COURSE CURRICULUM
(COURSES OF MS/MS LEADING TO PHD/PHD)
2017-ONWARD

i. **MS Physics**
ii. **Ph.D Physics**

DEPARTMENT OF BASIC SCIENCES & HUMANITIES
UNIVERSITY OF ENGINEERING & TECHNOLOGY, TAXILA

AUGUST, 2017

PHY- 6101 Mathematical Methods of Physics

Course Title: Mathematical Methods of Physics

Course Code: PHY-6101

Credit Hours: 3+0

Prerequisites: ODE's, PDE's, Linear Transformations

Course Contents: Fourier series: introduction and general properties, convergence of trigonometric series, Gibbs phenomenon, Parseval's theorem, applications to various phenomena. Integral transform, development of the Fourier integral, Fourier transform, inversion theorems, Fourier transform of derivatives, convolution theorem, momentum representation, transfer functions. Complex arguments in Fourier transforms. Laplace transform, Laplace transform of derivatives, convolution products and Faltung's theorem, inverse Laplace transform. Partial differential equations. Separation of variables in three dimensions, method of characteristics. Boundary value problems. Integral transforms, generating functions, Neumann series, separable (degenerate) kernels, Hilbert–Schmidt theory, integral equations. Calculus of variations: dependent and independent variables, Euler-Lagrange equation and applications, several independent and dependent variables, Lagrange multipliers, variational principle with constraints, Rayleigh–Ritz variational technique, application to discrete mesh.

Nonlinear methods and chaos, the logistic map, sensitivity to initial conditions and parameters, nonlinear differential equations.

Probability: definitions and simple properties, random variables, binomial distribution, Poisson distribution, Gauss's normal distributions, statistics.

Recommended Books:

1. *Mathematical Methods for Physicists,* Arfken & Weber (Academic Press, 6th edition, 2005).
2. *Mathematical Methods for Physicists,* Tai L. Chow (Cambridge University Press, 2002).

PHY- 6102 Classical Mechanics

Course Title: Classical Mechanics

Course Code: PHY-6102

Credit Hours: 3+0

Prerequisites: No

Course Contents: Survey of the elementary principles, Variational principles and Lagranges's equations, Oscillations, The classical mechanics of the special theory of relativity, Hamiltonian equations of motion, canonical transformations, Hamilton-Jacobi theory and Action angle variable, Classical Chaos, Canonical perturbation theory, Introduction to the Lagrangian and Hamiltonian formulations for continuous systems and fields, Classical mechanics of liquids and deformable solids; stress, deformation and strain flow.

Recommended Textbook:

1. Classical Mechanics (3rd Edition) by Herbert Goldstein, Charles P. Poole Jr., and John L. Safko, Pearson International Edition, 2001.

PHY- 6103 Quantum Mechanics I

Course Title: Quantum Mechanics I

Course Code: PHY-6103

Credit Hours: 3+0

Prerequisites: No

Course Contents: Waves and particles: Introduction to fundamental idea of Quantum mechanics. Electromagnetic waves and photons; Light quanta and the plank-Einstein relations, wave particle duality, Anal ysis of young double slit experiment, Quantum unification of two aspect of light, The Principle of spectral decomposition, Material particle and matter waves; The de Broglie relations, Wave functions: the Schrodinger equation, Quantum description of a particle Wave packets; Free particle, Form of the wave packet at given time, Heisenberg uncertainty relation, Time evolution of free wave packet, Particle in a time independent Scalar potential; Separation of variables. Stationary states, one dimensional square potential.

Order of magnitude of the wave length associated with the material particle, Constraints imposed by the uncertainty relation, the uncertainty relation and the atomic parameters, An experiment illustrating the uncertainty relation, A simple treatment of a two dimensional wave packet, the relation between one and three dimensional problem, One dimensional Gaussian wave packet: spreading of wave packet, Stationary state of a particle in one dimensional square well, behaviour of wave packet at a potential step.

The mathematical tool of quantum mechanics: One particle wave function space; Structure of the wave function space, Discrete orthonormal basis in wave function space, Introduction of basis not belonging to wave function space, State Space: Dirac notation; introduction, ket vectors and bra vectors, Linear operators, Hermitian conjugation

Representation in the state space; Relation characteristic of an orthonormal basis, Representation of kets and bras, Representation of operators, Eigen value equation: Observables; Eigen values and Eigen vectors of an operators, Observables, Sets of commuting observables, Two important example of representation and observables; {lr>} and {lp>} repsentations, The R and P representation.

The Schwartz inequality, Review of some useful properties of linear operator, Unitary operators, A more detail study of {lr>} and {lp>} repsentations, Some general properties of two observables, Q and P, The parity operator.

The postulates of quantum mechanics: Introduction, Statement of the postulates; Description of the state of the system, Description of a physical quantaties, the measurement of a physical quantaties, time evolution of a system, Quantization rule, The physical interpretation of the postulates, Postulate s concerning observables and their measurements, Quantization of certain physical quantaties, The measurement process, mean value of an observable, The root mean square deviation, Compatibility of observables, The physical implication of the Schrodinger equation; General properties of Schrodinger equation, The case of conservative system, The superposition principle and Physical prediction; Probability amplitudes and interference effects, Case in which several states can be associated with the same measurement result. Practical in infinite potential well, Study of the probability current in some special cases, Root mean square deviation of two conjugate observables, measurements bearing on only one part of a physical system, The density operator, The evolution operator, The Schrodinger and Heisenberg picture, The Gauge invariance, Propagator for the Schrödinger equation.

Application of the postulate to the simple cases: Spin1/2 and two level system.

Spin1/2 particle: Experimental demonstration, Quantization of the angular momentum, theoretical description, Illustration of the postulate in the case of a spin1/2; Actual preparation of a various spin states, spin measurements, Evolution of spin ½ in a uniform magnetic field, General study of two level system; Outline of the problem, Static aspect, Dynamical aspect: oscillation of the system between two unperturbed state. Pauli matrices, Diagnalization of 2cross2 matrices, Fictitious spin1/2 associated with two level system, system of two spin ½ particles, spin ½ density matrix, spin ½ particles in a static magnetic field and a rotating field, A simple model of ammonia molecule, coupling between a stable and unstable state.

