling. Intensities of fine structure lines. Alkali-type spectra and quantum defect, hyperfine structure. Width of a spectral line: Natural width, Doppler width and collision induced width. Selection rules.

UNIT 4
Vibrational states and spectra of diatomic molecule-harmonic and anharmonic approximation, Morse P.E. Curve, Rotation-vibration energy levels and spectrum, progression and sequence, Raman spectroscopy. Selection rules.

UNIT 5
Electronic ground states of homonuclear diatomic molecule. Electronic spectra of diatomic molecule-P, Q, R branches determination of band origin. Band intensities and Franck-Condon Principle, Hund coupling cases. Selection rules. Photoelectron spectroscopy – XPS and UPS.

References:

1. J M Hollas, Modern spectroscopy Wiley.

2. Bransden and Joachain, Physics of Atoms and Molecules 2 ed. Addison Wesley,
3. B S Tsukerblat, Group Theory in Chemistry and Spectroscopy: A Simple Guide to Advanced Usage Dover Books.
4. S Svanberg, Atomic and Molecular Spectroscopy: Basic aspects and Practical applications Springer
5. Willard Dean, Merritt and Settle, Instrumental methods of analysis CBS publishers.

Statistical Mechanics

Sub Code: PHY413
Semester: VII

Course Objectives:

- Discuss with students that what they know about the Thermodynamics and introduce Statistical Mechanics.
- Correct the flaws made by the students and clear all possible doubts asked by the students. Change the method of teaching based on their ability
- Ask the students to solve few problems using different ensemble and let them face the difficulties.
- Explaining the concept and clear the doubts and difficulties faced by the students.

Course Outcomes:

- Help the students for deeper understanding of the already known topics in statistical mechanics.
- Create an interest in advanced topics in forth coming semesters.
- Helpful to improve the independent thinking and creativity of the student.

1. **Introduction:** Microstates and macrostates- phase space and volume in phase space, density distribution in Phase space, Phase space evolution. Conditions for equilibrium. Different thermodynamic systems and concepts of ensemble. Time average and ensemble average; Ergodic theory. Microcanonical ensemble : Hypothesis of equal a priori probability, Boltzmann entropy; Statistical definition of temperature, pressure, and chemical potential. partition functions and properties, calculation of thermodynamic quantities, perfect gas in micro canonical ensemble; Gibbs Paradox; Sackur-Tetrode equation; correct enumeration of microstates. practical implication of microcanonical ensemble. Derivation of ideal and slightly non ideal gas equation.

2. **Canonical ensemble:** Equilibrium between a system and a heat reservoir; Gibb's canonical entropy, energy fluctuations in the canonical ensemble; derivation of equipartition theorem, ideal and slightly non ideal gas equation; application: a system of Harmonics oscillator; statistics of paramagnetism.

3..**Grand canonical ensemble:** Partition functions and properties, calculation of thermodynamic quantities, density and energy fluctuations. Various thermodynamic potentials and their connection with partition functions. Maxwell-Boltzmann (MB) distribution law:

Derivation. Calculation of thermodynamic quantities for ideal monatomic gases. Equivalence of ensemble.

4. **Quantum Statistics:** Bose-Einstein (BE) Statistics, Fermi-Dirac (FD) Statistics, examples illustrating counting procedures for MB, BE and FD statistics and derivation; Entropy maximization; Thermodynamics interpretation of Lagrange's undetermined multiplier; Comparison between the three statistics. Conditions under which the quantum mechanical distribution functions reduce to the classical MB distribution. Thermodynamic behaviour of Bosons and Fermions; Black body radiation and Planck's radiation; Bose- Einstein condensation (qualitative discussion); Fermi distribution at zero and nonzero temperatures.

5. **Brownian Motion:** Fluctuation, Einstein theory of Brownian motion, diffusion coefficient; Langevin theory (qualitative discussion); Fluctuation-dissipation theorem; random walks and self avoiding walks.

References:

1. Statistical Mechanics: K. Huang (John Wiley and Sons).
2. Fundamentals of Statistical and Thermal Physics, F. Reif, (Mc Graw Hill)
3. Statistical Mechanics by Pathria – Elsevier.

Suggested Reading:

1. P. T. Landsberg (Ed.), Problems in Thermodynamics and Statistical Physics
2. Statistical Mechanics and Thermal Physics: Rice (John Wiley).
3. L. Landau and E.M. Lifshitz: course in theoretical physics vol.5 (part-I) & vol.9 (part-II) - Statistical Mechanics, 3rd ed., Pergamon Press.
4. B. B.Laud, Fundamentals of Statistical mechanics, New Age Publication, 2007.
5. J. K. Bhattacharya, Statistical Mechanics, Allied Publishers Ltd., 1996.
6. L. E. Reichl, A modern course in Statistical Physics, Wiley & Sons, 2nd Ed., 1997.
7. Elementary Statistical Mechanics: C.Kittel (Dover Pub.)
8. Statistical Physics, F. Mandle (ELBS).
9. H. B. Callen, *Thermodynamics & Thermostatistics*, John Wiley & Sons. 2nd Ed.
10. R. Bowley and M. Sanchez, *Introductory Statistical Mechanics*, Oxford Press, 2007.
11. Statistical Mechanics by Laud – New age International.
12. Thermodynamics kinetic theory and statistical mechanics by sears & salinger – Narosa
13. Statistical Mechanics: B.K. Agarwal and Melvin Eisner (JohnWiley and Sons, 1988).

