THE ASSAM ROYAL GLOBAL UNIVERSITY
GUWAHATI

ROYAL SCHOOL OF APPLIED & PURE SCIENCES

(RSAPS)

DEPARTMENT OF PHYSICS

COURSE STRUCTURE & SYLLABUS
(BASED ON NATIONAL EDUCATION POLICY 2020)
FOR

M.Sc. IN PHYSICS
(2 YEARS)

W.E.F
AY - 2025 – 26

STRUCTURE OF THE SYLLABUS FOR 2 YEAR PG PROGRAMME

SCHOOL NAME - ROYAL SCHOOL OF APPLIED AND PURE SCIENCES
DEPARTMENT NAME - PHYSICS
PROGRAMME NAME - M.Sc. in PHYSICS

1st SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
PHY014C101	Classical Mechanics & Theory of Relativity	400	4	4-0-0
PHY014C102	Quantum Mechanics – I	400	4	4-0-0
PHY014C103	Mathematical Physics	400	4	4-0-0
PHY014C104	Nuclear & Particle Physics	400	4	4-0-0
PHY014C115	Physics Lab-I	400	4	0-0-8
SWAYAM CODE 1	Swayam 1	400	3/4/5	
TOTAL CREDIT FOR 1st SEMESTER			**20** + 3/4/5	
2nd SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
PHY014C201	Condensed Matter Physics	400	4	4-0-0
PHY014C202	Electrodynamics	400	4	4-0-0
PHY014C203	Quantum Mechanics – II	400	4	4-0-0
PHY014C204	Plasma and Space Physics	400	4	4-0-0
PHY014C215	Physics Lab - II	400	4	0-0-8
SWAYAM CODE 2	Swayam 2	400	3/4/5	
TOTAL CREDIT FOR 2nd SEMESTER			**20** + 3/4/5	
TOTAL CREDIT FOR 1st YEAR = 40 + 6/8/10				
3rd SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
PHY014C301	Atomic and Molecular Physics	500	4	4-0-0
PHY014C302	Statistical Mechanics	500	4	4-0-0
PHY014C303	Physics of Nanomaterials	500	4	4-0-0
PHY014C304	Advanced Condensed Matter Physics	500	4	4-0-0
PHY014C321	Project- I	500	8	
SWAYAM CODE 3	Swayam 3	500	3/4/5	
TOTAL CREDIT FOR 3rd SEMESTER			**24** + 3/4/5	
OR 3rd SEMESTER (For students with 3rd and 4th Semester Research)				
PHY014C322	**RESEARCH PROJECT – PHASE I**	**500**	**24** + 3/4/5	**0-0-0**
4th SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
	Dissertation (students with research in 4th Sem)			
(for 'Coursework only' in lieu of Research)				
PHY014C401	Laser and Raman Spectroscopy	500	4	4-0-0
PHY014C402	Semiconductor Devices	500	4	4-0-0
PHY014C403	Nonlinear Optics and photonics	500	4	4-0-0
PHY014C404	Astrophysics	500	4	4-0-0
PHY014C421	Project- II	500	12	
SWAYAM CODE 4	Swayam 4	500	3/4/5	
OR 4th SEMESTER (For students with 3rd and 4th Semester Research)				
PHY014C422	**RESEARCH PROJECT – PHASE 2**	**500**	**28** + 3/4/5	**0-0-0**
TOTAL CREDIT FOR 2nd YEAR = 52+ 6/8/10				

Level: Semester I

Course Level: 400

Name of the Subject: Classical Mechanics & Theory of Relativity

Type of Course:

Subject Code: PHY014C101 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objective: To provide knowledge of Lagrangian dynamics, Hamiltonian dynamics, small oscillation, rigid body dynamics, special theory of relativity and its consequences

Course Outcome:

On successful completion of the course, the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 2	**Understand** the laws of rotational motion, laws of small oscillation, postulates of special theory of relativity, mass energy relation.	**BT 2**
CO 3	**Apply** Lagrange's and Hamilton's equations of motion to solve the common physical problem.	**BT 3**
CO 4	**Analyze** analyses the role of generation function in canonical transformation, effect of Lorentz transformation in length, time, mass and force.	**BT 4**
CO 5	**Evaluate** motion of a force free symmetric top, relativistic mass, momentum and energy.	**BT5**

COURSE OUTLINE:

Modules	**Topics / Course content**	**Periods**
I	Constraints, d'Alembert's Principle, Lagrange's Equation and its Application to Simple Problems. Hamiltonian Function H and Conservation of Energy, Hamilton's Equations, Solution of Physical Problems Using Hamiltonian Dynamics. Canonical Transformations (CT), Generating Functions, Conditions for CT, Procedure of Application of CT, Hamilton Jacobi Theory and Equation.	**18**
II	Introduction to Small Oscillation and Normal Modes, Stable, Unstable and Neutral Equilibrium, Two Coupled Oscillators, Normal Coordinates and Normal Modes. Body and Space Reference Systems & Euler's Angles, Angular Momentum and Inertia Tensor, Euler's Equations for a Rigid Body, Force Free Motion of a Symmetrical Top.	**18**
III	Special theory of Relativity (STR): Lorentz transformation equation- Time dilation and Twin paradox, Experimental verification of Time dilation, space time continuum- mass energy equivalence ($E=Mc^2$) particles with zero rest mass, General Theory of Relativity (GTR): Covariant and contra variant vectors and tensors, quotient law, covariant differentiation, parallel displacement, geodesic equation alternative derivation from a Variational principle, curvature tensors,	**18**
IV	Einstein's law of gravitation: Einstein field equation, weak field approximation- Newtonian theory from Einstein law, motion of a test particle in a weak gravitational field, Poisson's equation from Einstein's law, Gravitational waves.	**18**
Total		**72**

Text books:

1. *Classical Mechanics*; Goldstein H., Narosa Publishing house, 2nd Ed., 2018, New Delhi

Reference books:

1. Upadhaya J. C; *Classical Mechanics,* Himalaya Publishing House, 3rd Ed.,2014, Mumbai
2. Rana & Yoag; *Classical Mechanics,* Tata McGraw-Hill Publishing Company Limited, 1st Ed., 2017, New Delhi

Study material:

Classical Mechanics - from Newtonian to Lagrangian Formulation:
https://archive.nptel.ac.in/courses/115/105/115105098/

Level: Semester I

Course Level: 400

Name of the Subject: Quantum Mechanics-I

Type of Course: Core

Subject Code: PHY014C102 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives:

This course will help the students in understanding of microscopic world. It will also help the student to analyze the impact of wave motion of particles in different physical system.