The one-dimensional harmonic oscillator: Introduction; Importance of harmonic oscill ator in physics, the harmonic oscillator in classical mechanics, General properties of quantum mechanical Hamiltonian, Eigen values of the Hamiltonian; Notation, Determination of the spectrum, Degeneracy of the eigen values,

Eigen State of the Hamiltonian; The {lϕ_n>} representation, Wave function associated with the stationary state, Discussion; Mean value and root mean square deviation of X and P in a state {lϕ_n>}, Properties of the ground state, Time evolution of mean values. Some example of harmonic oscillator, Study of the stationary state in the {lr>} representation, Solving the eigen value equation of the harmonic oscillator by the polynomial method, Study of the stationary state in the {lp>} representation, The isotropic three dimensional harmonic oscillator, A charged harmonic oscillator in uniform electric field, Coherent quasi classical state of harmonic oscillator.

General properties of angular momentum in Quantum mechanics: Introduction; The importance of angular momentum, Commutation relatio n; Orbital angular momentum, Generalization. Definition of angular momentum, Statement of the problem, General theory of angular momentum;. Definition and notation, Eigen values of J^2 and Jz, Standard {lk, j, m>} representation, Application to the orbital angular momentum; Eigen values and eigen function of L^2 and Lz, physical consideration.

Spherical harmonics, Angular momentum and rotation, Rotation of diatomic molecules, Study of the stationary state in the {lp>} representation, Angular momentum of stationary state two dimensional harmonic oscillator, A charged particle in magnetic field: Landau levels.

Particle in a central potential: the hydrogen atom: Stationary state in a central potential; Outline of the problem, Separation of variable, Stationary state of the particle in a central, Motion of the centre of mass and Relative motion for a system of two Interacting particle; Motion ofthe centre of mass and Relative motion in Classical mathematics, Separation of variable in Quantum mechanics, The hydrogen atom; Introduction, The Bohr model, Quantum mechanical theory of the hydrogen atom, Discussion of the result.

Hydrogen like system, a soluble example of the central potential, Probability current associated with the stationary state of the hydrogen atom, the hydrogen atom placed in a uniform magnetic field, Study of some atomic orbitals. Hybrid orbitals, Vibrational rotational levels of diatomic molecules.

Recommended Textbook:

1. Quantum Mechnics (Vol. 1) by Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe, Wiley-VCH, 1992.

Recommended Books:

1. Modern Quantum Mechanics (2nd Edition) by J. J. Sakurai, Jim J. Napolitano, Addison Wesley, 2010.
2. Principles of Quantum Mechanics (2nd Edition) by R. Shankar, Plenum Press, 1994.
3. Quantum Mechanics by Dirac, P. A. M (Oxford University Press)

PHY- 6104 Statistical Physics

Course Title: Statistical Physics

Course Code: PHY-6104

Credit Hours: 3+0

Prerequisites: No

Course Contents: Intensive and extensive quantities, thermodynamic variables, thermodynamic limit, thermodynamic transformations. Classical ideal gas, first law of thermodynamics, application to magnetic systems, heat and entropy, Carnot cycle. Second law of thermodynamics, absolute temperature, temperature as integrating factor, entropy of ideal gas. Conditions for equilibrium, Helmholtz free energy, Gibbs potential, Maxwell relations, chemical potential. First-order phase transition, condition for phase coexistence. The statistical approach: phase space, distribution function, microcanonical ensemble, the most probable distribution, Lagrange multipliers. Maxwell-Boltzmann distribution: pressure of an ideal gas, equipartition of energy, entropy, relation to thermodynamics, fluctuations, Boltzmann factor. Transport phenomena: collisionless and hydrodynamic regimes, Maxwell's demon, non-viscous hydrodynamics, sound waves, diffusion, conduction, viscosity. Quantum statistics: thermal wavelength, identical particles, Fermi and Bose statistics, pressure, entropy, free energy, equation of state, Fermi gas at low temperatures, application to electrons in solids and white dwarfs. The Bose gas: photons, phonons, Debye specific heat, Bose-Einstein condensation, equation of state, liquid helium. Canonical and grand canonical ensembles, partition function, connection with thermodynamics, fluctuations. minimization of free energy, photon fluctuations, pair creation. The order parameter, Broken symmetry, Ising spin model, Ginsburg Landau theory, mean-field theory, critical exponents, fluctuation-dissipation theorem, correlation length, universality.

Recommended Textbooks:

1. Introduction to Statistical Physics, Kerson Huang, (Taylor and Francis, 2001).
2. Statistical Mechanics, Raj Kumar Pathria, 2nd edition (India, 1996).

PHY- 6105 Electrodynamics I

Course Title: Electrodynamics I

Course Code: PHY-6105

Credit Hours: 3+0

Prerequisites: NO

Course Contents: Introduction to Electrostatics: Coulomb's Law , Electric Field , Gauss's Law , Differential Form of Gauss's Law , Another Equation of Electrostatics and the Scalar Potential ,Surface Distributions of Charges and Dipoles and Discontinuities in the Electric Field and Potential , Poisson and Laplace Equations, Green's Theorem, Uniqueness of the Solution with Dirichlet or Neumann Boundary Conditions Formal Solution of Electrostatic Boundary-Value Problem with Green Function, Electrostatic Potential Energy and Energy Density; Capacitance, Variational Approach to the Solution of the Laplace and Poisson Equations, Relaxation Method for Two-Dimensional Electrostatic Problems.

Boundary- Value Problems in Electrostatics I: Method of Images, Point Charge in the Presence of a Grounded Conducting Sphere, Point Charge in the Presence of a Charged, Insulated, Conducting Sphere, Point Charge Near Conducting Sphere at Fixed Potential, Conducting Sphere in a Uniform Electric Field by Method of Images, Green Function for the Sphere; General Solution for the Potential, Conducting Sphere with Hemispheres at Different Potentials, Orthogonal Functions and Expansions, Separation of Variables; Laplace Equation in Rectangular Coordinates, A Two-Dimensional Potential Problem; Summation of Fourier Series, Fields and Charge Densities in Two-Dimensional Corners and Along Edges, Introduction to Finite Element Analysis for Electrostatics.

Boundary- Value Problems in Electrostatics II: Laplace Equation in Spherical Coordinates, Legendre Equation and Legendre Polynomials, Boundary-Value Problems with Azimuthal Symmetry, Behaviour of Fields in a Conical Hole or Near a Sharp Point, Associated Legendre Functions and the Spherical Harmonics, Addition Theorem for Spherical Harmonics, Laplace Equation in Cylindrical Coordinates; Bessel Functions, Boundary-Value Problems in Cylindrical Coordinates, Expansion of Green Functions in Spherical Coordinates, Solution of Potential Problems with the Spherical Green Function.

