DETAILS OF SYLLABUS

THIRD SEMESTER

PH61112 : ADVANCED QUANTUM MECHANICS AND QUANTUM FIELD THEORY

Credits: 04 **Teaching Scheme:05 Hrs/Week**

Prerequisites: Basic knowledge on fundamentals of quantum mechanics

UNIT – I : Klein-Gordon Equation (8 Hours)
Klein-Gordon equation and its drawbacks need for a relativistic equation, Real and Complex Klein-Gordon fields.

UNIT – II: Dirac Equation (10 Hours)
Dirac equation, Properties of Dirac gamma-matrices, Non-relativistic reduction of Dirac equation, Magnetic moment of electron, Spin-Orbit coupling,

UNIT – III: Covariance of Dirac equation and Hole Theory (10 Hours)
Covariance of Dirac equation and bilinear covariant, Solution of Dirac Equation: Free particle solution of Dirac equation and its physical interpretation, Dirac hole theory, Projection operator for spin and energy, Zitterbewegung, Dirac Hole theory.

UNIT – IV : Symmetry in Dirac equation (12 Hours)
charge conjugation, space reflection, time reversal symmetries of Dirac equation, Continuous systems and fields, Transition from discrete to continuous systems, Lagrange and Hamiltonian formulation, Noether's theorem.

UNIT – V: Quantization of Free field (10 Hours)
Second quantization, Equal Time Commutators, Normal Ordering, covariant quantization of electromagnetic field, quantization of neutral scalar field , electromagnetic field and Dirac field, Propagators for scalar, spinor and vector fields

Text Books:

1. Advanced Quantum Mechanics- J. J. Sakurai, Pearson Publisher, 1st Edition , 2006.
2. Lectures on Quantum Field Theory - Ashok Das, World Scientific, 2nd Edition , 2008.

Reference Books:

1. Relativistic Quantum Mechanics- Bjorken and S. D. Drell ,Mc-Graw Hill, 1st Edition,1964.
2. An Introduction to Quantum Field Theory – M. Peskin, D.Schroeder, CRC press, Taylor and Francies, 1995

3. Quantum Field Theory – L. H. Ryder, Cambridge University Press (1985)
4. The Quantum Theory of Fields – S. Weinberg, Cambridge University Press, 6th Edition, 2006.

Course Outcomes:

After completing this course the students would be able to:

1. Understand the concept of Klein-Gordon equation and its drawbacks.
2. Understand the properties of Four-vector Dirac gamma matrices as obtained from Dirac equation.
3. Interpret the positive and negative energy solution through free particle solution of Dirac equation for Hole theory.
4. Formulate the charge conjugate and time reversal state through the usage of Dirac equation.
5. Apply the concept of second quantization for Klein-Gordon field and Dirac field.

PH61113: ANALOG AND DIGITAL ELECTRONICS

Credits: 04 **Teaching Scheme:05 Hrs/Week**

Prerequisites:
Basic knowledge on fundamentals of semiconductor devices.

UNIT – I: Amplifiers **(10 Hours)**
Transistor parameters and equivalent circuit, Amplifier characteristics of transistor in CE, CB and CC configurations, Small signal low and high frequency transistor circuits and analysis, The Miller effect, Gain band width product.

Effect of cascading, Frequency response of linear amplifier, Amplifier pass band, R-C, L-C and transformer coupled amplifier, Feed back amplifier, Effect of negative feedback on gain, Distortion, Input and output resistances, Different feedback circuits, Boot-strapping the FET, Stability of amplifier, Noise in amplifier

UNIT – II: Oscillators **(10 Hours)**
Feedback and circuit requirement for oscillators, Analysis of Hartley, Colpitt, RC (phase shift) and Wein-bridge oscillator, Klystron oscillator (principle, description, and operation) Multivibrator: Astable, Monostable, Bistable (Principle, Description and Operation)

UNIT – III: Operational amplifiers **(10 Hours)**
Basic OP-AMP-differential amplifier, Inverting and non-inverting type, Common mode rejection ratio, Use of OP-AMP in scale changing, Phase shifting, summing, Voltage to current (and vice-versa) conversion, Multiplying, Differentiating and integrating circuits, Solution of linear and differential equation using OP-AMPS.

UNIT – IV: Digital Electronics **(12 Hours)**
Logic fundamentals, Boolean theorem, Logic gates-RTL, DTL, TTL, Boolean algebra, De Morgan theorem, AND, NAND, NOT, NOR gates, Exclusive OR gate, Exclusive NOR gate (Logic symbol, truth table and circuit with operation), Sequential logic design: Different type of Flip-Flops and their characteristics, RS flip-flop, JK flip-flops, advantage of master-slave configuration.

UNIT – V: Radio Communication **(8 Hours)**
Ionospheric Propation, Antennas of different types, super heterodyne, receiver (Block Diagram), Various types of optical fibers and optical communications.

Text Books:

1. The art of electronics - Paul Horowitz, Winfield Hill, Cambridge University Press, 2nd Edition, 1989.
2. Electronic Devices and Circuit Theory - Robert L. Boylestad, Louis Nashelsky, Prentice Hall, 6th Edition, 1996.
3. Electronic Principles - Malvino and Bates, McGraw Hill. 8th Edition, 2016.