Course Outcomes:

On successful completion of the course, the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remembe**r Black-body radiation, Plank's Law, photoelectric effect, operators etc.	**BT 1**
CO 2	**Understand** the basic concepts of Wave-particle duality of radiation and matter, Schrödinger equation (time-dependent and time- independent), Compton effect, de-Broglie hypothesis, Schrödinger equation etc.	**BT 2**
CO 3	**Apply** Commutator of two operators on physical systems, Schrödinger equation in closed systems like particle in box, quantum harmonic oscillator etc.	**BT 3**
CO 4	**Analyze** Time independent perturbation theory for a nondegenerate case and for a degenerate case, Stark effect, Zeeman effect, Variational method etc.	**BT 4**

COURSE OUTLINE:

Modules	**Topics / Course content**	**Periods**
I.	Inadequacies of Classical Physics, Black-body radiation, Plank's Law, Photoelectric effect, Compton effect, de Broglie hypothesis, Wave-particle duality of radiation and matter, Schrödinger equation (time-dependent and time- independent); Physical interpretation of wave function; Born interpretation; Equation of continuity; Probability density and Probability current density. Heisenberg's Uncertainty Principle; Ehrenfest's theorem; Linear momentum operator; Physical variables as operators; Expectation value of a physical variable.	**18**
II.	Application of Schrodinger equation to one-dimensional problems; Particle in a box; linear harmonic oscillator; square well potentials; potential step; barrier potential; tunneling effect. General definition of an operator; different types of operators: linear, Hermitian, unitary etc. Commutator of two operators; Commutator algebra; Eigen values and Eigen functions of an operator; Commutator or position and momentum operators.	**18**
III.	Angular momentum operator in quantum mechanics; commutation relations of the three components; Commutation relation between position and angular momentum, between linear momentum and angular momentum; Angular momentum operator in spherical polar coordinates; particle in a central field, expressed in spherical polar coordinates; application of Schrodinger equation to hydrogen atom; the energy eigenvalues and eigenfunctions.	**18**
IV.	Approximation methods in quantum mechanics; Time independent perturbation theory for a nondegenerate case and for a degenerate case, Stark effect, Zeeman effect, Variational method, application to the helium atom, the WKB approximation.	**18**

Total	**72**

Text books:

1. *Introductory Quantum Mechanics; Liboff R.L., Pearson Education, 4th Ed., 2007, New Delhi.*

Reference Books:

1. L.I. Schiff, Bandhyopadhay J.; Quantum Mechanics, McGraw Hill Education; 4th Ed., 2017, New Delhi
2. Ghatak A. K. and Lokanathan S. Quantum Mechanics, Laxmi Publications Pvt. Ltd, 5th Ed., 2015, New Delhi

NPTEL LINK: https://archive.nptel.ac.in/courses/115/101/115101107

Level: Semester I

Course Level: 400

Name of the Subject: Mathematical Physics

Type of Course: Core

Subject Code: PHY014C103 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives:

This course will help the students in understanding of Vector algebra and vector calculus. It will also help the student to analyze the Cayley-Hamilton theorem, analytic function, residue etc.

Course Outcomes:

On successful completion of the course, the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** basis expansion, Schmidt orthogonalization, matrices etc.	**BT 1**
CO 2	**Understand** the basic concepts of Complex numbers, triangular inequalities, Schwarz inequality. Function of a complex variable: single and multiple-valued function	**BT 2**
CO 3	**Apply** Complex integrals on different functions, regular and irregular singular points, Residue theorem etc.	**BT 3**
CO 4	**Analyze** Theory of second order linear homogeneous differential equations Singular points: regular and irregular singular points; Frobenius method, Bessel, Legendre, Hermite and Laguerre functions.	**BT 4**

COURSE OUTLINE:

Modules	**Topics / Course content**	**Periods**
I.	Vector algebra and vector calculus, linear independence, basis expansion, Schmidt orthogonalization. Matrices: Representation of linear transformations and change of base; Eigenvalues and eigenvectors; Functions of a matrix; Cayley-Hamilton theorem; Commuting matrices with degenerate eigenvalues; Orthonormality of eigenvectors, Concepts of tensors.	**18**
II.	Complex variables Recapitulation: Complex numbers, triangular inequalities, Schwarz inequality. Function of a complex variable: single and multiple-valued function, limit and continuity; Differentiation; Cauchy-Riemann equations and their applications; Analytic and harmonic function; Complex integrals, Cauchy's theorem (elementary proof only), converse of Cauchy's theorem, Cauchy's Integral Formula and its corollaries; Classification of singularities; Residue theorem and evaluation of some typical real integrals using this theorem.	**18**
III.	Theory of second order linear homogeneous differential equations Singular points: regular and irregular singular points; Frobenius method. Linear independence of solutions: Wronskian, second solution. Sturm-Liouville's theory; Hermitian operators; Completeness. Inhomogeneous differential equations: Green's functions.	**18**

IV.	Special functions Basic properties (recurrence and orthogonality relations, series expansion) of Bessel, Legendre, Hermite and Laguerre functions, generating function Integral transforms Fourier and Laplace transforms and their inverse transforms, Bromwich integral [use of partial fractions in calculating inverse Laplace transforms]; Transform of Derivative and integral of a function; Solution of differential equations using integral transforms, Delta function.	**18**
Total		**72**

Text books:

1. *Mathematical Physics; Das H.K., S. Chand, 2018, New Delhi*

Reference Books:

2.Rajput B.S; Mathematical Physics, Pragati Prakashan, 23rd Ed. 2011, Meerut

3. Arfken and Weber Mathematical methods for physicists, Elsevier India, 7th Ed. 2012, Gurgaon

NPTEL LINK: Mathematical Methods In Physics -I - Course

Level: Semester I

Course Level: 400

Name of the Subject: Nuclear & Particle Physics

Type of Course: Core

Subject Code: PHY014C104 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives: This course will help the students in understanding of Vector algebra and vector calculus. It will also help the student to analyze the Cayley-Hamilton theorem, analytic function, residue etc.

Course Outcomes:

Upon successful completion of the course students will be able to:		
CO	**COURSE OUTCOME (CO)**	**BLOOM'S TAXONOMY LEVEL**
CO1	Apply the knowledge of basic concepts of nuclei in the determination of properties of processes in the subatomic world.	**BT3**
CO2	Analyze the different nuclear interactions, nuclear models, decays and reaction.	**BT4**
CO3	Work on elementary problem solving in nuclear and particle physics, and evaluate the results.	**BT5**
CO4	Develop the understanding for the nuclear and particle physics to formulate solutions to problems in nuclear and particle physics involving new concepts.	**BT6**

COURSE OUTLINE:

Modules	**Topics / Course content**	**Periods**
I	Nuclear Properties: Size, shape and charge distribution, spin and parity. Nuclear forces: Deuteron, Properties of the nuclear force, Spin dependence of nuclear force. Nuclear Reactions: The Q equation - theory of Nuclear reaction, Compound nucleus, Fission and fusion.	**18**
II	Nuclear Models: Binding energy, The Semi empirical mass formula –mirror nuclei, magic numbers, Spin orbit coupling, excited states, liquid drop model, the Shell Model and Single particle model of the nucleus.	**18**
III	Nuclear decay and radioactivity: Fermi's theory of beta decay, allowed and forbidden transitions, selection rules, non-conservation of parity in beta decay, direct evidence for the neutrino, gamma–decay and selection rules, Curie plots, selection rules, electron Capture, Parity violation.	**18**
IV	Elementary Particles: Classification – Types of Interactions, Conservation laws, CPT theorems, strangeness, hyper charge, Detection of Neutrino, Concept of Antiparticles, Elementary idea of quark model.	**18**
Total		**72**

Text Book:

1. *Introductory Nuclear Physics*- Krane Kenneth. S: S.CHAND, 1st Ed., 2008, New Delhi

References Books:

1. Enge H., *Introduction to Nuclear Physics*, Addison Wesley, 5st Ed. 2015, (available in open source only)
2. Tayal D.C., *Nuclear Physics*, Himalaya House, 5th Ed., 2011, New Delhi
3. Burcham W.C., *Elements of Nuclear Physics*, ELBS paperback, 2nd Ed. 1979, Longman
4. Griffiths D., *Introduction to elementary particles*, Wiley-VCH, 2nd Ed., 2008, New Jersey

NPTEL LINK: https://nptel.ac.in/courses/115103101

Level: Semester I

Course Level: 400

Name of the Subject: Physics Lab -I

Type of Course: Core

Subject Code: PHY014C115 **Scheme of Evaluation: Practical**

L-T-P: 0-0-8 **Total credits: 4**

Course Objectives: This course will help the students in understanding of Stefan's constant – Black body radiation, Planck's constant and other advanced experiments.