Expansion, Expansion of Green Functions in Cylindrical Coordinates, Eigenfunction Expansions for Green Functions, Mixed Boundary Conditions, Conducting Plane with a Circular Hole, Multi-poles, Electrostatics of Macroscopic Media, Dielectrics:

Multi-pole Expansion, Multi-pole Expansion of the Energy of a Charge Distribution in an External Field, Elementary Treatment of Electrostatics with Ponderable Media, Boundary-Value Problems with Dielectrics, Molecular Polarizability and Electric Susceptibility, Models for Electric Polarizability, Electrostatic Energy in Dielectric Media. Magnetostatics, Faraday's Law, Quasi-Static Fields:

Introduction and Definitions, Biot and Savart Law, Differential Equations of Magnetostatics and Ampere's Lawn Vector Potential, Vector Potential and Magnetic Induction for a Circular Current Loop, Magnetic Fields of Localized Current Distribution, Magnetic Moment, Force and Torque on and Energy of a Localized Current Distribution in an External Magnetic Induction , Macroscopic Equations, Boundary Conditions on B and H, Methods of Solving Boundary-Value Problems in Magnetostatics, Uniformly Magnetized Sphere, Magnetized Sphere in an External Field; Permanent Magnets, Magnetic Shielding, Spherical Shell of Permeable Material in a Uniform Field, Effect of a Circular Hole in a Perfectly Conducting Plane with an Asymptotically Uniform Tangential Magnetic Field on One Side, Numerical Methods for Two-Dimensional Magnetic Fields, Faraday's Law of Induction , Energy in the Magnetic Field, Energy and Self- and Mutual Inductances, Quasi-Static Magnetic Fields in Conductors; Eddy Currents; Magnetic Diffusion, Maxwell Equations, Macroscopic

Electromagnetism, Conservation Laws: Maxwell's Displacement Current; Maxwell Equations, Vector and Scalar Potentials, Gauge Transformations, Lorenz Gauge, Coulomb Gauge, Green Functions for the Wave Equation , Retarded Solutions for the Fields: Jefimenko's Generalizations of the Coulomb and BiotSavart Laws; Heaviside-Feynman Expressions for Fields of Point Charge, Derivation of the Equations of Macroscopic Electromagnetism, Poynting's Theorem and Conservation of Energy and Momentum for a System of Charged Particles and Electromagnetic Fields, Poynting's

Theorem in Linear Dissipative Media with Losses, Poynting's Theorem for Harmonic Fields; Field Definitions of Impedance and Admittance, Transformation Properties of Electromagnetic Fields and Sources Under Rotations, Spatial Reflections, and Time Reversal, On the Question of Magnetic Monopoles, Discussion of the Dirac Quantization Condition , Polarization Potentials (Hertz Vectors).

Recommended Textbook:

1. Classical Electrodynamics by J. D. Jackson (3 rd Edition), Wiley 1998.

PHY- 6106 Quantum Mechanics II

Course Title: Quantum Mechanics II

Course Code: PHY-6106

Credit Hours: 3+0

Prerequisites: Quantum Mechanics I

Course Contents: An elementary approach to quantum theory of scattering by potential: Introduction: Importance of collision phenomena, scattering by potential, Definition of scattering cross section, Organization of this chapter, Stationary scattering state. Calculation of the cross section, Definition of stationary scattering state, Calculation of the scattering cross section using probability current, Integral scattering equation. The Born approximation, scattering by central potential method of partial waves; Principle of the method of partial wave, Stationary state of the free particle, Partial wave in the potential, Expression for the cross section in terms of phase shift.

Electron spin: Introduction of electron spin; Experimental evidence, Quantum description: postulates of the Pauli theory, Special properties of an angular momentum1/2; Non relativistic description of Spin1/2 particles; Observables and state vectors, Rotation operator for spin ½ particle.

Addition of angular momenta: Introduction; Total angular momentum in classical mechanics, the importance of total angular momentum in Quantum mechanics, Addition of two ½ spin elementary method; Statement of the problem, The eigen values of S_z and their degree of Degeneracy, Diagnalization of S^2, Results: triplet and singlet, Addition of two arbitrary angular momenta; Review of the General theory of angular momentum, Statement of the problem, Eigen values of J^2 and J, Common Eigen vectors of J^2 and J_z. Example of addition of angular momenta, Addition of Spherical harmonics, Vector operator: The Wigner Eckert theorem, Electron multi-pole moments, Evolution of two angular momenta.

Stationary perturbation theory: Description of the method ; Statement of the problem, Approximate solution of the H(⅄) eigenvalue equation, Perturbation of non -degenerate levels; First order correction, Second order correction, Diagnalization of S^2 Results: triplet and singlet, Perturbation of degenerate levels. A one dimensional harmonic oscillator subjected to a perturbing potential in x, x^2, x^3, Interaction between the magnetic dipole of two spin1/2 particles, Van der wall forces, The Vabriational method, Energy band of electron in solids, A simple example of the chemical bond: The H ion.

An application of perturbation theory: the fine and hyperfine structure of hydrogen atom: Introduction; Additional terms in the Hamiltonian; The fine structure of Hamiltonian, Magnetic interaction related to proton spin: The hyperfine Hamiltonian, The fine structure of n=2 levels; Statement of the problem, Matrix representation: The fine structure of Hamiltonian, Resurts: The fine structure of n=2 levels, The hyperfine structure of n=1level; Statement of the problem, Matrix representation of W_f in the 1slevel, The hyperfine structure of n=1 level. The Magnetic hyperfine Hamiltonian, Calculation of the mean value of fine structure of Hamiltonian in the 1s, 2s,and 2p state, The influence of the electron spin on the Zeeman effect of the hydrogen resonance line, The stark effect for the hydrogen atom.

Approximation method for time dependent problems: Statement of the problem; Approximate solution of the Schrodinger equation; The Schrodinger equation in the $\{l\phi_n>\}$, Perturbation equation, An important special case: Sinusoidal or constant perturbation; Application of the general formulas, Sinusoidal perturbation which couple two discrete States: the resonance phenomena, Coupling with the state of continuous spectrum. Interaction of an atom with the electromagnetic wave, Linear and non–linear response of the two level system subjected to a sinusoidal perturbation, Oscillation of the system between two discrete states under the effect of resonant perturbation, Decay of discrete state resonantly coupled to a continuum of the final state.