<u>Atomic Physics and Optics Lab</u>

Course Code: PHY414
Semester: VII

<u>List of Experiments:</u>

1. Abbes Refracto meter- To Study the variation of RI with temperature of different liquid.
2. Half shade Polari meter- Determination the specific Rotation of given solution.
3. GM counting system-
4. Diffraction due to Helical Structure
5. Optical Characterization of given Solid/Thin film Liquid by UV
6. FTIR
7. Raman Spectroscopy
8. XPS

ELECTRONICS

Sub Code: PHY451
Semester: VII

Course Objectives:

- The aim of this paper is to give knowledge of Electronics. The students are expected to have previous knowledge in structure of materials, types of conductors especially semiconductors in order to follow the concepts. The students are expected to learn the concepts of VI characteristics of diodes, circuital theorems, different types of transistors, transistor characteristics, amplifiers, oscillators, digital circuits, and bridge circuits.

Course Outcomes:

After successful completion of this course, student should be able to:

- Discuss the VI characteristics of different diodes
- Explain the transistor characteristics, types of transistor, structure and applications
- Acquire clear knowledge in diodes, transistors, amplifiers, oscillators.
- Discuss the different type's amplifiers, oscillators
- Know how the transistors are working and understanding about the circuits.

Unit 1: Review of Series and Parallel LCR Circuits, ideal voltage and current sources, Superposition principle, Thevenin's theorem, Norton theorem, Millman theorem, Maximum power transfer theorem. Phasor analysis of circuits. Basis of Semiconductor Physics: Semiconductor diodes: p-n junction diode, I-V characteristics, Schockley model, construction and i-v characteristics of Zener, Avalanche, Schottky-barrier diode, Tunnel diodes, LED and photodiodes.

Unit 2: Construction, operation and Characteristics of BJT, UJT, FET, MOSFET and CMOS configuration. OPAMP - Basics of differential amplifiers-Characteristics of ideal and practical opamps-Applications; inverting, non-inverting, Summing, difference, integrating, differentiating amplifiers.

Unit 3: Introduction to elements of Boolean algebra, AND, OR, NOT, NAND, NOR, XOR and XNOR logics. Combinational circuits: Adders, subtractors, multiplexer/demultiplexer, decoder and encoders-Flip Flops; S-R, J-K, counters- synchronous, asynchronous, Modulo-n-counters-shift registers; Serial to parallel and vice-versa, universal shift registers, ring counter.

Unit 4: Rectifiers, Oscillators and Amplifiers: Half-wave and Full-wave rectifiers; Oscillators – RC, LC, crystal, negative resistance, Hartley , Colpitt oscillators – basic construction only. Amplifier – Class A, B, AB and C; voltage, current and power ampl ifiers.

Unit 5: Basics of Filter circuits: Low-pass, High-pass, Band-pass, Band-stop – implementation of the above filters using (a) LCR elements (b) diode/FET elements; Filter Topologies, Basics of electrical connections, Single phase and three phase connections, RMS values, Thyristor, and electronic switches.

References:

1. Integrated Electronics: Analog & Digital Circuit Systems – Jacob Millman & Halkias, TMH.
2. "Hands-On Electronics: A Practical Introduction to Analog and Digital Circuits" by Daniel M. Kaplan and Christopher G. White, Cambridge University Press, 2010.
3. Mehta V K, 'Principles of Electronics", S.Chand and Company Ltd., 2005.
4. Malvino A P and Leach D P, "Digital Principles and Applications", TMH Delhi, 2007.
5. Allen Mottershed, "Electronic Devices and Circuits", Prentice Hall of India Private Ltd., 2002
6. Electronic Fundamentals and Applications – D. Chattopadhyay and P. C. Rakshit
7. Electronics Fundamentals and Applications – J. D. Ryder (PHI Pvt. Ltd).
8. Electronic Device and Circuit Theory – R. Boylestad and L. Nashelsky (Prentice –Hall).
9. Integrated Electronics – J. Millman and C. C. Halkias (Mc Graw Hill).
10. Joseph P J Karr, "Elements of Electronic Instrumentation and Measurement", Prentice Hall, 1996.
11. Transistor Physics and Circuit Design, D.C. Sarkar.
12. Engineering Electronics, Terman.
13. A.P.MALVINO, Principles of Electronics, Tata Mc-Graw Hill 7th Edition.
14. B.L. Theraja, Basic Solid State Electronics, S.Chand Co. Ltd., 1997.
15. V.K.Mehta, Principles of Electronics, S.Chand Co. Ltd. 5th Edition
16. N N Bhargava , D C Kulshreshtha , S C Gupta , Basic Electronics and Linear Circuits, Tata McGraw Hill.

Suggested Reading:

1. Jacob Millman and Christos C Halkias, 'Electron Devices', McGraw Hill Publishing Co., 1996.
2. Robert Irvin, 'Linear Integrated Circuits', Mc Graw Hill Publishing Co., 1992.
3. A.P.Malvino, "Electronic principles', (6^{th} edition), Tata McGraw Hill Publ.Co. Ltd., New Delhi, 1999.
4. Electronic Devices and Circuit Theory – Boylestad & Nashelsky, 8th Ed. PHI.
5. T.L.Floyd, Electronic devices', (6^{th} edition), pearson Education Inc., New Delhi, 2003
6. P.Horowitz and W.Hill, "The art of electronics', (2^{nd} edition), Cambridge university press, Cambridge, 1995.
7. T. L. Floyd, Digital Fundamentals, (8^{th} deition), Pearson education Inc., New Delhi, 2003.
8. S.Brown and Z.Vranesic,'Fundamentals of digital logic with Verilog design', Tata McGraw Hill Publ Co.Ltd., New Delhi, 2003.
9. H.Skalsi, "Electronic instrumentation (2^{nd} edition), Tata McGraw Hill Publ. Co. Ltd., New Delhi,2004
10. Electronic Devices & Circuit Analysis – K. Lal Kishore, BS Publications
11. Electronic Fundamentals and Applications – D. Chattopadhyay and P. C. Rakshit
12. Electronics Fundamentals and Applications – J. D. Ryder (PHI Pvt. Ltd).
13. Electronic Device and Circuit Theory – R. Boylestad and L. Nashelsky (Prentice Hall).
14. "Electronic Devices and Circuit Theory" by Robert Boylested and Louis Nashdsky, PHI, New Delhi - 110001, 1991.