Course Outcomes:

On successful completion of the course, the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO1	**Operate** different physical devices.	**BT 1**
CO2	**Work** with different apparatus like interferometer, specific charge measurement device etc.	**BT2**
CO3	**Apply** different methods in different experiments.	**BT3**
CO4	**Analyze** different experimental results with error calculations.	**BT4**

LIST OF EXPERIMENTS

1. Stefan's constant – Black body radiation
2. Resistivity of 'Ge' at various temperatures by Four Probe method and determination of band gap.
3. Measurement of Planck's constant.
4. Determination of ionization and excitation potential using Michelson interferometer.
5. Determination of ionization and excitation potential using Fabry-perot interferometer.
6. Determination of wavelength and separation of D-lines using Michelson interferometer
7. Determination of wavelength and separation of D-lines using Fabry-perot interferometer.
8. Determine the velocity of Ultrasonic wave in liquid by using spectrometer.
9. Determination of e/m by Thomson method.
10. Determination of e/m by Millikan's oil drop method.

Text books:

1. A text book on practical physics Mazumdar K.G., Ghosh B, Sreedhar publishers, 16th Ed. 2011, Kolkata.

Reference Books:

2. Advance Practical Physics for students; Worsnop B.L. Flint H.T. Facsimile Publisher, 2nd Ed. 2019, New Delhi.

Level: Semester II

Course Level: 400

Name of the Subject: Condensed Matter Physics

Subject Code: PHY014C201 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives: On completion of this course, students will be able to gain interest on the following: Electrons' motion in one-dimensional potential well, three-dimensional potential well, quantum state and degeneracy, Bloch function, Kronig-Penney model, number of states in a band, Energy gap etc.

Course Outcomes:

On successful completion of the course the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the Free electron theory of metals, Band theory of solids, Magnetic properties of solids etc.	**BT 1**
CO 2	**Understand** electrons motion in one-dimensional potential well, insulators and semiconductors etc.	**BT 2**
CO 3	**Apply** the Concepts of quantum theory of diamagnetism and Para magnetism, diamagnetic and paramagnetic susceptibilities	**BT 3**
CO 4	**Analyze** the Critical temperature-persistent current-occurrence of super conductivity	**BT 4**

COURSE OUTLINE:

Modules	Topics / Course content	Periods
I	Free electron theory of metals: Free electron model, Electrons moving in one dimensional potential well, three-dimensional potential well, quantum state and degeneracy, the density of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution function, the electronic specific heat. Electrical conductivity of metals, relaxation time and mean free path, electrical conductivity and Ohm's law, Thermal conductivity, Wiedemann - Franz law, thermionic emission, Hall effect.	**18**
II	Band theory of solids: Elementary ideas of formation of energy bands. Bloch function. Kronig-Penney model, number of states in a band, Energy gap. Distinction between metals, insulators and semiconductors. Concept of holes, equation of motion for electrons and holes, effective mass of electrons and holes. Band structure of semi-conductors, Intrinsic and extrinsic semiconductors, expression for carrier concentration (only for intrinsic), ionization energies, charge neutrality equation.	**18**
III	Magnetic properties of solids: Fundamental concepts, quantum theory of diamagnetism and Para magnetism, diamagnetic and paramagnetic susceptibilities of free electrons, molecular field theory of ferromagnetism, anti-ferromagnetism and ferrimagnetism, anisotropic energy, electron paramagnetic resonance and nuclear magnetic resonance, Bloch equations, Heisenberg Hamiltonian for exchange interaction.	**18**
IV	Superconductors: Critical temperature-persistent current-occurrence of super conductivity, ideal and non-ideal superconductors-Destruction of super conductivity by magnetic field Meissner effect- heat capacity-energy gap- microwave and infrared properties- Isotope effect- BCS theory (qualitative)- Josephson tunneling-exotic superconductors- high Tc superconductors.	**18**
	Total	**72**

Text books:

1. Solid State Physics; C. Kittel, John Wiley & sons, Inc., 8th Ed., 2005, New Delhi.
2. Solid State Physics Dekker A. J. Macmillan India Ltd, 1st Ed., 2000, Bangalore.

Reference books:

1. *Verma A.R. and Srivastava O.N.; Crystallography Applied to Solid State Physics, 2nd edition, New Age International Publishers, 2001, Darya Ganj, Delhi*
2. Gupta H.C., Solid State Physics, Vikas Publishing House, 2nd Ed., 2010, New Delhi

NPTEL LINK: https://archive.nptel.ac.in/courses/115/106/115106061/

Level: Semester II

Course Level: 400

Name of the Subject: Electrodynamics

Subject Code: PHY014C202 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objective: To provide knowledge of electrostatic potential, magnetic vector potential, Maxwell's laws, effects of relativistic motion on the electromagnetic phenomena.

Course Outcome:

On successful completion of the course, the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 2	**Understand** different methods used in electrostatics and magnetostatics, Maxwell's equations, effects of relativity on electric and magnetic fields	**BT 2**
CO 3	**Apply** the concept of boundary equation; method of images, separation of variables method and multipole expansion method to solve electrostatics problems. Apply maxwells equation to understand the conservation of energy and momentum	**BT 3**
CO 4	**Analyze** the electric fields due to electric dipole, effects the material conductivity on the propagation of electromagnetic wave	**BT 4**
CO 5	**Evaluate** the dispersion of electromagnetic waves, relativistic effects on electric and magnetic fields	**BT5**

COURSE OUTLINE:

Modules	**Topics / Course content**	**Periods**
I	Recap of basics law in electrostatics like Gauss's law, Basic concept of electric potential, Poisson's and Laplace's equations, Laplace equation in different coordinate systems, uniqueness theorem, boundary value problems; method of images, separation of variables method, multipole expansion including approximate potential at large distances, electric dipole and its field and potential	**18**
II	Recap of basics law in magnetostatics like Biot-Savart law, divergence and curl of B, magnetic vector potential, magnetic dipole, energy of a dipole in an external electric and magnetic field, magnetic potential, Scalar and vector potentials, Gauge transformations; continuous charge distribution: retarded potential; point charges: Lienard-Wiechert potentials	**18**
III	Maxwell's equations, fixing of Ampere law by Maxwell, Maxwell's equations in matter, conservation of energy, Maxwell's stress tensor and conservation of momentum in electrodynamics, Poynting's theorem. Wave equation, reflection, refraction and propagation of electromagnetic waves in vacuum, dispersive media and conducting medium, concept of waveguide.	**18**
IV	Relativistic electrodynamics: Concept of proper and ordinary time, velocity, force and momentum; magnetism as a relativistic phenomenon; Lorentz transformation of four vector potential, transformation of fields, field tensor; electrodynamics in tensor notation; Minkowski force on a Charged particle; relativistic potential	**18**
	Total	**72**