References Book:

1. Electronic Devices and Circuits - Millman, Halkias and Jit, Tata McGraw Hill, 1988.
2. Op-amps and linear integrated circuits - R.A.Gayakwad, Prentice Hall of India, 6th Edition, 2000.
3. Principle of Electronics, V.K.Mehta, R. Mehta, S. Chand, 3rd Editon, 1980.

Course Outcomes:

After completing this course the students should be able to:

1. Understand the working of basic amplifiers, small signal modelling of CC, CE and CB configurations.
2. Analyze the frequency responses of amplifiers.
3. Analyze frequency responses and design feedback circuits and oscillators.
4. Compare the Bi-stable, Mono-stable and Astable circuits and its applications.
5. Demonstrate the use OP Amp to solve linear and differential equations.
6. Perform the sequential logic circuits design for various complex logic and switching devices and validate the outputs.
7. Understand the concepts of radio wave propagation and optical communication.

PH61114 : ATOMIC AND MOLECULAR PHYSICS

Credits: 04 **Teaching Scheme: 05 Hrs/Week**

Prerequisites:
Basic knowledge on fundamentals of quantum mechanics and hydrogen atom problems.

UNIT – I **(10 Hours)**
Quantum mechanics of H atom, Atomic Orbitals and Hund's rule, Magnetic dipole moment, Electron spin and vector atom model, Spin Orbit interaction, Hydrogen Fine structure, Lamb Shift, L-S & J-J Coupling: spectroscopic terms, selection rule, Lande Interval rule, Zeeman Effect (normal and Anamalus) and Paschen-Back Effect: Splitting of spectral lines and selection rules, Hyperfine Structure Spectral Lines: Isotope Effect, Nuclear spin and Hyperfine Splitting and selection rules, Zeeman Effect in Hyperfine structure, Back-Goudsmit effect.

UNIT – II **(10 Hours)**
Molecular Electronic States:
Molecules and Chemical bonds: Molecular Formation, Ionic binding, Covalent Binding,Valence-bond treatment of H_2^+, The LCAO method for H_2^+.
The Stability of Molecular States
Concept of molecular potential, Separation of electronic and nuclear wave functions, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Electronic angular momenta, Approximation methods for the calculation of electronic Wave function, The LCAO approach, States for hydrogen molecular ion, Coulomb, Exchange and Overlap integral, Symmetries of electronic wave functions, Shapes of molecular orbital and bond, Term symbol for simple molecules.

UNIT – III **(10 Hours)**
Rotation and Vibration of Molecules: Solution of nuclear equation; Molecular rotation: Non-rigid rotator, Centrifugal distortion, Symmetric top molecules, Molecular vibrations: Harmonic oscillator and the anharmonic oscillator approximation, Morse potential.

UNIT – IV **(10 Hours)**
Spectra of Diatomic Molecules: Transition matrix elements, Vibration-rotation spectra: Pure vibrational transitions, Pure rotational transitions, Vibration-rotation transitions, Electronic transitions: Structure, Franck-Condon principle, Rotational structure of electronic transitions, Fortrat diagram, Dissociation energy of molecules, Continuous spectra, Raman transitions and Raman spectra.

UNIT – V **(10 Hours)**
Vibration of Polyatomic Molecules: Application of Group Theory Molecular symmetry; Matrix representation of the symmetry elements of a point group; Reducible and irreducible representations; Character tables for C_{2v} and C_{3v} point

groups; Normal coordinates and normal modes; Application of group theory to molecular vibration.

BOOKS:

Text Books

1. Physics of Atoms and Molecules - Bransden and Joachain, Prentice Hall, 2nd Edition, 2003.
2. Atomic and Molecular Spectra: Laser , Raaj Kumar, Kedar Nath Ram Nath, India, 6th Edition, 2012.
3. Introduction to Atomic and Molecular Spectroscopy - V. K. Jain, Narosa, 4th Edition, 2007.

Reference Books:

1. Fundamentals of Molecular Spectroscopy, C. N. Banwell, Tata McGraw Hill, 4th Edition, 2012.
2. Molecular spectroscopy - J.M. Brown, Oxford University Press, 1st edition, 1998.
3. Molecular spectroscopy - Jeanne . L. McHale, C R C press, 2nd Edition, 2017
4. Spectra of atoms and molecules, P. F. Bemath, Oxford University Press, 3rd Edition, 2016.
5. Modern spectroscopy, J.M. Holias, John Wiley and Sons ltd., 4th edition, 2004.

Course Outcomes:

After completing this course the students should be able to:

1. Analyse energy splitting and allowed transitions of atomic spectra under various conditions.
2. Explain the molecular formation and their stability.
3. Determine internuclear separation, atomic mass, moment of inertia from fundamental aspects of rotational and vibrational spectroscopy.
4. Demonstrate the origin of molecular electronic states and their intensities distribution.
5. Determine symmetry element of molecules and their allowed modes of vibrations of in rotational and vibrational spectroscopy.

CORE ELECTIVE -I

PH61115 : FIBER OPTICS AND OPTOELECTRONICS-I

Credits: 04 **Teaching Scheme:05 Hrs/Week**

Prerequisites:
Basic knowledge on fundamentals of optical fibers and phenomenon associated with propagation of light

Unit – I **(8 Hours)**
Semiconductor laser sources: Energy bands and carrier distribution in semiconductors, absorption and emission in semiconductors, optical gain in a semiconductor, gain in a forward biased p-n junction, laser oscillations and threshold currents, double hetero-structure lasers.