Electronics Lab

Sub Code: PHY452
Semester: VII

1. Study of CRO fundamentals.
2. Verification of Norton's theorem
3. Verification of Thevenin's theorem.
4. IV characteristics of a junction diode

CORE experiments:

1. Study of IV characteristics of a zener diode and voltage regulation by zener diode.
2. Clipping and clamping circuits using junction diode.
3. Half wave, full wave and bridge rectifier using diodes.
4. A study of Transistor Characteristics (a) CB, (b) CE and (c) CC.
5. Characteristics of MOSFET.
6. Voltage regulator using IC 7805
7. Construction of Logic Gates: AND, OR, NOT using Transistor 8. Designing Circuits using universal building block gates
9. Flipflops: RS, JK
10. Operational amplifier: Summing, Inverting, , Differentiator , Integrator

MODERN OPTICS

Sub Code: PHY421
Semester: VIII

Objectives:

- This course aims to introduce the IMSc students who have knowledge of the basics in ray optics in previous years, to the exciting area of wave optics. Before entering directly in to the concepts of wave optics (interference, diffraction etc.), the students are initially acquainted with some of the more fundamental concepts regarding optics in general such as Huygen's principle, Fermat's principle, Snell's law, total internal refection and mirage formation, origin of refractive index, and the superposition principle. After these basic topics are discussed, the course is aligned to proceed in a methodical way into the concepts of interference, diffraction, polarization, Fourier optics, and Quantum and Nonlinear optics.

Course Outcomes:

- After the successful completion of this course, students will understand the experimental procedures and practical applications in modern optics. Students will also gain knowledge on advanced topics in optics such as quantum and nonlinear optics. At the end of this course, students will get acquainted with the principle and working of important experiments such as Michelson interferometer, grating spectrometer, Fabri-Perot interferometer, applications of wave-plates, Laurent's half-shade polarimeter, Michelson stellar interferometer.

UNIT 1
Wave Propagation : One dimensional wave, the differential wave equation, harmonic waves, superposition principle, graphical method for superposition principle, the complex

representation, plane waves, three dimensional wave equation, spherical waves, cylindrical waves, electromagnetic wave, Rayleigh scattering, origin of refractive index, Huygen's principle, Fermat and mirages, Fresnel's equation, total internal reflection

UNIT II

Interference and Diffraction : Interference of light: single and double slit interference, Michaelson interferometer, Multiple beam-interference, Fabry-Perot Etalon, Fabry-Perot Interferometer – resolving power, Diffraction - Fraunhoffer diffraction – Single Slit and Double Slit diffraction, Diffraction grating N-Slit diffraction, resolving power of gratings and prisms. Fresnel diffraction – Half period zones, Diffraction by a circular aperture, opaque disc, zone plate.

UNIT III

Polarization: Polarization of light - polarization by reflection, refraction and scattering - Plane, elliptically and circularly polarized light- Double refraction - Brewster law - Nicol prism - wollaston prism - Rochon prism polarizer and analyzer - Malus's law- wave plate & half wave plate - polaroid- Birefringence, Birefringence crystals, Birefringence polarizer - polarization by scattering - Optical Activity - Fresnel's explanation of rotation - origin of optical rotation in liquid and in crystals - Determination of specific rotatory power using Laurent's half-shade Polarimeter.

UNIT IV

Fourier Optics : Fourier series, nonperiodic waves, Fourier integrals, pulses and wave packet, phase and group velocity, Normal and anomalous dispersion, coherence length, Discrete Fourier transform, Coherence Time and Line width via Fourier Analysis, Spatial Coherence and Temporal Coherence – Transform of the Gaussian wave packet - Michelson Stellar Interferometer - Fourier Transform Spectroscopy

UNIT-V

Quantum and Non-linear optics : Quantization of electromagnetic field in a cavity, Fock states of radiation field, quadrature operators, coherent and squeezed states of radiation, photon statistics, mechanical effects of light - laser cooling and trapping of atoms, principle of complimentarity, quantum erasure, Non Linear Processes: Propagation of Electromagnetic Waves in a Nonlinear medium, Parametric Amplification, Singly resonant and doubly resonant parametric oscillator, Second Harmonic generation, Optical Mixing, Self Focusing, optical bistability – absorptive and dispersive bistability.