Text books:

1. *Introduction to Electrodynamics*; Griffiths D.J., PHI, 4th Ed., 2013, New Delhi
2. *Classical Electrodynamics;* Jackson J. D., Wiley, 3rd Ed., 2007 New York

Reference books:

1. Chakraborty B.; *Principles of Electrodynamics*, Books & Allied Ltd, 1st Ed., 2010, Kolkata

Study material:

Foundations of Classical Electrodynamics
https://archive.nptel.ac.in/courses/115/105/115105132/

Level: Semester II

Course Level:400

Name of the Subject: Quantum Mechanics-II

Type of Course: Core

Subject Code: PHY014C203 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives:

This course will help the students in understanding time dependent dynamics. It will also help the student to analyze the consequences of the indistinguishability of identical quantum particles, relativistic quantum mechanics etc.

Course Outcomes:

On successful completion of the course, the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remembe**r Time dependent phenomena: Heisenberg picture for a time-dependent Hamiltonian; the sudden approximation.	**BT 1**
CO 2	**Understand the s**cattering cross-section in quantum mechanics; scattering amplitude; the inhomogeneous Schrodinger equation for a two-particle scattering	**BT 2**
CO 3	**Apply** the quantum mechanical concept on Identical Particles: Consequences of the indistinguishability of identical quantum particles; the exchange operator; symmetric and antisymmetric wave functions	**BT 3**
CO 4	**Analyze** Klein-Gordon equation; problems related to its interpretation; Dirac Hamiltonian and equation for a free particle; determination of the Dirac matrices	**BT 4**

COURSE OUTLINE:

Modules	**Topics / Course content**	**Periods**
I.	Time dependent phenomena: Heisenberg picture for a time-dependent Hamiltonian; the sudden approximation; Time-dependent perturbation theory; perturbation expansion; first order transition; harmonic perturbation; transition into a continuous spectrum; Fermi golden rule; interaction of matter with electromagnetic radiation; electric dipole approximation; Rayleigh scattering.	**18**
II.	Theory of scattering: Scattering cross-section in quantum mechanics; scattering amplitude; the inhomogeneous Schrodinger equation for a two-particle scattering; integral equation for the wave function using the technique of Green‘s function; the integral equation for the scattering amplitude; the successive Born approximations; the scattering amplitude in the first Born approximation for a Central potential; Scattering by a Screened Coulomb potential; the Rutherford Scattering formula; validity of Born approximation; Method of partial waves; asymptotic solution, the scattering amplitude; general expression for scattering cross-section, the S-wave scattering	**18**
III.	Identical Particles: Consequences of the indistinguishability of identical quantum particles; the exchange operator; symmetric and antisymmetric wave functions; Pauli exclusion principle; inclusion of spin; Pauli spin matrices; spin functions for a two-electron system; the wave function for the ground state of helium atom. Particle number representation in quantum mechanics; application and creation operators; applications to fermions and bosons.	**18**
IV.	Relativistic Quantum Mechanics: Klein-Gordon equation; problems related to its interpretation; Dirac Hamiltonian and equation for a free particle; determination of the Dirac matrices; probability density and probability current density; existence of spin of the Dirac particle; Dirac electron in an electromagnetic field; non-relativistic reduction; spin magnetic moment of the electron; negative energy states and Dirac’s hole theory; prediction of positrons.	**18**
Total		**72**

Text books:

2. *Introductory Quantum Mechanics; Liboff R.L., Pearson Education, 4th Ed., 2007, New Delhi.*

Reference Books:

3. L.I. Schiff, Bandhyopadhay J.; Quantum Mechanics, McGraw Hill Education; 4th Ed., 2017, New Delhi
4. Ghatak A. K. and Lokanathan S. Quantum Mechanics, Laxmi Publications Pvt. Ltd, 5th Ed., 2015, New Delhi

NPTEL LINK: NPTEL :: Physics - NOC:Advanced Quantum Mechanics with Applications

Level: Semester II

Course Level: 400
Name of the Subject: Plasma and Space Physics
Type of Course: Core
Subject Code: PHY014C204 **Scheme of Evaluation: Theory**
L-T-P: 4-0-0 **Total credits: 4**
Course Objectives:
This course will help the students in understanding Lagrangian and Hamiltonian dynamics. It will also help the student to analyze the impact of different constraints of motion in a few physical systems.
Course Outcomes:

On successful completion of the course, the students will be able to:		
CO	Course Outcome	Blooms Taxonomy Level
CO 1	**Remembe**r fourth state of matter, plasma, ionosphere etc.	BT 1
CO 2	**Understand** the Debye shielding, fluid equation of motion, Solar flares, Sunspots	BT 2
CO 3	**Apply** equation of continuity, equation of state to understand plasma, ionospheric density.	BT 3
CO 4	**Analyze** MHD waves: magneto-sonic and Alfven waves, Solar flares, Sunspots, plasma in the Earth's middle and inner magnetosphere	BT 4

COURSE OUTLINE:

Modules	Course Contents	Periods
I.	**Plasma Physics:** Understanding of elementary concepts: plasma oscillations, Debye shielding, plasma parameters, criteria for plasmas, analysis of Plasma confinement: single particle motion, ∇B⊥B: Grad- B drift, curvature drift, their applications and analysis. ∇B ll B: magnetic mirrors, non-uniform E Field, time-varying E Field, time-varying B Field, adiabatic invariants: first, second and third adiabatic invariant (Pinch effect, magnetic mirrors); Evaluation of related problems.	1 8
II	**Plasma as fluids:** Analysis of relation of plasma physics to ordinary electromagnetics: Maxwell's equations, dielectric constant of a plasma; fluid equation of motion, convective derivative, stress tensor, collisions, comparison with ordinary hydrodynamics, analysis of equation of continuity, equation of state; plasma approximation. Evaluation of related problems. MHD waves: magneto-sonic and Alfven waves, propagation at arbitrary directions: pure Alfven wave, fast and slow MHD waves, phase velocities, wave normal surfaces.	18
III.	**Space Physics:** Introduction: Understanding of early studies on geomagnetic field, ionosphere and magnetosphere, magnetospheric exploration, planetary and interplanetary exploration. Analysis of Solar phenomena: structure of the Sun, Solar activity, prominences, coronal heating, Solar flares, Sunspots. Analysis of solar wind properties, solar wind formations, interaction of Solar wind with magnetized and unmagnetized planets. Evaluation of related problems.	18
I V	Ionosphere: Concept of Ion production and loss, determination of ionospheric density. Magnetosphere: Analysis of magnetopause, magnetotail, magnetic reconnection, plasma flow in the magnetosphere, magnetic field configuration of the Earth's magnetosphere, plasma in the Earth's middle and inner magnetosphere, Ionosphere-Magnetosphere coupling, Evaluation of related problems.	18
	Total	72