System of identical particles: Statement of the problem; Identical particles: definition, Identical particles in classical mechanics, Identical particles in quantum mechanics, Permutation operators; Two particle system, System containing an arbitrary number of particles, The symmetrization postulate; Statement of the postulate, Removal of exchange degeneracy, Construction of physical kets, Application of the other postulates, Discussion; Difference between bosons and fermions. Pauli's exclusion principle, Consequences of particle indistinguishablility on the calculation of physical predictions Many electron atoms. Electron configuration, Energy level of the helium atom, Physical properties of an electron gas. Application to solids.

PHY- 6107 Electrodynamics II

Course Title: Electrodynamics II

Course Code: PHY-6107

Credit Hours: 3+0

Prerequisites: Electrodynamics I

Course Contents: Plane Electromagnetic Waves and Wave Propagation. Plane Waves in a Non-conducting Medium, Linear and Circular Polarization; Stokes Parameters, Reflection and Refraction of Electromagnetic Waves at a Plane Interface Between Two Dielectrics, Polarization by Reflection, Total Internal Reflection; Goos-Hanchen Effect, Frequency Dispersion Characteristics of Dielectrics, Conductors, and Plasmas, Simplified

Model of Propagation in the Ionosphere and Magnetosphere, Magnetohydrodynamic Waves, Superposition of Waves in One Dimension; Group Velocity , Illustration of the Spreading of a Pulse As It Propagates in Dispersive Medium, Causality in the Connection Between D and E; Kramers-Kronig Relations, Arrival of a Signal After Propagation Through a Dispersive Medium, Waveguides, Resonant Cavities, and Optical Fibers: Fields at the Surface of and Within a Conductor, Cylindrical Cavities and Waveguides, Waveguides, Modes in a Rectangular Waveguide, Energy Flow and Attenuation in Waveguides, Perturbation of Boundary Conditions, Resonant Cavities, Power Losses in a Cavity; Q of a Cavity, Earth and Ionosphere as a Resonant Cavity: Schumann Resonances, Multimode Propagation in Optical Fibers, Modes in Dielectric Waveguides, Expansion in Normal Modes; Fields Generated by a Localized Source in a Hollow Metallic Guide, Radiating Systems, Multi-pole Fields and Radiation: Fields and Radiation of a Localized Oscillating Source, Electric Dipole Fields and Radiation, Magnetic Dipole and Electric Quadrupole Fields, Center-Fed Linear Antenna, Multi-pole Expansion for Localized Source or Aperture in Waveguide, Spherical Wave Solutions of the Scalar Wave Equation, Multipole Expansion of the Electromagnetic Fields, Properties of Multi-pole Fields, Energy and Angular Momentum of Multi-pole Radiation, Angular Distribution of Multi-pole Radiation, Sources of Multi-pole Radiation; Multi-pole Moments, Multi-pole Radiation in Atoms and Nuclei, Multi-pole Radiation from a Linear, Center-Fed Antenna 444.

Scattering and Diffraction: Scattering at Long Wavelengths, Perturbation Theory of Scattering, Rayleigh's Explanation of the Blue Sky, Scattering by Gases and Liquids, Attenuation in Optical Fibers, Spherical Wave Expansion of a Vector Plane Wave, Scattering of Electromagnetic Waves by a Sphere, Scalar Diffraction Theory, Vector Equivalents of the Kirchhoff Integral, Vectorial Diffraction Theory, Babinet's Principle of Complementary Screens, Diffraction by a Circular Aperture; Remarks on Small Apertures, Scattering in the Short Wavelength Limit, Optical Theorem and Related Matters.

Special Theory of Relativity: The Situation Before 1900, Einstein's Two Postulates, Some Recent Experiments, Lorentz Transformations and Basic Kinematic Results of Special Relativity, Addition of Velocities; 4-Velocity, Relativistic Momentum and Energy of a Particle, Mathematical Properties of the Space-Time of Special Relativity Matrix Representation of Lorentz Transformations, Infinitesimal Generators, Thomas Precession, Invariance of Electric Charge; Covariance of Electrodynamics, Transformation of

Electromagnetic Fields, Relativistic Equation of Motion for Spin in Uniform or Slowly Varying External Fields Note on Notation and Units in Relativistic Kinematics, Dynamics of Relativistic Particles and Electromagnetic Fields: Lagrangian and Hamiltonian for a Relativistic Charged Particle in External Electromagnetic Fields, Motion in a Uniform, Static Magnetic Field, Motion in Combined, Uniform, Static Electric and Magnetic Fields, Particle Drifts in Non-uniform, Static Magnetic Fields, Adiabatic Invariance of Flux Through Orbit of Particle, 12.6 Lowest Order Relativistic Corrections to the Lagrangian for Interacting Charged Particles: The Darwin Lagrangian, Lagrangian for the Electromagnetic Field, Proca Lagrangian; Photon Mass Effects, Effective "Photon" Mass in Superconductivity; London Penetration Depth , Canonical and Symmetric Stress Tensors; Conservation Laws, Solution of the Wave Equation in Covariant Form; Invariant Green function.

Recommended Textbook:

Classical Electrodynamics by J.D. Jackson (3rd Edition), Wiley 1998.

PHY- 6108 Advanced Quantum Mechanics

Course Title: Advanced Quantum Mechanics

Course Code: PHY-6108

Credit Hours: 3+0

Prerequisites: Quantum Mechanics-I

Course Contents:

Relativistic Quantum Mechanics: Paths to relativistic quantum mechanics; The Dirac Equation; Symmetries of the Dirac equation; Solving with a central potential; Relativist quantum field theory. Relativistic Quantum Mechanics of Spin ½ Particles. Probability conservation in relativistic quantum mechanics; The Dirac equation; Simple solution; nonrelativistic approximations, plane waves; Relativistic covariance; Bilinear covariance; Dirac operators in the Heisenberg representation; Zitterbewegung and negative energy solutions; Central force problems; the hydrogen atom; Hole theory and charge conjuagation; quantization of the Dirac field; Weak interactions and parity nonconservation; the two-component neutrino.