Unit – II **(8 Hours)**
Optical detectors: Principle of detectors, PIN photo detector, Responsivity and quantum efficiency, and Elementary idea of avalanche photo diode.

Unit – III **(12 Hours)**
Planar Optical Waveguides: Maxwell's equations in a medium – TE and TM modes, TE modes of a symmetric step index planar optical waveguide, Physical understanding of modes, TM modes of a symmetric step index planar optical waveguide, Power associated with a mode and Relative magnitude of the longitudinal components of E and H, elementary idea about rectangular waveguides (rib and channel waveguides)

Unit – IV **(10 Hours)**
Optical fibers: Numerical aperture of an optical fiber, Attenuation in optical fibers-absorptive and radiative loss and Pulse dispersion in a step index fiber (using ray treatment).

Ray paths and pulse dispersion in optical waveguides: One dimensional ray equation, Ray paths in a homogeneous and in a square law medium. Transit time calculation-Pulse dispersion in parabolic index medium.

Unit – V **(12 Hours)**
Modes: Weakly guiding approximation and scalar (LP_{lm}) modes, Modal analysis of a step index fiber, Fractional modal power inside core, Concept of cut-off of a mode, Single mode fiber, Gaussian approximation for a single mode fiber, Gaussian spot size, mode field diameter, Expressions (without derivation) for splice loss due to longitudinal, transverse and angular misalignments.

Text Books:

1 Introduction to Fiber Optics, A. K. Ghatak and K. Thyagarajan, Cambridge University Press, Cambridge, UK, 2002
2. Optical Waveguide Theory, A.W. Snyder and J. D. Love, Chapman and Hall, London, 1983

Reference Books:

1. An Introduction to Optical Waveguides, M. J. Adams, John Wiley and Sons, Chichester,1981
2. Fiber Optics through Experiments, M.R. Shenoy et al, Viva publications, third edition, 2011
3. Fundamentals of Optical Waveguides, K. Okomoto, Academic press, 2nd edition,2005
4. Optical Fiber Communication, Gred Keiser, Mc-GrawHill International edition, 5th edition ,2013
5. Photonics, A.Yariv, P. Yeah, Oxford University Press, 6th edition, 2007
6. Fundamentals of Photonics, B.E. A.Saleh & M.C. Tiesch, John Wiley& Sons, 2nd edition, 2007

Course Outcomes:

After completing this course the students should be able to:

1. Explain the working principle of Semiconductor laser sources and optical detectors
2. Identify the propagation aspects of Planar Optical Waveguides
3. Analyze the propagation parameters of Optical fibers
4. Discuss the concept of modes in optical fibers
5. Compute the pulse dispersion in optical waveguides Modes

PH61116: MATERIALS SCIENCE AND TECHNOLOGY- I

Credits: 04 **Teaching Scheme:05 Hrs/Week**

Prerequisites:
Basic knowledge on fundamentals of crystal structure and energy band theory

Unit-I **(10 Hours)**
Structure of Materials: Introduction to Materials Science, Classification of Materials, Crystal Structures (SC, BCC, FCC, HCP), Ceramics (Rock Salt, Diamond Structure, Spinel, Perovskite, Silicate), Polymers, Classification, Glass transition, Composites (classification, combination effect)

Unit-II **(8 Hours)**
Imperfection in Solids: Point Defects (vacancies, interstitial, self-interstitials, Schottky and Frankel defects), Impurities in metals and ceramics, dislocations—linear defects (Burger vector, Edge dislocation, screw dislocation), Interfacial defects (grain boundary, stacking faults)

Unit-III **(10 Hours)**
Diffusion: Introduction, Diffusion mechanism (vacancy diffusion, interstitial diffusion), steady-state diffusion, nonsteady-state diffusion, factors that influence diffusion (diffusing species, temperature), diffusion in ionic and polymeric materials

Unit-IV **(10 Hours)**
Phase diagram and transformation: Solubility limit, Phase, Phase Equilibria, Phase diagram, Unary phase diagram, Gibb's phase diagram, lever rule, Iron carbon phase diagram, Phase transformation, Nucleation and growth of phases, Introduction to TTT curves.

Unit-V **(12 Hours)**
Functional materials and Applications: Piezoelectric Materials, Ferroelectric materials, Ferromagnetic material, Opto-electronic Materials, Superconducting materials, Shape Memory Materials, Fuel cell materials & Applications.

Text Books:

1. Fundamentals of Materials Science and Engineering (F I FT H E D I T I O N), William D. Callister, Jr, John Wiley & Sons, Inc. (2001).
2. An introduction to materials engineering and science for chemical and materials engineers, Brian S. Mitchell, John Wiley & Sons, Inc., Publication. (2004)
3.

Reference Books:
1. Materials science and Engineering - V. Raghavan, Prentice-Hall Pvt. Ltd.
2. Chemistry of Advanced Materials - Edited L. V. Interrante, and M. J. Hampden-Smith, Wiley, VCH, U. S. A

Course Outcomes:

After completing this course the students should be able to:

1. Analyze the Structure of materials.
2. Understand the concept of various defects in crystalline materials.
3. Explain the concept of diffusion mechanism.
4. Explain the concept of phase & phase diagram.
5. Construction and identification of phase diagrams and reactions.
6. Explain the features of functional materials and its applications.