Texts:

1. *Plasma Physics and Controlled Fusion*; Chen F.F., Springer International, 3rd Ed., 2016, Switzerland
2. *Fundamentals of Plasma Physics;* Bittencourt J.A. 3rd Ed., 2004, *Springer* (India)
3. *Introduction to Space Physics*; Russell C. T., Cambridge University Press ; 1st Ed., 1995, Cambridge

References:

1. Gurnett D. A. and Bhattacharjee A.; *Introduction to Plasma Physics with space and laboratory applications*, Cambridge University Press, 1st Ed., 2005, Cambridge.
2. Robert J. G. and Rutherford P. H.; *Introduction to Plasma Physics*, IOP Publishing Ltd, 1st Ed. (Reprint) 1995, Philadelphia

NPTEL LINK: Plasma Physics and Applications - Course

Level: Semester II

Course Level: 400

Name of the Subject: Physics Lab -II

Type of Course: Core

Subject Code: PHY014C215 **Scheme of Evaluation: Practical**

L-T-P: 0-0-8 **Total credits: 4**

Course Objectives:

This course will help the students in understanding of photo-diode, solar cell and other experiments.

Course Outcomes:

On successful completion of the course, the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Operate** different physical devices.	**BT 1**
CO 2	**Work** with different apparatus like G M counter, Photo detector etc.	**BT 2**
CO 3	**Apply** different methods in different experiments.	**BT3**
CO 4	**Analyze** different experimental results with error calculations.	**BT 4**

LIST OF EXPERIMENTS

1 . Simple experiments using GM counter

2. Forbidden Energy Gap from P-N junction

3. Forbidden Energy Gap using four probe methods.

4. Study of characteristics of LED and PIN Photo Detector

5. Photo-diode Characteristics

6. Solar-Cell Characteristics.

7. Determination of Hall co-efficient, mobility using Hall Effect Set-up (Digital).

8. Determination of dielectric constant of solids

9. Measurement of numerical aperture and V-parameter using laser kit.

10. Determination of lattice vibrational frequency of monoatomic and diatomic lattice using lattice vibrational kit.

Text books:

A text book on practical physics Mazumdar K.G., Ghosh B, Sreedhar publishers, 16th Ed. 2011, Kolkata

Reference Books:

Advance Practical Physics for students; Worsnop B.L. Flint H.T. Facsimile Publisher, 2nd Ed. 2019, New Delhi

Level: Semester III

Course Level: 500

Name of the Subject: Atomic and Molecular Physics

Type of Course: Core

Subject Code: PHY014C301 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives:

This course begins with a review about the modern developments in experimental techniques, especially spectroscopy, and to realize the role and practical application of physics of atoms and molecules in the modern world. Hyperfine structure, Classical and Quantum mechanical concept, coupling scheme and idea of symmetry are the importance of this syllabus.

Course Outcomes:

On successful completion of the course, the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the Quantum states of Electron in atoms, Hydrogen atom spectrum, LS–JJ coupling Schemes.	**BT 1**
CO 2	**Understand,** Hyperfine structure and isotopic shift, one and two electron systems, Lande's g factor, Selection Rules, Stark effect, Inner Shell vacancy.	**BT 2**
CO 3	**Apply** the concept of lattice relaxation times, and Zero field splitting	**BT 3**
CO 4	**Analyze** the concept of Born-Oppenheimer approximation, idea of symmetry for diatomic and polyatomic molecules	**BT 4**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I.	Quantum states of Electron in atoms, Hydrogen atom spectrum, relativistic correction for energy levels of hydrogen atoms, Electron Spin, Stern Gerlach Experiment, Spin Orbit interaction, Two electron systems, LS–JJ coupling Schemes, Fine structure, Spectroscopic terms and selection rules.	**18**
II.	Hyperfine structure and isotopic shift, width of spectral lines, spectrum of helium and alkali atoms, Zeeman and Paschen Back Effect of one and two electron systems, Lande's g factor, Selection Rules, Stark effect, Inner Shell vacancy.	**18**
III.	Classical and Quantum mechanical description, Spin-spin and Spin-lattice relaxation times, Chemical shift. ESR, Basic principles, Nuclear interaction and Hyperfine Structure, Zero fields splitting.	**18**
IV.	Born-Oppenheimer approximation, rotation, vibration and electronic structure of diatomic molecules, the Franck-Condon principle, electron spin and Hund's cases, idea of symmetry for diatomic and polyatomic molecules	**18**
	Total	**72**

Text books:

1. *Physics of Atoms and Molecules*, B.H. Branden and C. J. Jochain, Pearson Education, 2nd Ed., 2015, Noida
2. *Fundamentals of Molecular Spectroscopy*, C.N. Banwell, McGraw-Hill, 4th Ed., 2004, New York

Reference books:

1. H. E. White, *Introduction to Atomic Spectra,* , McGraw-Hill Book Company, 1st Ed., 1934, New Delhi
2. G. Herzberg, *Molecular Spectra and Molecular Structure*,2nd Ed.,2008, Vancouver
3. W. Demtroder, *Laser Spectroscopy*, Springer, 3rd Ed., 2003, New Delhi
4. Hollas, *Modern Spectroscopy*; Wiley India Pvt. Ltd, 4th Ed.,2010, Noida

Level: Semester III

Course Level: 500

Name of the Subject: Statistical Mechanics

Subject Code: PHY014C302 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives: The objective of this course is to provide a comprehensive understanding of the statistical foundations of thermodynamics and their application to various physical systems. The course introduces different statistical ensembles—microcanonical, canonical, and grand canonical—emphasizing the role of the partition function and energy fluctuations. The students will study strongly interacting systems through models such as the Ising and Heisenberg Hamiltonians, exploring various approximation methods and exact solutions to understand complex interactions in many-body systems.

Course Outcomes:

On successful completion of the course the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the fundamentals of Thermodynamics and relation with statistical mechanics, The canonical ensemble and its thermodynamics, partition function	**BT 1**
CO 2	**Understand** the basic concept of statistical mechanics to describe systems containing huge numbers of particles; Ideal Bose System, Thermodynamic behavior of an ideal Fermi Gas	**BT 2**
CO 3	**Apply** the Concepts of Thermodynamics and Statistical Physics to Phase Transitions: Phenomenology, Brownian motion	**BT 3**
CO 4	**Analyze** the Strongly interacting systems: Ising model, Bragg-William's approximation.	**BT 4**

COURSE OUTLINE:

Modules	Topics / Course content	Periods
I	Statistical basis of thermodynamics; the microstate and the macrostate; probability; probability distribution function; postulates of equal a priori probability; phase space; Liouville theorem. Concept of ensembles, microcanonical; canonical and grand canonical ensembles; The grand canonical ensemble and significance of statistical quantities, partition function; principle of equipartition energy. Energy of Harmonic oscillator; partition function for canonical ensemble; energy fluctuations in the canonical ensemble; partition function and Thermodynamic function for grand canonical ensemble; density fluctuations in the grand canonical ensemble.	**18**
II	Ideal Bose System: Thermodynamic behaviour of ideal Bose gas, Bose-Einstein condensation (Experimental evidences), Liquid Helium: two fluid hydrodynamics, Second sound. Ideal Fermi System, Black body radiation, Stefan Boltzmann law. Wien's displacement law, Thermodynamic behaviour of an ideal Fermi Gas, Degenerate Fermi Gas.	**18**
III	Phase Transitions: Phenomenology: First and Second order phase transitions, elementary idea of critical phenomena, Universality of critical exponents. Fluctuations. Thermodynamic fluctuations. Spatial correlations in a fluid. Brownian motion: Einstein-Smoluchowski's theory.	**18**
IV	Strongly interacting systems: Ising model; Idea of exchange interaction; Heisenberg Hamiltonian. Ising Hamiltonian as a truncated Heisenberg Hamiltonian. Exact solution of one-dimensional Ising system. Bragg-William's approximation (Mean field theory); Bethe-Pearls approximation.	**18**
	Total	**72**

Text books:

3. R. K. Patharia; Statistical Mechanics, Academic Press, 3rd Ed., 2011, Cambridge.
4. Gupta and Kumar; *Statistical Mechanics;* Pragati Prakashan, 24th Ed., 2015, Meerut

Reference books:

3. *Fundamentals of Statistical and Thermal Physics*; F. Reif, Sarat Book House Pvt. Ltd, 1st Ed., 2009, Kolkata
4. Lokanathan S. and Gambhi R.S.; *Statistical and Thermal Physics- An introduction,* P.H.I., 1st Ed., 2008, New Delhi.

NPTEL LINK: https://archive.nptel.ac.in/courses/104/101/104101125/

Level: Semester III

Course Level: 500

Name of the Subject: Physics of Nanomaterials

Subject Code: PHY014C303 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

The emphasis of this course is to impart the understanding of the Nanoscale and its significance, Challenges in Nanotechnology and properties of nanoparticles, Semiconducting nanoparticles, Synthesis methods and Special Nanomaterials.

Course Outcomes:

Upon successful completion of the course students will be able to:		
CO	**COURSE OUTCOME (CO)**	**BLOOMS TAXONOMY LEVEL**

CO1	Remember the fundamental understanding of nanomaterials and their properties.	**BT1**
CO2	Understand the concept of various characterization tools required to study the properties of nanomaterials and various synthesis methods.	**BT2**
CO3	Apply the knowledge to resolve the related problems.	**BT3**
CO4	Analyze the concepts of the physics of nanomaterials, to solve problems, with logical interpretations and critical thinking.	**BT4**

COURSE OUTLINE:

Modules	Topics / Course content	Periods
I.	Introduction: Nanoscale and its significance, surface to volume ratio, exciton, Quantum Confinement: Introduction of Quantum wells, wires and dots, size and dimensionality effects, Bohr excitons, Properties of nanoparticles: Structural properties, optical properties - Blue shift, Emission Stokes shift, electrical properties, mechanical properties and magnetic properties.	**10**
II.	Nanostructure growth and Synthesis Techniques: Homogeneous and heterogeneous nucleation, Growth of nanocrystals in solution, Top down and bottom up approaches- Chemical route, Chemical vapor deposition, Physical vapour deposition, Magnetron sputtering, Molecular beam epitaxy, Lithography.	**10**
III.	Characterization of Nanomaterials: Introduction, Structural Characterization - X-ray diffraction (XRD), Small angle X-ray scattering (SAXS), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Scanning probe microscopy (SPM), Chemical Characterization- Optical spectroscopy- Absorption and transmission spectroscopy, Photoluminescence (PL), Electron spectroscopy.	**10**
IV.	Electron transport in semiconductors and nanostructures: Time and length scales of the electrons in solids- Electron fundamental lengths in solids, Size of a device and electron spectrum quantization, Time scales and temporal (frequency) regimes, Statistics of the electrons in solids and nanostructures, Electron transport in nanostructures, Applications of nanomaterials: Light emitting and detecting device, photo voltaic cell, gas sensor, Spintronic devices and spin field effect transistors (SPINFET).	**10**
	Total	**40**

Text books:

1. *Nanostructures and Nanomaterials: Synthesis, Properties, and Applications*; G. Cao, Y. Wang, World Scientific, 2nd Ed., 2011, Singapore

Reference books:

1. Edelstein A.S., and Cammarata, R.C., *Nanomaterials: Synthesis, Properties and Applications,* Institute of Physics, 1st Ed., 2001, Bristol
2. C. P. Poole, J. F. J. Owens, *Introduction to Nanotechnology;* Wiley India ,1st Ed.,2003, New Delhi

Level: Semester III

Course Level: 500

Name of the Subject: Advanced Condensed Matter Physics

Subject Code: PHY014C304 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives: On completion of this course**,** students will be able to gain interest on the following: Born-von Karman periodic boundary condition, optical and acoustical modes, periodicity of Bloch functions, Niel model of anti-ferromagnetism etc.

Course Outcomes:

On successful completion of the course the students will be able to:		
CO	Course Outcome	Blooms Taxonomy Level
CO 1	**Remember** the harmonic approximation, Classical lattice heat capacity, consequences of lattice periodicity etc.	BT 1
CO 2	**Understand** Born-von Karman periodic boundary condition, optical and acoustical modes, periodicity of Bloch functions etc.	BT 2
CO 3	**Apply** the energy bands in a general periodic potential of free electrons, the tight-binding approximations etc.	BT 3
CO 4	**Analyze** the exchange interaction and its origin, Niel model of anti-ferromagnetism etc.	BT 4

COURSE OUTLINE:

Modules	Topics / Course content	Periods
I	Lattice dynamics: The harmonic approximation; normal modes of a one-dimensional mono-atomic lattice; Born-von Karman periodic boundary condition; the dispersion curve; normal modes of a one-dimensional diatomic lattice; the salient features of dispersion curves; optical and acoustical modes; general theory of harmonic approximation; normal modes of a real crystal; quantization of lattice vibration; Phonons.	18
II	Thermal properties of solids: Classical lattice heat capacity; quantum theory of lattice capacity; average energy of a quantum harmonic oscillator; the Einstein model; phonon density of sates; the Debye model; an-harmonic effects; thermal expansion; phonon-phonon collisions; normal and Umklapp processes.	18
III	Band theory of solids: Consequences of lattice periodicity; Statement and proof of the Bloch theorem; periodicity of Bloch functions and the eigen values; nearly free electron model and band structure; energy bands in a general periodic potential; solution of the zone boundary; the tight-binding approximation; the Wigner-Seitz cellular method; ideas of OPW, APW and pseudopotential methods.	18
IV	Ferro-, anti-ferro and Ferri-magnetism: The exchange interaction and its origin; the Heisenberg Hamiltonian and model of ferromagnetism; anisotropic energy, The Bloch Wall; Origin of magnetic domains; Niel model of anti-ferromagnetism; Spin Waves, one-dimensional ferromagnet and magnons; magnon dispersion relations; Bloch $T^{3/2}$ law.	18
	Total	**72**

Text books:

5. Solid State Physics; C. Kittel, John Wiley & sons, Inc., 8th Ed., 2005, New Delhi.
6. Solid State Physics Dekker A. J. Macmillan India Ltd, 1st Ed., 2000, Bangalore.