References:

1. David Halliday, Robert Resnick and Jearl Walker (2004) Fundamentals of Physics. 7th edition. John Wiley & Sons. 8th Ed. (2008)
2. Optics, Ajoy Ghatak, Fourth Edition (2009), Tata McGraw Hill
3. Optics: Principles and Applications, Kailash K. Sharma, 1st Edition (2006), Academic Press.
4. Introduction to Fourier Optics, Joseph W. Goodman, 3rd Edition (2016), Roberts Publisher.
5. F. W. Sears, M. W. Zemansky, and H D Young, University Physics, Addison Wesley (1976).
6. Lasers Theory and Applications: K. Thyagarajan and A.K. Ghatak (McMillan).
7. Christopher Gerry and Peter Knight, Introductory Quantum Optics, Cambridge University Press; First Edition, 2005.
8. Mark Fox, Quantum Optics An Introduction, Oxford University Press, First Edition, 2006.
9. Marlan O. Scully and M. Suhail Zubairy, Quantum Optics, Cambridge University Press,

First Edition, 1997.
10. Robert W. Boyd, Nonlinear Optics, Academic Press (London), 1992.
11. Johannes Fankhauser, Taming the Delayed Choice Quantum Eraser, arXiv: 1707.07884

Suggested Reading:

1. Optics : B. K. Mathur
2. Fundamentals of Optics : Jenkins and White
3. Fundamentals of Optics: K. G. Mazumdar
4. Geometrical and Physical Optics : P. K. Chakraborty
5. Optics : A. N Matveev

Nuclear and Particle Physics

Sub Code: PHY422
Semester: VIII

Course Objectives:

- This subject is an introduction to nuclear physics and elementary particle physics. Unit one introduces the concept of atomic nucleus and its general properties like size, mass, binding energy, charge, electric and magnetic moments and spin etc. The properties of nuclear forces and the interaction between nucleons and the different nuclear models is discussed in the second unit. Unit three introduces the concept of radioactivity and different radioactive decays like alpha, beta and gamma decays. The fourth unit talks about the different quantum numbers for the elementary particles and conservation of these quantum numbers in different nuclear reactions. This unit also discusses the fundamental interactions and the basic quark model. The fifth and the sixth units introduce the concepts of nuclear reactions, particularly nuclear fission and fusion reactions, conditions for fission and fusion reactions, energy released in nuclear reactions, construction of nuclear reactors and the different types of nuclear reactors, nuclear materials and nuclear waste management

Course Outcomes:

- At the end of this course students will have a good knowledge of atomic nucleus and the basic properties of subatomic particles.

Properties of Nuclei: Nuclear mass, charge, size, binding energy, spin and magnetic, electric quadrupole moment. Isobar, isotope and isotones. Mass spectrometer (Bainbridge). Binding energy per nucleon versus mass number curve and its characteristics.

Nuclear structure: Nature of forces between nucleons, nuclear stability, binding energy of the nucleus, qualitative description of the liquid drop model of the nucleus, extreme independent shell model of the nucleus and its predictions for magic numbers and ground state spin parity of the nucleus, Bethe-Weizsacker mass formula (only statement and explanation of the terms in the formula). Parity, Sub-barrier fusion, Symmetries in nuclei, Quantum Mechanical features of nuclear system.

Radioactivity: alpha, beta and gamma rays, velocity and energy of alpha particles, Geiger-Nuttal law, Beta decay, nature of beta ray spectra, neutrinos and positrons, inverse beta decay, range and strength of weak force, half-life and decay rate of radioactive elements, radioactive series. Description of detectors and scintillation counters.

Qualitative Approach to Nuclear Reactions: Conservation principles in nuclear reactions, Threshold energy, nuclear reaction cross-sections - Types of fission-distribution of fission products – fissile and fertile materials – neutron emission in fission – spontaneous fission - Explanation of nuclear fission using liquid drop model, fission products and energy release. Spontaneous and induced fission transuranic elements. Chain reaction - fusion- energy released – stellar energy – controlled thermo nuclear reaction – plasma confinement. **Reactors**: Qualitative description of fission reactors, schemes for nuclear fusion, fuels, moderators, and coolants.

Elementary Particles: Four basic interactions in nature and their relative strengths, examples of different types of interactions, Quantum numbers-mass, charge, spin, isotropic spin, intrinsic parity, hypercharge, Charge conjugation. Conservation of various quantum numbers, Classification of elementary particles, hadrons and leptons, baryons and mesons, elementary idea about quark structure of hadrons, octet and decuplet families. Introduction to Neutrino structure, Solar Neutrinos, Neutrino detection, Solar Processes - R, S process – Astrophysics.

References:

1. Introductory Nuclear Physics: S. Wong (Prentice Hall of India).
2. Nuclear Physics – Cottingham and Greenwood (Cambridge University Press).
3. Concepts of Nuclear Physcics – R. Cohen (Tata-Mc Graw Hill).
4. Introductory Nuclear Physics, Kenneth S. Krane (John Wiley)
5. Introduction to Elementary Particles, David Griffiths (Wiley, VCH 2nd Edition)
6. An Introductory Course in Modern Particle Physics, Francis Halzen and Alan D. Martin (Wiley, 1984).

Suggested Reading:

1. Problems and solutions in nuclear physics: Mouaiyad M.S.Alabed (iUniverse)
2. Atomic and Nuclear Physics – S. N. Ghoshal (S. Chand).
3. Nuclear Physics – S. B. Patel (New Age).
4. Evans, Atomic Physics, Tata McGraw Hill, New Delhi, 1986.
5. R.R.Roy and B.P.Nigam, Nuclear Physics, Wiley Easter, New Delhi, 1985.
6. Structure of Nucleus: M.A. Preston and R.K. Bhaduri (Addison Wesley).
7. Introduction to Nuclear Physics: H. Enge (Addison Wesley).
8. The Atomic Nucleus: R.D. Evans (McGraw Hill).
9. Nuclear Physics: Kaplan (Addison Wesley).
10. Radiation Detection and Measurement: G. F. Knoll (John Wiley, 1989).
11. Concepts of Nuclear Physics: Cohen (Tata McGraw Hill).
12. Tayal D C, "Nuclear Physics", Himalaya Publishing House, Mumbai, 2000.