PH61117: PLASMA PHYSICS-I

Credits: 04 **Teaching Scheme:05 Hrs/Week**

Prerequisites:

Basic knowledge on fundamentals of electromagnetic theory

UNIT – I **(8 Hours)**

Definition: Quasi-neutrality, Collective Behaviour, Occurrence; Plasma properties, Debye Shielding, Plasma parameters, Plasma Temperature, Plasma sheath, Plasma frequency, Criteria for plasmas, Plasmas in nature and laboratory.

UNIT – II **(12 Hours)**

Plasma Fluid Theory: Single particle motion in uniform, non-uniform and time varying E and B field, Relation of Plasma Physics to Ordinary" Electromagnetic, Fluid description of a plasma, Fluid Drifts Perpendicular to **B**, Fluid Drifts Parallel to **B**, Diffusion and Mobility in Weakly Ionized Gases, Decay of a Plasma by Diffusion, Steady State Solutions, Recombination, Diffusion across a Magnetic Field, Collisions in Fully Ionized Plasmas, The MHD Equations, Diffusion in Fully Ionized Plasmas, Solutions of the Diffusion Equation , Bohm Diffusion.

UNIT – III **(12 Hours)**
Elements of Plasma Kinetic theory: Phase space, Single particle phase space, Many particle phase space, Volume elements, Distribution function, Number density and Average velocity, The Boltzmann equation, Collision less Boltzmann equation, Jacobian of the transformation in phase space, Effect of particle interactions, Relaxation model for the collision term, BBGKY theory- the Vlasov Equation, Correction to Vlasov Equation, Effect of particle interaction, Relativistic form of Vlasov equation, Moment Equations, Plasma oscillations and Landau damping.

UNIT – IV **(10 Hours)**
Plasma Oscillations and waves: Langmuir oscillations, The wave equation, Solution in Plane waves, Harmonic waves, Polarisation, Energy flow, Wave packets and group velocity, Electron Plasma waves, Ion waves, Electrostatic Electron Oscillations Perpendicular to **B**, Electrostatic Ion Waves perpendicular to **B**, The Lower Hybrid Frequency, Electromagnetic waves perpendicular to $\mathbf{B_o} = 0$, Electromagnetic waves perpendicular to finite $\mathbf{B_o}$, Cut offs and resonances, Electromagnetic waves parallel to finite $\mathbf{B_o}$, Magneto-sonic waves, Magneto hydrodynamic waves (Alfven waves, sound waves, Magnetosonic waves).

UNIT – V **(8 Hours)**
Magnetic Confinement: Condition for fusion, The need for magnetic confinement, The Mirror Machine, Toroidal Confinement, Magnetic Surfaces and

Toroidal equilibrium, Confinement in TOKAMAKs, Theory of TOKAMAK Equilibrium.

Text Books:

1. Introduction to Plasma Physics and Controlled Fusion, Francis F. Chen, Springer International Publishing Swetzerland, 3rd Edition, 2016.
2.Fundamentals of plasma physics, J. A. Bittencourt, 3rd Edition Springer Verlag New York Inc., 2004.

Reference Books:

1. The Physics of Plasmas, T. J. M. Boyd and J. J. Sanderson, Cambridge University Press, 2003
2. Fundamentals of Plasma Physics, P.M.Bellan, Springer, Third Edition, 2004

Course Outcomes:

After completing this course the students should be able to:

1. Understand the fundamentals of plasma.
2. Analyze the motion of charged particles in electric and magnetic fields in plasma state.
3. Formulate kinetic descriptions of plasma.
4. Explain the physical mechanism behind Landau damping
5. Interpret the physical mechanisms of electrostatic and electromagnetic waves that can propagate in magnetised and non-magnetised plasmas
6. Explain the use of thermonuclear fusion for energy production
7. Apply the concept of plasma confinement for current directions of research with reference to TOKAMAK.

PH61219 : ANALOG AND DIGITAL ELECTRONICS LAB

Credits: 06 **Teaching Scheme: 06 Hrs/Week**

1. Determination of knee voltage and break down voltage from the I-V characteristics of Semiconductors Diodes (Si, Ge).
2. Evaluation of input resistance, output resistance and current amplification from Input and Output characteristics of a Bipolar Junction Transistor (BJT).
3. Estimation of Zener voltage and resistance of a Zener Diode.
4. Verification of forward and reverse characteristics of LED.
5. Evaluation of output signal frequency of Hartley oscillator.
6. Evaluation of output signal frequency of Colpitt Oscillator.
7. Determination of percentage of regulation and ripple factor of Junction Diode Rectifier.
8. Verification of over load response and frequency response of a single stage triode amplifier.
9. Estimation of ripple factor of capacitor filter, L-filter and π-filter.
10. Verification of Boolean equations using Logic gates.

Course Outcomes:

After completing this course the students should be able to:

1. Evaluate various parameters associated with semiconductor diodes (Si, Ge, Zener, LED) and transistors.
2. Understand the mechanism of ac to dc conversion in electronic circuit and their importance in the operation of electronic devices.
3. Know about the oscillator circuit and their applications in electronic instruments.
4. Understand the fundamentals of logic gates and its use in implementing basic Boolean functions.