Covariant Perturbation Theory: Natural units and dimensions; s-matrix expansion in the interaction representation; First-order process: Mott scattering and hyperon decay; Two-photon annihilation and Compton scattering: the electron propagator;

Feynman's space-time approach to the electron propagator; Moller scattering and the photon propagator: one-meson exchange interactions; Mass and charge renormalization: radiative corrections.

Text Books:

1. Advanced Quantum Mechanics by J. J. Sakurai and Jim Napolitano, (2^{nd} Edition).
2. Modern Quantum Mechanics by J. J. Sakurai and Jim Napolitano (2^{nd} Edition)

PHY- 6109 Methods and Techniques of Experimental Physics

Course Title: Methods and Techniques of Experimental Physics

Course Code: PHY-6109

Credit Hours: 3+0

Prerequisites: NO

Course Contents: Numerical methods. Solutions of equations by the method of iteration (Newton-Rapson method). Solution of differential equations of higher order. Gaussian quadrature. Random numbers. Monte-Carlo methods. Resume of theory of errors and experimental statistics. Least -squares fit to a polynomial. Nonlinear functions. Data manipulation, smoothing, interpolation and extrapolation, linear and parabolic interpolation. High vacuum techniques. Physical principles of diffusion and rotary pumps. Ultra high vacuum by ionization. Sorption and cryogenics. Measurement of pressure. Leak detection. X-ray. Electron and neutron diffraction techniques. Methods of recording diffraction patterns. Examples of structure determination. Analysis of results.

Recommended Books:

1. Methods of Experimental Physics by R. L. Horovitz and V. A. Johnson, (Academic press).
2. Methods of Experimental Physics by D. Williams, (Academic).
3. Elements of X-Ray Crystallography by L. V. Azaroff, (McGraw-Hill).
4. High Vacuum Technique by J. Yarwood (Chapman Hall).

PHY- 6110 Magnetism in Condensed Matter

Course Title: Magnetism in Condensed Matter

Course Code: PHY-6110

Credit Hours: 3+0

Prerequisites: NO

Course Contents:

Introduction to magnetism, Isolated magnetic moments, Enviro nments, Interactions, Order and Magnetic structures, Order and Broken symmetry, Magnetism in Metals.

Recommended Textbook:

1. Magnetism in Condense Matter by Stephen Blundell.

Recommended Books:

1. Magnetism in Condensed Matter, by Stephen Blundell, Oxford Press 2001.
2. Introduction to the theory of Ferromagnetism by Amikam Aharoni, Oxford Press, 1998.
3. Permanent Magnetism by R. Skomski and J. M. D. Coey, IOP Publishing, 1999.
4. The Physical Principles of Magnetism by Allan H. Morrish, John Wiley 1965.
5. Introduction to Solid State Physics by Charles Kittel, John Wiley 8^{th} Edition.

PHY- 6111 Quantum Optics-I

Course Title: Quantum Optics-I

Course Code: PHY-6111

Credit Hours: 3+0

Prerequisites: NO

Course Contents: Field Quantization: Quantization of a single-mode field, Quantum fluctuations of a single-mode field, Quadrature operators for a single mode field, multimode fields, Thermal fields, Vacuum fluctuations and zero point energy, The quantum phase Coherent state: Eigenstates of the annihilation operator and minimum uncertainty states, Displaced vacuum states, Wave packet and time evolution, Generation of coherent states, Phase space pictures of Coherent states, Density operators and phase space probability distribution, Characteristic functions.

Emission and Absorption of Radiation by Atoms: Atom-field interactions, Interaction of an atom with classical field, Interaction of an atom with quantized field, The Rabi model, Fully quantum-mechanical model: the Jaynes-Cumming model, the dressed states, Density operator approach: application to thermal states, The Weisskopf-Wigner theory of spontaneous emission between two atomic levels. Quantum Coherence Functions: Classical coherence functions, Quantum coherence functions, Young’s interference, Higher-order coherence functions.

Textbooks/References:

1. Introductory Quantum Optics, Christopher C. Gerry and Peter L. Knight, Cambridge University Press (2005)

2. Quantum Optics, Marlan O. Scully and M. Suhail Zubairy, Cambridge University Press (1997).
3. Fundamentals of Quantum Optics and Quantum Information, Peter Lambropoulos and David Petrosyan, Springer-Verlag Berlin Heidelberg (2007).

PHY- 6112 Condensed Matter Theory-I

Course Title: Condensed Matter Theory-I

Course Code: PHY-6112

Credit Hours: 3+0

Prerequisites: NO

Course Contents: Introduction: Overview of modern condensed matter physics, more is different, emergent properties. Broken symmetry, quasiparticles and collective phenomena: Symmetry, importance of broken symmetry, adiabatic co ntinuity and universality.

Landau's Fermi liquid theory: The free electron theory, why does the free electron theory work so well? Adiabatic continuity applied to Fermi systems, Landau's Fermi liquid theory, physical consequences. Second quantization and its applications: Bosons, Fermions, Fermion operators, quantum magnetism, spin waves and magnons, Su-ShrieferHeeger model of a conducting polymer chain. Electron interactions: Hartree and Hartree-Fock theory, Metals in the HartreeFock approximation, correlation energy of jellium, Wigner crystallization, Inhomogeneous electron systems, Kohn-Hohenberg theory, The Kohn-Sham equation, Exchange-correlation functional. Response functions: An overview of modern experimental techniques, linear response theory, fluctuation-dissipation theorem, dielectric response function. Luttinger liquid theory: Why is 1D special? The Luttinger model, spin-charge separation. Electron-lattice interactions: harmonic chain, electron-phonon interaction, electrical conduction, effective electron-electron coupling.

Recommended Textbooks:

1. Advanced Solid State Physics, by P. Philips, publisher: Westview Press; 1st edition, (2003).
2. Condensed Matter Field Theory, by A. Altland and B. Simons, publisher: Cambridge University Press, 1st edition (2006).
3. Advanced Condensed Matter Physics, by L. M. Sander, publisher: Cambridge University Press, 1st edition (2009).