Laser Physics

Sub Code: PHY461
Semester: VIII

Principles of Lasers: Interaction of radiation with matter – Absorption, spontaneous and stimulated emission – Einstein coefficients – relation between spontaneous and stimulated emmision rates, Light amplification – Threshold condition for laser action, Line broadening mechanisms – Natural, Collision and Doppler broadening. Laser operations – Two level system, Population inversion in three level and four level systems- Threshold pump power, relative merits and de-merits of three and four level system.

Laser Types - Mathematical description of Gaussian beams using Maxwell's equations. Propagation of Gaussian beams through optical elements. ABCD law for Gaussian beams. Hermite-Gaussian beams. Laser Systems - Gas lasers: He-Ne laser, Carbondioxide laser, Nitrogen gas laser, Argon ion gas laser – Solid state lasers: Ruby laser, Nd-YAG laser, Dye lasers - Optically pumped laser systems

Laser Operations: Resonant cavities, modes of a rectangular cavity, quality factor of an optical resonator, ultimate laser line width , Longitudinal and Transverse mode selection, Pulsed lasers - Q-switching and Mode locking concepts and techniques. - Resonator configurations - Stability of resonators, - Characteristics of Gaussian beam.

Fiber Lasers: Erbium doped fiber laser – basic equations for amplification and its steady state solutions, derivation for doped fiber length, threshold pump power and laser output power, Erbium doped fiber amplifier, mode locking using non-linear polarization, semiconductor lasers, optical gain in semiconductors, density of states, interaction of semiconductor with light, light amplifcation and gain coefficient in semiconductors, Quasi-Fermi levels, Gain in diode laser, Quantum-Well lasers – derivation for gain coefficient.

Laser Applications: Holography , Basic Principle – Holographic interferometry – Speckle Metrology, Material processing- welding, cutting, and drilling. laser tracking, pollution monitoring using lasers, lasers in isotope separation, lasers in precision length measurement, lasers in information storage, bar-code scanner, Biological and Medical applications of lasers.

References:

1. Lasers Theory and Applications: K. Thyagarajan and A.K. Ghatak (McMillan).
2. C.O. Shea, W.R. Callen and N.T. Rhodes, "An Introduction to Lasers and their Applications"", Addison Wesley, 1969.
3. J. Verdeyen, 'Laser Electronics', Second Edition, Prentice Hall, 1990.
4. Goldman and Rockwell, 'Lasers in Medicine', Gordon and Breach, New York, 1985.
5. B.B. Laud, 'Laser and Non-Linear Optics', Second Edition, New Age International (p) Limited publishers, 1996.
6. Optics and Atomic Physics – B. P. Khandelwal (Siblal Agarwala).
7. Optical Electronic – A. K. Ghatak and K. Tyagrajan.
8. Introduction to Fibre Optics - R. A. Shotwell (EEE, Prentice Hall).

Suggested Reading:

1. Optoelectronics: an introduction, J. Wilson and J.F.B. Hawkes (prentice Hall of India).
2. Solid State Electronic Devices, B.G. Streetman and S. Banerjee (Pearson).
3. Fibre Optics and Optoelectronics: R.P. Khare (Oxford).

4. Optical Fibre Communications: G. Keiser (Tata McGraw Hill).
5. Laser Cooling and Trapping: P.N. Ghosh.
6. Frontiers in Atomic, Molecular and Optical Physics : S.P. Sengupta.
7. Laser in Industry, S.S. Charschan, (Vol Nostrand), 1972.
8. Solid State Laser Engineering, Walter Koechner, (Springer-Verlag), 1976.
9. Applied non-linear optics, Fzernik and J. Midwinte, (John Wiley), 1973.
10. Laser Handbook, Vol.1-4, F.T. Arechi, E.O. Schul Dobois, (North Holland), 1973.
11. Application of lasers, John F. Ready.
12. Principles of lasers, Fourth edition-by Orazio Svelto
13. Lidder, R.E., Fundamental and Applied Laser Physics, John Wiley, New York, 1985.

Laser Physics Laboratory

Course Code: PHY462
Semester: VIII

List of Experiments:

1) Diffraction due to surface tension waves on water.
2) Diffraction due to helical structure.
3) Laser beam characteristics a) Beam waist b) Intensity profile
4) a) Determination of laser parameter-divergences and wavelength for a given laser source using grating. (b) Particle size determination.
5) Fibre optics characterisation-To find numerical aperture of single mode fibre and losses.
6) Brewster's Angle experiment to find refractive index.
7) Polarization of Laser (Verification of Malus Law).
8) Light Intensity Vs Distance using by light source.
9) Interference and Diffraction through slit.

EXPERIMENTAL METHODS AND DESIGN

Sub Code: PHY463
Semester: VIII

Course Objectives:

- The objective of this course is introduce proper methods for conducting controlled physics experiments, including the acquisition, analysis and physical interpretation of data. The course involves experiments which illustrate the principles of modern physics, optics, solid state physics and nuclear physics. The course will also cover all of the essential core and qualitative aspects of selected topics at the forefront of current research.