CORE ELECTIVE LAB-I

PH62220: FIBER OPTICS AND OPTOELECTRONICS –I

Credits: 06 **Teaching Scheme: 06 Hrs/Week**

1. Plot the V-I characteristics of LED.
2. Determine the relationship between laser current and output optical power of Laser Diode.
3. Preparation of Fiber ends and launching of light into an optical fiber (single mode & multimode).
4. Measurement of Mode field diameter of optical fiber.
5. Measurement of the numerical aperture of multimode optical fiber.
6. Determination of Refractive index profile of a multimode optical fiber by the near-field scanning technique.
7. Measurement of microbending/macrobending loss in an optical fiber.

Course Outcomes:

After completing this course the students should be able to:

1. Couple light into an optical fiber.
2. Analyze the behaviour of Laser source.
3. Compute various propagation parameters associated with Fiber optics communication

PH62221: MATERIALS SCIENCE AND TECHNOLOGY-I

Credits: 06 **Teaching Scheme: 06 Hrs/Week**

1. Determination of lattice parameter of unknown structure obtained from X-Ray diffraction data by using Checkcell software.
2. Determination of Miller indices and lattice parameter of cubic crystal system from XRD data.
3. Determination of particle size from XRD data
4. Determination of dielectric constant of unknown sample
5. Measurement of Remnant polarization and Coercive field of an unknown sample.
6. Determination of density of solid specimen by Archimedes sample
7. Determination of concentration of sugar or salt using UV-Vis spectroscopy.

Course Outcomes:

After completing this course the students should be able to:

Analyze the structural and ferroelectric properties of materials

PH62222: PLASMA PHYSICS-I

Credits: 06 **Teaching Scheme: 06 Hrs/Week**

1. Determination of critical spark length of a DC plasma unit
2. Verification of Paschen's law using a DC plasma unit.
3. Measurement of electron temperature of Plasma by using a single probe.
4. Measurement of electron temperature of plasma using double probe.
5. Measurement of electrons density of plasma using single probe.
6. Measurement of Ion density of Plasma using double probe.
7. Measurement of electron density of moving plasma.

Course Outcomes:

After completing this course the students should be able to:

1. Demonstrate the laboratory scale plasma production methods
2. Measure the plasma parameters through probe techniques in laboratory scale plasma

FOURTH SEMESTER

PH61123: INSTRUMNTATAL TECHNIQUES FOR MATERIALS CHARACTERIZATION

Credits: 04 **Teaching Scheme: 05 Hrs/Week**

Prerequisites:

Basic knowledge on fundamentals of electromagnetic radiation and optical behaviour of light

UNIT – I **(10 Hours)**
Construction and working principle of X-Ray diffraction and X-Ray photo electron spectroscopy.

UNIT – II **(10 Hours)**
Infra Red and Far Infra Red spectroscopy – construction and principle, Diffuse Reflectance spectroscopy.

UNIT – III **(10 Hours)**
Construction and line diagram and working principle of Optical Microscopy, Scanning electron microscopy, Transmission electron microscopy, Energy dispersive X-ray spectroscopy.

UNIT – IV **(10 Hours)**
Construction and line diagram and working principle of UV- Visible and Photoluminescence spectroscopy

UNIT – V **(10 Hours)**
Construction and line diagram and working principle of Electron spin resonance (ESR), Nuclear magnetic resonance spectroscopy (NMR), X-ray photoelectron spectroscopy (XPS).

Text Books:
1. Physical Methods for Materials Characterisation - P. E. F. Flewitt and R. K. Wild, Institute of Physics (IOP) Publishing Ltd., 2nd Ed, 2003.
2. Encyclopaedia of Materials Characterization - C.R. Brundle, C. A. Evans Jr., and S. Wilson, Butterworth – Heinemann and Manning Publications Co. 1992

Reference Books:

1. Scanning Electron Microscopy and X-Ray Analysis J. Goldstein, D. Newbury, D. Joy, C. Lyman, P. Echlin, E. Lifshin, L. Sawyer, and J. Michael, Springer, 3rd Edition, (2003)
2. Element of X-ray Diffraction - B. D. Cullity, 2nd ed., Addison-Wiley Publisher, 2014.
3. Fundamentals of Molecular Spectroscopy - C. N. Banwell, E. M. McCash, 4th ed., London, New York, McGraw-Hill, 2000

Course outcomes:

After completing this course the students should be able to:

1. Understand the working of X-ray diffractometer and interpret the data.
2. Interprete the Infra Red spectra of samples.
3. Demonstrate the instrumentation and working of optical and electron microscopy.
4. Apply the instrumentation and working of UV Visible spectroscopy for optical study.
5. Analyse NMR and EPR spectra.

PH61124 : NUCLEAR AND PARTICLE PHYSICS

Credits: 04 **Teaching Scheme: 05 Hrs/Week**

Prerequisites :

Elementary idea of quantum mechanics and nuclear structure

Unit-I **(8Hours)**
General nuclear properties:
Radius, Mass binding energy, Nucleon separation energy, Angular momentum, Parity, Electromagnetic moments, Excited states.

Unit-II **(8Hours)**
Two Nucleon Problems:
Central and noncentral forces, Deuteron and its magnetic moment and quadruple moment, Force dependent on isospin, Exchange force, Charge independence and charge symmetry of nuclear force, Mirror nuclei.