PHY- 6113 Quantum Information Theory-I

Course Title: Quantum Information Theory-I

Course Code: PHY-6113

Credit Hours: 3+0

Prerequisites: NO

Course Contents: Review of Classical Information Theory: Information and Physics, Quantifying Information, Shannon Entropy, Data Compression, Huffman Coding, Relative Entropy, Joint Entropy, Conditional Entropy, Mutual Information, Shannon's noiseless channel coding theorem. Review of Quantum Mechanics: Pure and Mixed States, Density Operator, Trace and Partial Trace Operations, Postulates of Quantum Mechanics in Density Operator Formulism. Basics of Quantum Information Theory: Von-Neumann Entropy, Quantum Data Compression, Relative Entropy, Conditional Entropy and Mutual Information. Quantum circuits, operation of quantum computer, universal gates for quantum computation, building blocks of a quantum computer, quantum algorithms, Deutsch algorithm and Deutsch-Jozsa algorithm. Physical implementations of quantum computation: Physical requirements for the physical implementation of quantum information processing, Rydberg atoms in microwave cavity, Ion trap quantum computer, cavity QED based quantum computer, optical quantum computer. Quantum Cryptography: Review of Classical Cryptography, Quantum Key Distribution Protocols, privacy amplification and information reconciliation, security of quantum key distribution.

Text/Reference Books:

1. Elements of Information Theory, T.M. Cover and J.A. Thomas, John and Wiley Sons (1991)
2. Quantum Computation and Quantum Information, M.A. Nielson and I.I Chuang, Cambridge University Press (2000)
3. Introduction to Quantum Information Science, Vlatko Vedral, Oxford University Press (2006).

PHY- 6114 Materials Science

Course Title: Materials Science

Course Code: PHY-6114

Credit Hours: 3+0

Prerequisites: NO

Course Contents: Interatomic Bonding in Materials: Bonding in Elemental Materials (Covalent, Metallic and van der Waals Bonding), Bonding in Multielement Materials (Ionic, Mixed Ionic-Covalent Bonding, Hydrogen Bonding), Effects of Nature of Bonding on Materials Properties.

Structure of Crystalline Solids: Basic Structural and Symmetry Concepts, Concept of Diffraction in a Periodic Lattice Structural Information from X-ray Diffraction and other Diffraction Techniques. Crystal Structures of Metals and Ceramic Materials.

Defects and Imperfections in Crystalline Solids: Point Defects (vacancies, interstitials, impurities, F-centres) and their stability Line and Extended Defects (Dislocations, Grain Boundaries, Stacking Faults, Interfacial, Surface and Volumetric Defects). Effect of Defects on the Properties of Materials.

Non Crystalline Solids: Amorphous Materials/Glasses (Glass formation, Glass Transition and Crystallization of Glasses, Various Glass Forming Systems). Random Closed Packing in Metallic Glasses, Continuous Random Network in Covalent Glasses.

Phase Diagrams and Phase Transformations: Basic Concepts, Equilibrium Phase Diagrams, Phase Transformations Basic Concepts, Kinetics, Metastable versus Stable Transformations, Microstructure Development, Precipitation and Dispersion Hardening, Multi Component and Multi Phase Systems, Alloys, Equilibrium Structures, Phase Separation.

Surfaces and Interfaces: Geometry of Interfaces, Coherent and Commensurate Interfaces, Stacking Period and Interplanar Spacing, Defects on Surfaces, Experimental Determination and Creation of Surfaces, Surface Characterization Techniques (LEED, RHEED, MBE, STM and AFM) and Their Principles.

Soft Condensed Matter: Introduction to Soft Matter, Colloidal Dispersions, Gels and Gelation, Liquid Crystals; Structures and Textures in Liquid Crystals. Polymers; Molecular Weight, Molecular Structure, Stereo and Geometric Isomerism, Thermoplastics, Thermosets and Elastomers, Crystallinity of Polymers, Copolymers, Biological Molecules, Concept of Self Assembly in Block Copolymers and Biomolecules.

Text / Reference Books:

1. Materials Science and Engineering an Introduction, by W. D. Callister, Jr., publisher John Wiley & Sons Inc (2007)
2. The Physics and Chemistry of Materials, by J. I. Gersten and F. W. Smith, publisher John Wiley & Sons Inc (2001)
3. Fundamentals of Ceramics, by M. W. Barsoum, IOP Publishing Ltd (2003)
4. The Physics of Amorphous Solids, by Richard Zallen, publisher John Wiley & Sons Inc. (1998).

5. An Introduction to Polymer Physics, D. I. Bower, publisher Cambridge University Press, Cambridge (2002).
6. Materials Science of Thin Films, by M. Ohring, (2^{nd} Edition) publishers Academic Press (2002)
7. Soft Condensed Matter, R. A. L. Jones, publishers Oxford University Press(2002)
8. Solid State Physics, by J.S. Blakemore (2^{nd} Edition), publishers Cambridge University Press (1995)
9. Introduction to Solid State Physics, Charles Kittel, 7^{th} Edition, publisher Wiley & Sons Inc.(1996).

PHY- 6115 Plasma Physics-I

Course Title: Plasma Physics-I

Course Code: PHY-6115

Credit Hours: 3+0

Prerequisites: NO

Course Contents: Relation between fluid equations and guiding center drifts, diamagnetic drift in uniform and non-uniform magnetic fields, polarization current in the fluid model and parallel pressure balance. Single fluid magneto hydrodynamic equations, quasi-neutrality approximation, small Larmor radius approximation, approximation of infinite conductivity of plasma, conservation of magnetic flux and energy, MHD equilibrium, magnetic pressure: the concept of plasma beta, the cylindrical pinch: the cylindrical tokamak. Diffusion in fully and partially ionized plasmas, diffusion as a random walk, the diffusion equation, steady state solutions, diffusion across a magnetic field, diffusion in fully ionized plasma, Bohm diffusion and solution of diffusion equation. Classification of instabilities, two-streaming instability, the Rayleigh-Taylor and flute instabilities, the gravitational R-T instability, physical mechanisms of R-T instability, Flute instability due to field curvature, MHD stability of the tokamak. Kinetic theory of plasmas, the need for a kinetic theory, the particle distribution function, the Boltzmann-Vlasov equation, the Vlasov-Maxwell equations, kinetic effects on plasma waves: Vlasov’s treatment, the linearized Valsov equation for electrostatic perturbations, time asymptotic solutions, simplified derivation for electrostatic waves for Maxwellian and nonMaxwellian plasmas: Langmuir waves, ion-sound waves and Landau damping.

Text/Reference Books:

1. Introduction to Plasma Physics, by R. J. Goldston and P. H. Rutherford, publisher: IoP, Bristol and Philadelphia; 1^{st} Edition, (1995).