Course Outcomes:

- Students will be able to demonstrate competency in experimentation including experiment design, system calibration, scientific data acquisition, analysis and presentation. Plan and conduct experimental measurements in physics while employing proper note-taking methods. Calculate uncertainties for physical quantities derived from experimental measurements or in other words, the students will be able to understand how to quantify error and uncertainty in physical measurements. The students will be able to gain hands-on experience with modern instrumentation and systems-level experimentation. Also, they will be able to demonstrate competency in their understanding of scientific information.

UNIT 1: Measurement of fundamental constants: e, h, c – Measurement of high and low resistances, inductance and capacitance – Detection of X-rays, Gamma rays, charged particles, neutrons – Ionization chamber – Proportional counter – GM counter – Scintillation detectors – Solid State detectors –

UNIT 2: Emission and Absorption Spectroscopy – Measurement of Magnetic field – Hall effect – Magnetoresistance – X-ray and neutron Diffraction.

UNIT 3: Vacuum Techniques – Basic idea of conductance, pumping speed – Pumps: Mechanical Pump – Diffusion pump – Gauges – Thermocouple gauge – Penning gauge – Pirani gauge – Hot Cathode gauge – Low temperature systems – Cooling a sample over a range up to 4 K – Measurement of low temperatures.

UNIT 4: Measurement of energy and time using electronic signals from the detectors and associated instrumentation – Signal processing – A/D conversion – multichannel analyzers – Time-of-flight technique – Coincidence Measurements – true to chance ratio – Correlation studies. Error Analysis and Hypothesis testing – Propagation of errors – Plotting of Graph – Distributions – Least squares fitting – Criteria for goodness of fits – Chi square test.

UNIT 5: Design of experiment – need for experiments (validation of theory/ verification of theory/ addition to database); computer interfacing; Data collection and analysis – errors and accuracy of data collected, types of errors, propagation of errors, reporting data – mean, variance, method of least Bsquares fit, central limit theorem, error bars. Data reproducibility and ethics of data collection.phase sensitive detection; shielding of cables.,

References:

1. J.P. Holman, Experimental Methods for Engineers. 7th Edition. McGraw Hill (2000).
2. J. M. Lafferty (Editor) (1998), Foundations of Vacuum Science and Technology, Wiley Interscience.
3. Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley(2004).

Suggested Reading:

4. Anthony Kent, Experimental Low-Temperature Physics ,Macmillan Physical Science (1993).
5. T. G. Beckwith, R. D. Marangoni and J. H. Lienhard ,Mechanical Measurements,6th Edition(2006),Prentice Hall.
6. Ernest O Doebelin, Measurement Systems: Application and Design. 5th edition, Tata McGraw Hill.
7. Albert D Helfrick and William D Cooper (1992), Modern Electronic Instrumentation and Measurement Techniques. Prentice Hall.
8. Hermann K P Neubert, Instrument Transducers: An introduction to their performance and design. Oxford University Press(2003).
9. J. A. Blackburn Modern Instrumentation for Scientists and Engineers, Springer (2001),

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EXPERIMENTAL TECHNIQUES LAB

Course Code: PHY464
Semester: VIII

List of Experiments:

1) Measurement of resistivity of semiconductors by four probe method.

2) Verify the following laws (i) AC Wheatstone bridge (ii) Maxwell's Bridge (iii) De Sauty's bridge
3) Determine the refractive index and thickness of the given Thin film deposited on fused silica

(refractive index=1.5) Using by Spectrophotometer
4) Determine the electric dipole moment of organic molecule (Acetone)
5) Determine the dielectric constant of Non polar liquid (Benzene)
6) Experimentally determine the temperature dependence of the capacitance of a ceramic capacitor
7) Permittivity of dielectric materials (LCR meter)
8) (i) Measurement of High Resistance by leakage
(ii) Measurement of Low Resistance
9) Lock in amplifier

Condensed Matter Physics-II

Sub Code: PHY511
Semester: IX

Course Objectives:

- Soft matter Physics is the study of materials that have high yield to small shear forces. They encompass a wide range of materials from sol-gels to colloids and liquid crystals to proteins. These materials have a wide range of applications in industry including liquid crystal displays and soaps and detergents. This course will introduce the Physics of these materials, with special reference to understanding them through statistical methods and relating these to the experimentally observed physico-chemical characteristics.

Course Outcomes:

- At the end of the course, the student will have an introduction to various types of soft matter, to theories such as phase transitions, DLVO theory etc., that explain the properties of these materials along with the need for using statistical methods to understand the properties of mesoscopic materials. The students will also be introduced to the ideas to computer simulations of soft matter, with a focus on proteins.

UNIT 1: Length, time and energy scales in condensed matter systems
Basic phenomenology of soft condensed matter systems: Liquid crystals, polymers, membranes, colloidal systems, phase behaviour, diffusion and flow, viscoelasticity..

UNIT 2: Order Parameter, Phases and Phase transitions
Mean-field theory and phase diagrams, defining order parameters, elasticity, stability, metastability, interfaces, Basic liquid crystal physics as examples, Frank free energy, Landau-de Gennes model of Â isotropic-nematic transition, Onsager's mean field theory, nematicsmectic transition.

UNIT 3: Colloidal systems
Â Poisson-Boltzmann theory, DLVO theory, sheared colloids, stability of colloidal systems, measurement of interaction.

UNIT 4: Polymers & Membranes

Model systems, chain statistics, polymers in solutions and in melts, flexibility and semiflexibility,distribution functions, selfavoidance, rubber elasticity, viscoelasticity, reptation ideas. Fluid vs. solid membranes, energy and elasticity, surface tension, ÂÂ curvature, de Gennes-Taupin length, brief introduction to shape transitions.