Reference books:

5. *Verma A.R. and Srivastava O.N.; Crystallography Applied to Solid State Physics, 2nd edition, New Age International Publishers, 2001, Darya Ganj, Delhi*
6. Gupta H.C., Solid State Physics, Vikas Publishing House, 2nd Ed., 2010, New Delhi

NPTEL LINK: https://archive.nptel.ac.in/courses/115/106/115106061/

Level: Semester III

Course Level: 500

Name of the Subject: Project-I

Type of Course: Core

Subject Code: PHY014C321 **Scheme of Evaluation: Presentation**

L-T-P: **Total credits: 8**

Course Objectives:

This course will help the students in understanding of different interesting research physics.

Student will complete under the guidance with Faculty member.

Level: Semester IV

Course Level: 500

Name of the Subject: Laser and Raman Spectroscopy

Type of Course: Core

Subject Code: PHY014C401 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives:
This course aims to develop knowledge in the basics of lasers and enhance comprehension in the principles of

lasers and to explore the control of laser properties and study Raman spectroscopy phenomena.

Course Outcomes:

On successful completion of the course, the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember**: Interaction of radiation with matter, two and three level laser systems	**BT 1**
CO 2	**Understand different types of lasers like,** Solid state lasers, Gas lasers, Liquid and dye lasers.	**BT 2**
CO 3	**Apply** the concept of modes of resonators, mode locking and apply to find the loss in cavity.	**BT 3**
CO 4	**Analyze** the concept of Raman spectroscopy, Rotational and vibrational Raman Spectra	**BT 4**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Interaction of radiation with matter: Interaction of light with atoms and molecules, absorption, emission, stimulated and spontaneous emission, Principle of lasers, population inversion, conditions of lasing action, characteristics of a laser- coherence, monochromaticity, divergence, intensity, Einstein's co-efficient, laser pumping, two and three level laser systems.	**18**
II	Solid state lasers: the ruby laser, Nd: YAG Laser, Semiconductor lasers, features of semiconductor lasers, diode lasers, Gas laser: He-Ne laser, CO_2 laser, liquid lasers: dye lasers and chemical lasers.	**18**
III	Laser pumping, resonators, vibrational modes of resonators, number of modes/unit- volume, open resonators, confocal resonators, Q factor, losses in the cavity, threshold condition, quantum yield, mode locking (active and passive).	**18**
IV	Raman spectroscopy: Raman effect, Quantum theory of Raman effect, Rotational Raman Spectra Vibrational Raman Spectra, Raman spectra of polyatomic molecules, Raman Spectrometer, experimental techniques.	**18**
Total		**72**

Texts books:

1. *Principles of Lasers,* O. Svelto., Polytechnic Institute of Milan and National Research Council. Milan. 5th Ed., 2014, Italy
2. *Physics of Atoms and Molecules*, B.H. Bransden and C. J. Jochain, Pearson Education, 2nd Ed., 2009, New Delhi.
3. *Laser and nonlinear optics*, B.B. Laud**,** New Age International (P) limited, 3rd Ed., 2010, New Delhi

Reference books:

1. Arthur Beiser*, Concepts of Modern Physics*, 6th Ed., Tata McGraw-Hill, 2010, New Delhi.
2. M. C Gupta, *Atomic and molecular spectroscopy,* New Age International (P) limited,2nd Ed., 2005, New Delhi
3. B.P. Straughan and S. Walker, *Spectroscopy Volume I*, John Wiley & Sons, Inc., 2nd Ed., 1976, New York.
4. K. Thyagarajan and A. K. Ghatak*, Lasers: Theory and Application*, Plenum Press, 2nd Ed., 2010, London

Level: Semester IV

Course Level: 500

Name of the Subject: Semiconductor Devices

Subject Code: PHY014C402 **Scheme of Evaluation: Theory**

L-T-P : 4-0-0 **Total credits: 4**

Course Objectives:

This course aims to introduce students to the fundamentals of semiconductor devices, including p-n junctions, BJTs, JFETs, and optoelectronic components along with their characteristics and applications. It covers the working principles of various transducers used for measuring various physical quantities. The course also provides foundational knowledge of digital electronics, focusing on number systems, Boolean algebra, logic gates, and key digital components such as flip-flops, counters, and converters. Additionally, students will learn about operational amplifiers and their applications in analog signal processing, including amplification, filtering, and oscillation. The principles of modulation and demodulation for communication systems, as well as basic concepts of integrated circuits, microprocessors, and microcontrollers, are also introduced to prepare students for modern electronic measurement and control systems.

Course Outcomes:

On successful completion of the course the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the basic structure, functions, and characteristics of semiconductor devices such as p-n junction diodes, BJTs, JFETs, LEDs, photodetectors, and solar cells.	**BT 1**
CO 2	**Understand** the fundamentals of number systems and Boolean algebra and how logic gates, flip-flops, registers, counters, and other digital components are used to design and analyze digital circuits.	**BT 2**
CO 3	**Apply** operational amplifier concepts to implement analog signal processing functions such as amplification, addition, etc.	**BT 3**
CO 4	**Analyze** different modulation and demodulation techniques to compare their efficiency, bandwidth requirements, and suitability for specific communication systems.	**BT 4**

COURSE OUTLINE:

Modules	**Topics / Course content**	**Periods**
I	**Semiconductor devices:** p-n junction diodes, metal-semiconductor junction diodes, BJT/JFET devices and their characteristics, Homo and Heterojunction devices. Transducers (temperature, pressure/vacuum, magnetic fields vibration, optical and particle detector), photo-detector, LED and Solar cell	**18**
II	**Number systems & Boolean Algebra:** De Morgan's laws, Basic logic gates, universal gates, Logic families, Karnaugh map, Arithmetic circuits, Flip-Flops, Registers, Counters, comparators, A/D and D/A converters, Multiplexer, Demultiplexer.	**18**
III	**Operational amplifier and its applications**: Introduction to operational amplifiers, Ideal operational amplifier, Characteristics of OM-AMP, op-amp with negative feedback, inverting and non-inverting amplifier, OM-AMP as adder, subtractor, differentiators, integrators, Logarithmic & Differential amplifier, Filters and noise reduction, Impedance matching, amplification, Feedback theory, Oscillators.	**18**
IV	**Modulation and Demodulation:** Amplitude and Frequency modulation, Demodulation techniques, Bandwidth requirements, Pulse communication, Measurement and control, Signal conditioning and recovery. Basic concepts of Integrated Circuits, Basics of Microprocessors and Microcontrollers.	**18**
	Total	**72**

Text Book:

1. Integrated Electronics; Jacob Millman, Christos Halkias and Chetan D. Parikh, McGraw Hill Education; 2nd edition (1 July 2017).
2. Handbook of Electronics; Gupta & Kumar, Pragati Prakashan, 38th Edition 2012.
3. R.P. Jain , “Modern Digital Electronics”, Tata Mc Graw Hill, 3rd Edition, 2007.

Reference Book:

1.Talukdar P. H.; Digital Logic and System Design, Mani Manik Prakash, 1st Ed., 2016, Guwahati.

2.Chattopadhyay D.; Electronics: Fundamentals & Applications; New Age International, 1st Ed., 2010, New Delhi.