2. Principles of Plasma Physics, by N. A. Krall and A. W. Trivelpiece, publisher: McGraw-Hill Book Company, New York; 1st Edition, (1973).

PHY- 6116 Group Theory

Course Title: Group Theory

Course Code: PHY-6116

Credit Hours: 3+0

Prerequisites: NO

Course Contents: Finite Groups: groups and representations, the regular representations, irreducible representations, transformation groups and applications, Schur's lemma, orthogonality relations, characters, eigenstates, tensor products. Lie groups: generators, Lie algebras, Jacobi identity, the adjoint representation, simple algebras and groups, states and operators. SU(2): eigenstates of J3, raising and lowering operators, tensor products. Tensor operators: orbital angular momentum, Wigner Eckart theorem and examples, product of tensor operators. Isospin: charge independence, creation operator, number operators, isospin generators, symmetry of tensor products, the deuteron, superselection rules. Roots, weights and SU(3): Gellmann matrices, weights and roots of su(3), positive weights, simple roots, constructing the algebra, Dynkin diagrams and examples, the Cartan matrix, the trace of generator, fundamental representation of SU(3), constructing the states, the Weyl group, complex conjugation and example of other representation.

Tensor method: lower and upper indices, tensor components and wave functions, irreducible representation and symmetry, invariant tensor, Clebsch Gordon decomposition, triality, matrix elements and operators, normalization, tensor operators. Hypercharge and strangeness: the eight-fold way, the Gellmann-Okubo formula, hadron resonances, quarks. Young tableaux and SU(n): raising and lowering indices, Clebsch-Gordan decomposition, U(1), generalization of Gell-mann matrices, SU(N) tensors, dimensions, complex representations. The Lorentz and Poincare groups and space-time symmetries: generators and the Lie algebra, irreducible representation of the proper Lorentz group, unitary irreducible representation of the Poincare group, relation between representation of the Lorentz and Poincare groups, relativistic wave functions, fields and wave equations.

Recommended Textbooks:

1. Lie algebras in Particle Physics: From Isospin to Unified Theories, Westview Press; 2nd Edition, 1999.

2. Group Theory in Physics, Wu-Ki-Tong, World Scientific, 1985.

PHY- 6117 Superconductivity

Course Title: Superconductivity

Course Code: PHY-6117

Credit Hours: 3+0

Prerequisites: NO

Course Contents: Introductory survey: basic phenomenon; lossless currents, energy gap, Meissner effect, critical fields, currents etc. Phenomenology of superconductivity with applications: a: London equations; magnetic field penetration into a superconductor. Penetration depth and coherence length; non-local effects. Thermodynamics of superconductors. b: Ginzburg-Landau model . Energy of NS boundary in GL theory. Type I and type II superconductors. Proximity effect, critical field of thin films and other applications of GL equations. Microscopic theory (introductory): Formation of superconducting pairs, pairing energy and energy gap. Introduction to the basics of BCS theory. Flux quantization. Josephson effects AC and DC; SIS, SNS junctions; weak links. Applied superconductivity: Vortices in Type II superconductors, critical fields Hcm, Hc1, Hc2 and Hc3. Structure of a vortex. Vortex pinning. Motion of vortices, flux flow. Bardeen-Stephan model.

Advanced topics: a: High Tc superconductors and physics of 2D superconductors; 2D penetration depth and vortices in 2D superconductors.

b: BKT transition: Coulomb gas analogy and Critical behavior of the resistance above the transition and current-voltage characteristics below.

c: Fluctuation effects in superconductors.

Recommended Books: 1. Introduction to Superconductivity, by M. Tinkham, publishers Dover Publications (Second Edition) 1996.

2. The Physics of Superconductors, Introduction to Fundamentals and Applications, by V.V. Schmidt, publisher Springer Books 1982.

3. Superconductivity of Metals and Alloys, by P. G. De Gennes, publishers Westview Press, 1999.

4. Special Reading: G. Blatter. “Vortices in high-temperature superconductors”, Rev. Mod. Phys.66, 1125 (1994).

PHY- 6118 Particle Physics

Course Title: Particle Physics

Course Code: PHY-6118

Credit Hours: 3+0

Prerequisites: NO

Course Contents: Relativistic quantum mechanics, Klein Gordon and Dirac equations. Pauli and Weyl representations of gamma matrices, antiparticles, Majorana representation, left and right handed particles, zitterbewung. Continuous symmetries and the Noether theorem, space reflection, time reversal, charge conjugation, and other discrete symmetries. Scattering matrix, relation to crosssections, crossing symmetry, dispersion relations, Cutkosky rules. Minimal coupling to electromagnetic field, diagrammatic perturbation theory, Ruther, Moller, and Bhabha scattering. Introduction to the gauge principle, non-abelian transformations, examples of SU(2) and SU(3) gauge theories.

The parton model, deep inelastic scattering, running of the coupling constant, beta function, limitations of the perturbative approach. V-A Theory of weak interactions, beta decay, tests of C and P-violation, time reversal invariance, leptonic and semileptonic decays. Spontaneous symmetry breaking, Goldstone theorem, Higgs mechanism, standard model, experimental tests of standard model of particle physics. Neutrino oscillations, mass matrices and mixing, tests for generations beyond three.

Recommended Texts:

1. Quarks and Leptons, An Introductory Course in Modern Particle Physics" by F. Halzen and A.D. Martin, Publisher: Wiley; 1st edition (January 6,1984)
2. An Introduction to Quantum Field Theory, by M.E. Peskin and D.V. Schroeder, Publisher: Addison Wesley Publishing Company, 1995.
3. Collider Physics, by V.D. Barger, R.J.N. Phillips, Publisher: Westview Press; Upd Sub edition (December 17, 1996)
4. A Modern Introduction to Particle Physics, Fayyazuddin and Riazuddin, Publisher: World Scientific Pub Co Inc. 2nd Edition, September 29, 2000.