UNIT 5: Dynamics and Numerical Methodologies
Stokes limit, Rouse and Zimm Model for polymers, membranes, relaxation, computational studies, multiscale modeling.

References:

1. Soft Matter Physics, M. Kleman and O.D. Lavrentovich, Springer-Verlag (2003).
2. Statistical Mechanics of Surfaces, Interfaces and Membranes, S.A.Safran, Addison-Wesley, Reading, MA (1994).
3. Colloidal Dispersions, W.B. Russel, D.A. Saville and W.R. Showalter, Cambridge University Press, New York, (1989).
4. Condensed Matter Physics, Michael P. Marder (John Wiley, 2015)

Suggested Reading:

R. A. L. Jones, Soft Condensed Matter (Oxford, 2002).

Computational Physics

(i) Computational Elctromagnetics

Sub Code: PHY551

Course Objectives:

- This course has three major objectives. First it is intended to teach the students how to pose, numerically analyze, and solve EM problems. Second, it is designed to give them the ability to expand their problem solving skills using a variety of available numerical methods. Third, it is meant to prepare graduate students for research in EM. Students with limited or no prior modelling experience will find that the Finite Difference Time Domain (FDTD) method is the simplest and most insightful method from which to start their modelling education, and they can write practical and useful simulations in a matter of minutes.

Course Outcomes:
After successful completion of this course, student should be able to:

- Gain some fundamental concepts of electromagnetic theory.(Maxwell equations with boundary conditions).
- Solve the differential equations using Euler and Runge – kutta methods.
- Acquire clear knowledge in waveguides with different modes (TE/TM/TEM).
- Understand variational methods which serves as a preparatory ground for the two major topics: moment methods and finite element methods.

Unit 1: Review of Electromagnetics – Maxwells equations, boundary conditions, various methods to solve for electrostatic potential, Numerical methods to solve for ODE – Euler and Runge-Kutta – review of waves guides and field patterns – TE/TM/TEM modes.

Unit 2: Variational methods - operators in linear spaces, calculus of variations, construction of functional from PDE, Rayleig-Ritz Method, Weighted residual method – Galerkin and least square methods.

Unit 3: Moment Methods: Integral equations, connection between differential and integral equations, Green's functions – for free space and for domains with boundaries, examples.

Unit 4: – Methods for constant fields – Method of curvilinear squares, Method of moments, Finite Element method, Boundary element Method, Finite Difference Method.

Unit 5: Numerical techniques – for time dependent fields – Finite Difference Time domain method – Concept of particle inn a cell and Yee algorithm – Leap frog/Verlet algorithms – boundary conditions, Computation of radioactive half-life, long half-life and short half-life, and two-level decay.

References:

1. Numerical Techniques in Electromagnetics – M N O Sadiku, CRC Press2001
2. Fundamentals of Electromagnetics with MATLAB, 2e Karl E. Lonngren,Sava V.Savov, Randy J. Jost, SciTech Publishing, Inc., 2007.
3. Numerical Methods in Engineering with Python, Jaan Kiusalaas, Cambridge.

(i) Monte Carlo

Sub Code: PHY551

1. **Introduction :** Basic concepts of computation and simulation. Difference between numerical computation and simulation. Computational Languages, Algorithms, Codes, Pseudo Codes, Flow charts. Modelling of Natural phenomena: Interatomic potentials, Equations of motion. Various computation techniques for different physical systems.

2. **Probability distributions:** Probability theory, Probability density or distribution, Discrete and Continuous Distributions. Uniform distribution, Binomial, Poisson's, Gaussian, Lorentz and Exponential distributions. Marginal density and Joint density. Mean, Variance, Covariance and correlation functions.

3. **Random Numbers:** Random processes, random variables, random number. True random numbers, Pseudo random numbers. Pseudo random number generators: Linear congruential generator, Lagged Fibbonacci generator, ran3 generator, Mersenne Twister generator. Various test for pseudo random number generators.

4. **Monte Carlo Methods:** Coin tossing experiments, Die Experiment, Validity of Stirling Approximation, Box-Muller algorithm, Inversion Method, Rejection Method, Averages and Standard deviations, Errors and Numerical convergence. Numerical Verification of Central Limit Theorem.

5. **Sampling Techniques:** Simple sampling, importance sampling, acceptance ratio, Details balance condition, Metropolis algorithms; Implementation of Monte Carlo algorithms: Random walk, self-avoiding walk, Ising model, nucleation, crystal growth, fractal system etc.

References:

1. H. Gould and J. Tobochnik, An Introduction to Computer Simulation Methods.
2. K.P.N. Murthy, Monte Carlo Methods in Statistical Physics, University Press, 2004.
3. D. Frenkel and B. Smith, "Understanding molecular simulation from algorithm to applications", Kluwar Academic Press, 1999.
4. The future of Nuclear energy, Physics Today Vol. 34, Page. 48, March 1981

Suggested Reading:

1. Newman, M.E.J. and Barkema, G.T. "Monte Carlo Methods in Statistical Phyiscs", Oxford University Press.(1999).
2. Wolfson, M.M. and Pert, G. J., "An Introduction to Computer Simulation", Oxford Press. (1999)
3. Landau, D.P. and Binder, K., "A Guide to Monte Carlo Simulation in Statistical Physics", Cambridge University Press. (2005).
4. Ohno K Esfarjani K and Kawazoe Y, "Introduction to Computational Materials Science from ab initio to Monte Carlo Methods", Springer-Verlag, 1999.
5. W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, Numerical Recipes in FORTRAN 77: The Art of Scientific Computing. (Similar volumes in C, C++).
6. V. Rajaraman, Computer Programming in Fortran 77.
7. H.M. Antia, Numerical Methods for Scientists and Engineers.
8. D.W. Heermann, Computer Simulation Methods in Theoretical Physics.