NPTEL LINK: https://nptel.ac.in/courses/122106025

Level: Semester IV

Course Level: 500

Name of the Subject: Non-Linear Optics and Photonics

Type of Course: Core

Subject Code: PHY014C403 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives:
This course aims to understand the significance of Nonlinear Optics and Photonics and its contribution in communication system.

Course Outcomes:

On successful completion of the course, the students will be able to:

CO	Course Outcome	Blooms Taxonomy Level
CO 1	**Remembe**r the concept of linear and nonlinear optics and the different effect arising out of it	BT 1
CO 2	**Understand**. The basics of linear and nonlinear wave propagation and frequency mixing.	BT 2
CO 3	**Apply** the properties of photonics in different field of technology	BT 3
CO 4	**Analyze** the properties and its uses and apply in future technological amplification.	BT 4

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Introduction to Nonlinear Optics:** Overview of linear vs. nonlinear optics, Historical development and significance, Applications in modern technology, Maxwell's equations in nonlinear media, Second-order nonlinear effects (e.g., second-harmonic generation),,Third-order nonlinear effects (e.g., third-harmonic generation, four-wave mixing), Polarization and its role in nonlinear optics, Criteria for material selection in photonics	18
II	**Nonlinear Wave Propagation and Frequency Mixing:** Self-focusing and self-phase modulation, Solitons and their properties, Three-wave mixing processes, Four-wave mixing processes, Optical parametric oscillation and amplification, Techniques and applications, Coherent anti-Stokes Raman spectroscopy (CARS), Medical imaging and diagnostics.	18
III	**Introduction to Photonics:** Nature of Light, Wave-particle duality, Electromagnetic spectrum, Photons and their properties, Absorption, emission, and scattering, Refractive index and dispersion, Nonlinear optical effects, Lasers: principles and types, Optical fibers and waveguides, Photodetectors and sensors, Telecommunications: fiber optic communication, Medical imaging: optical coherence tomography (OCT), Industrial applications: laser cutting and welding.	18
IV	**Advanced Topics on Photonics:** Quantum photonics, Photonic crystals, Integrated photonics, Photonics in modern technology, advancements in various fields such as healthcare, information technology, and manufacturing Nonlinear photonic crystals, Terahertz nonlinear photonics, Nonlinear effects in fiber optics	18
	Total	**48**

Text books:

1. *Non-Linear Optics*; R.W. Boyd; Elsevier, 3rd Ed., 2008, New Delhi
2. *Nonlinear Optics and Photonics*, by Guang S. He; Oxford University Press 2014

Reference Books:

1. G.D. Baruah, *Essentials of Non-linear Optics and Lasers*, Pragati Prakashan, 4th Ed., 2016, Meerut
2. N. Bloembergen, *Non-linear Optics*, World Scientific, 4th Ed., 2002, Singapore
3. Y.R Shen, *The principles of nonlinear optics, ,* Wiley-Inter science, 1st Ed., 2010, New Jersey
4. Geoffrey (New), *Introduction to Nonlinear Optics*, Cambridge University Press 2011
5. B.B. Laud *Laser and nonlinear optics***,** New Age International (P) limited, 3rd Ed., 2010, New Delhi

Level: Semester IV

Course Level: 500

Name of the Subject: Astrophysics

Subject Code: PHY014C404 **Scheme of Evaluation: Theory**

L-T-P: 4-0-0 **Total credits: 4**

Course Objectives:

Starting with the fundamental principles of astrophysics, the course is designed to provide an understanding of the structure, formation, and evolution of stars, galaxies, and the universe as a whole and to familiarize students with key observational techniques and instruments used in modern astronomy. It also promote the use of computational and simulation tools in understanding and modeling astrophysical systems.

Course Outcomes:

On successful completion of the course the students will be able to:		
CO	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** theoretical and practical aspects of modern observational astronomy, Photometry, spectroscopy, stellar classification, detectors, and basic information of telescopes.	**BT 1**
CO 2	**Understand** the fundamental concepts of astrophysics including celestial mechanics, stellar structure, and galactic dynamics.	**BT 2**
CO 3	**Apply** knowledge of astrophysics to practical application of observational techniques.	**BT 3**
CO 4	**Analyze** and evaluate astrophysical calculations of fundamental character.	**BT 4**

COURSE OUTLINE:

Modules	Topics / Course content	Periods
I	**Basics of Astronomy**: Evolution of Astronomy, The celestial sphere, Altitude and Azimuth, Declination and hour-angle, coordinate systems and transformation equations. Concept of time — solar time and sidereal time. Magnitude scales, apparent, absolute, and instrumental magnitudes. Measuring stellar distance method parallax and other methods to determine stellar distances, HR Diagram, Color Index, Spectral Class.	**18**
II	**Telescopes and Detectors**: Different types of astronomical telescopes, Mounting of telescope, Radio Telescope, Space based telescope, Astronomical Spectrograph, Photographic Photometry, Detectors, Radiation theory: Equation of radiative transfer — concepts of flux, intensity, and temperature. Formation of emission and absorption lines, limb darkening.	**18**
III	**Integral theorems of hydrostatic equilibrium of stars**: Formation of stars, Evolution of stars, Compact stars (White dwarf, Neutron star, Black Hole), Degenerate stars, mass–radius relation and Chandrasekhar mass limit, Jeans criterion, Integral theorems of hydrostatic equilibrium of stars, Transport of energy inside a star, Binary stars, Nucleosynthesis – hydrogen burning (pp chain and CNO cycle), triple alpha reaction.	**18**
IV	**Galaxies and Universe:** The Milky way Galaxy, Dark Matter, Kinematics, Hubble classification scheme for external galaxies, Normal galaxies and AGNs, Unified model, Basics of X-ray astronomy, black holes, and gamma ray bursts, Hubble's law, nucleo-synthesis, Cosmic Microwave Background radiation, Elementary ideas on structure formations **Principle of Equivalence.** Gravity and Geometry. Metric Tensor and its properties. Curved space time. Tensor calculus: co-variant differentiation, parallel transport, Particle trajectories in Gravitational field. Einstein's Field equations and Stress-energy tensor, Schwarzschild metric.	**18**
	Total	**72**

Text books:

1. An Introduction to Astrophysics; Baidyanath Basu, Prentice Hall Publication, 2nd Ed.,2013, New Delhi
2. An Introduction to Astronomy and Astrophysics, Pankaj Jain, CRC Press; 1st edition (8 April 2015)

Reference books:

3. V.B.Bhatia; Text Book on Astronomy and Astrophysics with elements of cosmology, Narosa Publishing House, 2nd Ed.,2001, New Delhi
4. K. D. Abhayankar; Astrophysics: Stars and Galaxies, Abe Books,1st Ed., 2002, Hyderabad

NPTEL LINK: https://onlinecourses.nptel.ac.in/noc23_ph21/preview

Level: Semester IV

Course Level: C-500

Name of the Subject: Project-II

Type of Course: Core

Subject Code: PHY014C421 **Scheme of Evaluation: Presentation**

L-T-P: **Total credits: 12**

Course Objectives:

This course will help the students in understanding of different interesting research physics.

Student will complete under the guidance with Faculty member.