Unit-III **(10Hours)**
Nuclear models:
Liquid drop model, Fission, Magic numbers, Shell model, Analysis of shell model predictions, Beta stability line, Collective rotations & vibrations, Nuclear Structure: Form factor and charge distribution of the nucleus, Hofstadter form factor.

Unit-IV **(12Hours)**
Nuclear reaction:
Energetic of nuclear reaction, Conservation laws, Classification of nuclear reaction, Radioactive decay, Radioactive decay law, Production and decay of radioactivity, Radioactive dating, Alpha decay: Gamow theory and branching ratios, Beta decay: energetic angular momentum and parity selection rules, Compound nucleus theory, Resonance scattering, Breit- Wigner formula, Fermi's theory of beta decay, Selection rules for allowed transition, Parity violation.

Unit-V **(12Hours)**
Particle Physics:
The Standard model of particle physics, Particle classification, Fermions and Bosons, Lepton avors, Quark avors, Electromagnetic, Weak and strong processes, Spin and parity determination, Isospin, Strangeness, Hypercharge and Baryon number, Lepton number, Gell-Mann-Nishijima Scheme, Quarks in hadrons: Meson and Baryon octet, Elementary ideas of SU(3) symmetry, Charmonium, Charmed mesons and B mesons, Quark spin and colour

Text Books:

1. Nuclear Physics- Dr. S. N. Ghosal. (Revised Enlarged edition), 2016.
2. Nuclear Physics - R. R. Roy and B. P. Nigam, 2nd Edition, 1996.
3. Nuclear Physics- Satya Prakash , 4th Edition, 2015.

Reference Books:

1. Atomic and Nuclear physics - Shatendra Sharma, 1st Edition (2008)
2. Theoretical Nuclear Physics - J. M. Blatt and V. F. Weisskopt, Wiley, New York (1979)
3. Introductory Nuclear Physics- Samuel S. Wong, Prentice Hall International Inc., (1990)

Course outcomes:

After completing this course the students should be able to:

1. Understand the basic nuclear properties and nuclear stability.
2. Determine the magnetic moment and quadruple moment of Deuteron by applying the concept of non-central nature of nuclear force.
3. Interpret the nuclear models associated with nuclear structure and stability.
4. Explain process associated with alpha decay and beta decay.
5. Identify the quantum mechanical properties of elementary particles on the basis of strong and weak interactions.

CORE ELECTIVE THEORY-II

PH62125 : FIBER OPTICS AND OPTOELECTRONICS-II

Credits: 04 **Teaching Scheme: 05 Hrs/Week**

Prerequisites: Basic knowledge on fundamentals of propagation of light into optical fiber

UNIT – I **(8Hours)**
Pulse dispersion in single mode fibers: Calculation of material dispersion, Group delay and waveguide dispersion, Zero dispersion fiber, dispersion shifted fiber and dispersion compensating fiber.

UNIT – II **(8Hours)**
Optical fiber amplifiers: Optical amplification, Energy levels of erbium ions in a silica matrix and Amplifier modelling-variation of pump and signal powers with length.

UNIT – III **(12Hours)**
Guided Wave Optical Components: Planar waveguide directional couplers, coupled mode theory, power exchange between the waveguides and coupling coefficient, Optical fiber directional couplers, Power exchange and coupling coefficients in identical fiber directional couplers, Fabrication of fiber directional couplers, Fiber Bragg gratings, Principle of operation and fabrication techniques, Long period Fiber Bragg gratings.

UNIT – IV **(12Hours)**
Optical fiber fabrication technique: Elementary idea about double crucible method, Rod-in-tube method, Chemical Vapour Deposition (CVD) method and Modified Chemical Vapour Deposition (MCVD) method, Fabrication of planar and channel waveguides (Ion exchange and Ti indiffusion methods). Prism coupling technique to measure propagation constant of discrete guided modes.

UNIT – V **(10Hours)**
Pulse code modulation and Digital Transmission: Elements of analog and digital modulation, Basic idea of RZ and NRZ pulse trains, Elementary idea about shot noise, thermal noise, signal to noise ratio (SNR) and Bit-Error-Rate (BER), Elementary idea about WDM system of transmission.

Text Books:

1. Introduction to Fiber Optics, A.K.Ghatak and K. Thyagarajan, Cambridge University Press, Cambridge, UK, 2002
2. Fundamentals of Photonics, B.E.A.Saleh & M.C. Tiesch, John Wiley& Sons, 2nd edition,2007

Reference Books:

1. Planar Optical Waveguides and Fibers, H.-G. Unger, Clarendon Press, Oxford, 1993.
2. An Introduction to Optical Waveguides, M. J. Adams, John Wiley and Sons, Chichester, 1981.
3. Fiber Optics through Experiments, M.R. Shenoy et al, Viva publications, third edition, 2011.
4. Fundamentals of Optical Waveguides, K. Okomoto, Academic press, 2nd edition,2005.
5. Optical Fiber Communication, Gred Keiser, Mc-GrawHill International edition, 5th edition ,2013
6. Photonics, A.Yariv, P. Yeah, Oxford University Press, 6th edition, 2007.