(ii) Molecular Dynamics

Sub Code: PHY551

1. **Introduction :** Basic concepts of computation and simulation. Difference between numerical computation and simulation. Computational Languages, Algorithms, Codes, Pseudo Codes, Flow charts. Modelling of Natural phenomena: Interatomic potentials, Equations of motion. Various computation techniques for different physical systems.

2. **Force fields :** Bond length potential : harmonic, an harmonic – Morse potential, Bond angle potentials, Torsion angle potential, Coloumb potential, Hard core potential, Hard sphere potential, Van der Waals potential, Lenard Jones potential. Parameterization, interatomic potentials, equations of motion, integration, pair distribution, constraints and free energy

3. **Integration Algorithms:** Long Range Forces, Cutoffs and Neighbor Lists, Verlet Neighbor Lists, Cell-index Method, Constraint Methods, Periodic Boundary Conditions, Verlet algorithm, Predictor Corrector Algorithms, Leap-frog algorithm, Velocity Verlet algorithm, Beeman's algorithm.

4. **Sampling Techniques:** Sampling of various ensembles, Constant Temperature Simulations, Berendsen thermostat, Nosé-Hoover thermostat, Constant pressure Simulations, Berendsen arostat, Parrinello-Rahman barostat, Langevin Dynamics, Langevin barostat. Implementation of Molecular dynamics simulation: Solvation, implicit and explicit solvation scheme, energy optimization, equilibration, ensemble averages etc.

5. Correlation analysis: Time and velocity correlation functions, time and velocity autocorrelation functions, pair correlation function, cross correlation, relaxation times, spherical densities, practical issues in propagation, simulation convergence.

References:

1. H. Gould and J. Tobochnik, An Introduction to Computer Simulation Methods.
2. Computer Simulation of Liquids, M.P. Allen & D.J. Tildesley, Clarendon, Oxford, 1987.
3. D. Frenkel and B. Smith, "Understanding molecular simulation from algorithm to applications", Kluwar Academic Press, 1999.

Suggested Reading:

1. Wolfson, M.M. and Pert, G. J., "An Introduction to Computer Simulation", Oxford Press. (1999)
2. D. C. Rapaport , The Art of Molecular Dynamics Simulation, Cambridge University press.
3. Ohno K Esfarjani K and Kawazoe Y, "Introduction to Computational Materials Science from ab initio to Monte Carlo Methods", Springer-Verlag, 1999.
4. W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, Numerical Recipes in FORTRAN 77: The Art of Scientific Computing. (Similar volumes in C, C++).
5. H.M. Antia, Numerical Methods for Scientists and Engineers.
6. D.W. Heermann, Computer Simulation Methods in Theoretical Physics.
7. http://www.ccp5.ac.uk/about

COMPUTATIONAL LABORATORY II

Sub Code: PHY552
Semester: IX

List of Experiments:
1. Random Number Generators
2. Inversion Techniques – Gaussian Random number Generation
3. Metropolis Algorithm
4. Reweighting Techniques
5. Molecular Dynamics - Demo
6. DFT -Demo
7. Random Walks
8. Self-Avoding walk

Advanced Physics Laboratory

Sub Code: PHY571
Semester: IX

List of Experiments:

1. KDP Crystal
2. ADP Crystal.
3. Thin film coating using Thermal Evaporation method.
4. Thin film Coating Spray Pyrolysis techniques (PVA)
5. FTIR Study of binary liquids (Ethylene glycol-Ethylene system).
6. Determine the lattice parameters of SrTiO3 using the given XRD pattern.
7. DSC – study of phase transitions in liquid crystals
8. Preparation of thin film (Solid/soft matter)

Open Elective Courses

ELECTIVES

Topics for propesed Elective Courses:

1) Semiconductor Physics
2) Solar Energy and its applications
3) Properties of Materials
4) Physics of Materials Synthesis
5) Materials Characterization techniques
6) Cosmology
7) Fundamentals of Nano Science and Technology
8) Environmental Physics
9) Bio Materials
10) Energy conservation and Management
11) Preparation and Characterization of Nanomaterials
12) Laser Technology and Applications
13) Bio Physics
14) Energy Storage devices and Fuel Cells
15) Microwave Physics
16) Astrophysics
17) Surface and Interfacial Physics
18) Relativity and Electrodynamics
19) Advanced Experimental Techniques
20) Advanced Computational Physics
21) Nonlinear Optics
22) Nonlinear Dynamics and Chaos
23) Nonlinear Fiber Optics
24) Polymer Physics
25) Soft condensed Matter
26) Advanced Statistical Mechanics
27) Advanced Mathematical Physics

28) Advanced Electromagnetic Theory
29) Advanced Particle Physics
30) Quantum Optics
31) Physics of Information Theory
32) Quantum field theory
33) Plasma Physics
34) Low temperature Physics and Superconductivity
35) Nano Electronics and Spintronics
36) Introduction to Nuclear Technology
37) Solid State Ionics
38) Vacuum Scinece and Thin Film Physics
39) Multifunctional Materials
40) Crystal Growth and Characterization
41) Fluid Dynamics
42) Physics of rts