Course outcomes:

After completing this course the students should be able to:

1. Compute the pulse dispersion in single mode fibers
2. Explain the working principle of Optical fiber amplifiers
3. Discuss the basic principle of Fiber coupler and Fiber Bragg grating
4. Explain various techniques of Optical fiber fabrication
5. Interpret the pulse code modulation technique and Digital Transmission

PH62126 : MATERIALS SCIENCE AND TECHNOLOGY- II

Credits: 04 **Teaching Scheme: 05 Hrs/Week**

Prerequisites :

Basic knowledge of thermodynamics and crystal structure

UNIT – I **(10 Hours)**
Materials Preparation Techniques
Single crystal growth: Single crystal growth from melt: Czochralski methods, Float-Zone process for single crystal Si growth, Bridgmen Technique for GaAs growth.
Thin Film growth: Fundamentals of film growth, Vacuum evaporation, Sputtering Comparison of Evaporation and sputtering, Molecular beam epitaxy, Chemical vapour deposition (CVD): Typical chemical reactions, Reaction kinetics, transportant phenomena in CVD, Atomic Layer Deposition, Sol-gel Spin coating.

UNIT – II **(10 Hours)**
Nanomaterials:
Importance of Nano-technology, Emergence of Nano-Technology, Bottom-up and Top-down approaches, challenges in Nano Technology.
Nanomaterials synthesis:
Nanopowder synthesis through solid solution technique: mechanical mixing; grinding, Ball Milling, Wet chemical synthesis: hydrothermal solvothermal methods, electrochemical synthesis, Vapour phase methods: Chemical vapour deposition, Metal organic chemical vapour deposition. Applications: Nanogenerator, Field emitter, Drug delivery

UNIT – III **(10 Hours)**
Materials Characterizations techniques:
X-ray diffraction (XRD)- X-ray spectrum, methods to remove K_β radiation, Bragg's law, Basic powder diffraction, Crystallinity, particle/crystallite size determination, structural analysis, and Phase identification.

UNIT – IV **(10 Hours)**
Scanning Electron Microscopy (SEM)- electron-matter interaction, imaging modes (secondary and backscattered), Specimen preparation, effect of spot size, apertures and accelerating voltage on SEM imaging, Morphology, grain size analysis.
Transmission Electron Microscopy (TEM)- TEM sample Preparation pre thinning, final thinning, Image modes- mass density contrast, diffraction contrast, phase contrast, Applications, Limitations

UNIT – V **(10 Hours)**
Energy dispersive X-ray spectroscopy (EDS)- sample preparation, scanning mode, qualitative and quantitative analysis.
X-ray photoelectron spectroscopy (XPS)- peak identification, chemical shift, qualitative and quantitative analysis.

Text Books:

1. Fundamental of materials science and Engineering, 5th edition, William D.Callister, Jr.John Wiley and Son. 2001
2. Materials science and engineering, V.Raghvan, 5th edition, Prentice-Hall Pvt.Ltd. 2011
3. Physical Metallurgy, Vijendra Singh, 1st edition, Standard publishers distributors, 2008

Reference Books:

1. An introduction to materials engineering and science for chemical and materials engineers, Brian S. Mitchell, John Wiley and Sons, 2004
2. Physics of thin films, Ludmila Eckertova, 1st edition, Plenum Publishing Corporation and SNTL - Publishers of Technical Literature, Prague ,2007

Course outcomes:

After completing this course the students should be able to:

1. Demonstrate the various technique of preparation of single crystal
2. Explain the various techniques of thin film and nanoparticles preparation
3. Compute the structural parameter using X-ray diffraction
4. Explain various microscopic techniques
5. Discuss the compositional characterization of materials

PH62127 : PLASMA PHYSICS-II

Credits: 04 **Teaching Scheme: 05 Hrs/Week**

Prerequisites:

Basic knowledge of plasma and plasma processing

UNIT – I **(10Hours)**
Equilibrium, stability and non-linear effects: Introduction, Hydromagnetic Equilibrium, The Concept of β, Classification of Instabilities, Two-stream instability, The Gravitational Instability, Resistive Drift Waves, The Weibel Instability, Nonlinear effect**s:** Sheaths, Ion Acoustic Shock waves, Ponder motive Force, Parametric instabilities (Coupled Oscillators, frequency matching, Instability threshold, the oscillating two stream instability, the parametric decay instability).

UNIT – II **(10Hours)**
Basic Processes in plasmas and plasma equilibrium models: Classical Townsend Mechanism and Electrical Breakdown in Gases, Streamer mechanism and micro discharges, Degree of Ionisation and Saha Ionisation formula, Paschen's laws and different regimes of E/p in a discharge, Collisions in plasmas, Thermal Equilibrium (TE), Local Thermal Equilibrium (LTE), Corona Equilibrium (CE), Collisional Radiative Equilibrium (CRE). Recombination.

UNIT – III **(10Hours)**
Production of Plasma in the laboratory: Arc discharge, Glow discharge, radio frequency (RF) discharges, di-electric barrier and corona discharge, ionization breakdown of gases, electrode less discharge, capacitively and inductively coupled plasmas, Other methods (Ohmic heating, heating by LASER, heating with particle beams) of producing plasmas.

UNIT – IV **(10Hours)**
Plasma Diagnostics: High frequency current measurement (Rogowski Coil), Magnetic Probe. Single and Double Langmuir Probe, Emissive Probe, Plasma Spectroscopy: Radiations from Plasmas and recombination, Optical Emission Spectroscopic (OES) characterisation of Plasmas.

UNIT – V **(10Hours)**
Processing plasmas and applications: Hot and Cold Plasmas, Dusty plasmas, Weiding, Cutting, Hardening, Nitriding, Coating (sputtering), Spraying, Etching, Plasma Wall Reactor for Diamond Films, Applications of Non-equilibrium Plasma in Lighting, Industrial, biomedical, hazardous waste disposal, sterilization, preservation etc.

Text Books:

1. Introduction to Plasma Physics and Controlled Fusion, Francis F. Chen, Springer International Publishing Swetzerland, 3rd Edition, 2016.
2. Plasma Physics (Plasma State of Matter), S.N. Sen, Pragati Prakashan, Eleventh Edition, 2015
3. Lecture Notes on Principle of Plasma Processing, Francis F. Chen, Jane P. Chang, Plenum/Kluwer Publishers, 2002

Reference Books:

1. Cold Plasma in Materials Fabrication from Fundamentals to Applications, A. Grill, (IEEE Press, New Jersey, 1994)
2. Principles of Plasma Diagnostics by I. H. Huchinson, Cambridge 2nd Edition, 2005.
3. Industrial Plasma Engineering (Vol I & II), J Reece Roth, IOP Publishing, Reprinted 2000.

Course outcomes:

After completing this course the students should be able to:

1. Interpret the thermodynamic stability of Plasma.
2. Distinguish break down mechanisms of plasma equilibrium models.
3. Explain the production of plasmas in the laboratory.
4. Estimate Plasma parameters using laboratory conditions.
5. Discuss processing and applications of Plasma in industries as well as in research.

PH61229 : MODERN PHYSICS LAB

Credits: 06 **Teaching Scheme: 06 Hrs/Week**

Experiment Details:

1. Measurements of Lande splitting factor using electron spin resonance spectrometer.
2. Determination of the resistivity of semiconductor by Four-probe method.
3. Estimation of excitation potential of Argon by Franck-Hertz Experiment.
4. Determination of mobility of a semiconductor by Hall apparatus.
5. Evaluation of dielectric constant and curie temperature of ferroelectric ceramics
6. Estimation of energy band gap and diffusion potential of PN junction.
7. Determination of Planck's constant by total radiation method
8. Verification of Richardson's $T^{3/2}$ law.
9. Verification of
   (i) Plateau Characteristics
   (ii) Inverse Square law
   (iii) Absorption co-efficient of beta-ray and gamma-rays in Aluminium foils
   (iv) Dead time characteristics by single source and double source methods.
   Using GM counter.
10. Determination of vibrational frequencies of stokes and antistokes line of given sample using Raman spectroscopy.

Course Outcome:

After completing this course the students should be able to:

Explain the behaviour associated with semiconductor, magnets, dielectrics, atoms and molecules.

CORE ELECTIVE LAB-II

PH62230: FIBER OPTICS AND OPTOELECTRONICS-II

Credits: 06 **Teaching Scheme: 06 Hrs/Week**

Experiment Details:

1. Measurement of propagation constant using Prism Coupling technique.
2. Modulate optical intensity using fiber optic sensor.
3. Characterization of directional coupler.
4. Measurement of power attenuation of the long length optical fiber.
5. Measurement of the splice loss of optical fibers.
6. Characterization fiber Bragg Gratings.
7. Power launching and measurement of optical power loss between two plastic optical fibers in ST connectors.

Course Outcomes:

After completing this course the students should be able to:

1. Determine various propagation parameters of Optical fiber
2. Characterize of Fiber Bragg Grating, Directional Coupler
3. Measure output power using Fiber Optic Sensor

PH62231: MATERIALS SCIENCE AND TECHNOLOGY LAB- II

Credits: 06 **Teaching Scheme: 06 Hrs/Week**

Experiment Details:

1. Measurement of Tensile test of metal sheet using UTM
2. Determination of energy band gap of unknown powder from UV-Vis spectroscopy
3. Determination of grain size from SEM images
4. Determination of density of solid specimen by Archimedes sample
5. Determination of energy band gap of unknown liquid sample from UV-Vis spectroscopy
6. Estimation of strain in thin film/powder from XRD spectrum.
7. Phase identification of unknown sample from FTIR spectroscopy

Course Outcome:

After completing this course the students should be able to:

Analyze the compositional, microstructure and mechanical properties of materials

PH62232 : PLASMA PHYSICS LAB-II

Credits: 06 **Teaching Scheme: 06 Hrs/Week**

Experiment Details:

1. Calibration of emission spectroscope using Mercury vapour lamp.
2. Determination of unknown electrodes from the prominent lines of the emission spectra of supplied Arc plasma by measuring their wavelengths.
3. Measurement of electron temperature, electron and ion velocities using optical emission spectroscopic (OES) method.
4. To deposit metallic thin films of desired thickness using DC magnetron sputtering unit.
5. In-situ measurement of electron temperature at varied working pressure during thin film deposition using DC magnetron sputtering techniques.
6. In-situ measurement of electron temperature at varied DC power during thin film deposition using DC magnetron sputtering techniques.
7. Determination of different emission series of Hydrogen plasma from emission spectra.
8. Measurement of collision cross section of electrons in plasma.

Course Outcome:

After completing this course the students should be able to:

1. Understand of vacuum systems using laboratory scale plasma units
2. Analyse of plasma parameters through spectroscopic techniques in laboratory scale plasmas