PHY- 6119 Plasma Physics-II

Course Title: Plasma Physics-II

Course Code: PHY-6119

Credit Hours: 3+0

Pre-requisites:

Course Contents: Basic concepts of inertial and magnetic confinement fusion schemes, fusion reactor physics, thermonuclear fusion reaction criteria and driver requirements, scenario for ICF, fusion fuel burn physics. The physics of hydrodynamic compression, plasma hydrodynamic, shock wave propagation in plasmas, isentropic compression, hydrodynamic stability of the implosion process, equation of state models, and ablation driven compression. Energy transport in ICF plasmas, electron thermal conduction, thermal conduction inhibition, spontaneous magnetic field generation, suprathermal electron transport, radiation transport models. Nonlinear mechanisms in plasmas, solitary waves and solitons, ion-acoustic solitary wave, the Korteweg-de-Vries (KdV) equation, ion-acoustic and Alfven wave solitons, Nonlinear Schrodinger equation, Nonlinear Landau damping, Bernstein-Greene-Kruskal (BGK) modes, and introduction to dusty plasmas with applications.

Recommended Textbooks:

1. Inertial Confinement Fusion, by J. J. Duderstadt and G. A. Moses, publisher: John Wiley & Sons, New York; 1st edition, (1982).

2. Plasma Waves, by D. G. Swanson, publisher: IoP, Bristol and
Philadelphia; 2nd edition, (2003).

3. Introduction to Dusty Plasma Physics, by P. K. Shukla and A. A. Mamun,
publisher: IoP, Bristol and Philadelphia; 1st edition, (2002).

PHY- 6120 General Relativity and Cosmology

Course Title: General Relativity and Cosmology

Course Code: PHY-6120

Credit Hours: 3+0

Pre-requisites:

Course Contents: Principles of special relativity and relativistic mechanics: the addition of velocities and Michelson-Morley experiment, Einstein's resolution and its consequences, space-time, time dilation and twin paradox, Lorentz boosts, four vectors, special relativistic kinematics and dynamics, variational principle for free particle motion, light rays, observers and observations. The curved space time of general relativity: testing of equality of gravitational and inertial mass, equivalence principle, geodesics, metric coordinate transformations, Christoffel symbols, geodesics and coordinate transformations. The physics and geometry of geodesics: geodesic equation from variational principle, the Newtonian limit, the gravitational red-shift, locally inertial and Riemann normal coordinates, affine and non-affine parameterization. Tensor algebra and tensor analysis: from Einstein equivalence principle to the principle of general covariance, tensor algebra, tensor density, the covariant derivative of vector fields, extension of covariant derivative and other tensor fields, main properties of covariant derivatives, the principle of minimal coupling, covariant differentiation along a curve, parallel transport and geodesics, generalizations. Physics in a gravitational field: particle mechanics and electrodynamics in a gravitational field, conserved quantities from covariantly conserved currents and tensors. Lie derivatives, symmetries and Killing vectors: symmetries of a metric, the Lie derivative for scalars, vector fields, tensor fields, metric and Killing vectors. Curvature: the Riemann curvature tensor, intrinsic geometry, parallel transport, geodesic derivative equations, Einstein equations, weak field limit, Bianchi identities, cosmological constant, Weyl tensor, Einstein-Hilbert action, the matter Lagrangian and consequence of the variational principle. Tests of general relativity: black holes, relativistic star models, cosmological models, early stages of evolution of the universe, gravitational waves.

Recommended Textbooks:

1. Gravity: an Introduction to Einstein's General Relativity, J. B. Hartle
(Addison-Wesley 2003).

2. Space-Time and Geometry: An Introduction to General Relativity, Sean
Caroll (Addison-Wesley 2004).

3. Gravitation and Cosmology, S. Weinberg (Wiley, 1972).

PHY- 6121 Condensed Matter Theory-II

Course Title: Condensed Matter Theory-II

Course Code: PHY-6121

Credit Hours: 3+0

Pre-requisites:

Course Contents: Interacting Bosons and superfluidity: Quantum liquids, Bose-Einstein condensation, the macroscopic wave function, superfluid properties of He II, flow quantization and vortices, quasiparticle excitations, Landau-Ginzburg theory of phase transitions, the macroscopic coherent state, spontaneous symmetry breaking, off-diagonal long range order, macroscopic quantum interference, the weakly interacting Bose gas, Bogoliubov's theory. Conventional superconductivity: Phenomenology, electron-phonon effective interaction, Cooper pairs, pair amplitude, BCS ground state, pair fluctuations, ground state energy, critical magnetic field, energy gap, quasiparticle excitations, thermodynamics, experimental applications, Josephson tunneling. Superfluid 3He and unconventional superconductivity: The Fermi liquid normal state of 3He, the pairing interaction in liquid 3He , superfluid phases of 3He, unconventional superconductors.

Quantum Hall effects: Introduction, Landau levels, the role of disorder, currents at the edge, Laughlin state and its quasiparticles, effective Chern- Simons theory for quantum Hall states. Quantum phase transitions: Quantization with path integral methods, the path integral for

Bosons, the path integral for Fermions, quantum rotor models,symmetry breaking transition and Mott insulator in a quantum rotor model,scaling, mean field solution. The renormalization group: The one-dimensional Ising model, general theory of renormalization group, Berezinskii-Kosterlitz-Thouless transition.

Recommended Textbooks:

1. Advanced Solid State Physics, by P. Philips, publisher: Westview Press;
1 st edition, (2003).

2. Condensed Matter Field Theory, by A. Altland and B. Simons, publisher:
Cambridge University Press, 1st edition (2006).

3. Superconductivityy, Superfluids and Condensates, by J. F. Annett,
publisher: Oxford University Press, 1st edition (2004).

PHY- 6122 Experimental Plasma Physics

Course Title: Experimental Plasma Physics

Course Code: PHY-6122

Credit Hours: 3+0

Pre-requisites:

Course Contents: Pinch, and plasma focus devices. Cold plasma generation, characteristics of DC glow discharge, RF discharges and cold plasma reactors. Plasma generation: Energy storage and transfer for high temperature plasma generation and current drive techniques. Z-pinch, Probes for plasma diagnostics: Rogowski coil, high voltage probe, magnetic probe, Langmuir probe, voltage loops and Mirnov coils. Charged particle and neutron diagnostics: Faraday cups and solid state nuclear track detectors for detection and analysis of charged particles, Timeresolved and time-integrated neutron measurement. Laser as a diagnostic tool Propagation of (optical frequency) electromagnetic wave through plasma both in the absence and presence of magnetic field, shadowgraphy and schlieren imaging, interferometry and determination of plasma density, measurement of magnetic field by Faraday rotation, Thomson and Rayleigh scattering. X-ray diagnostics of plasmas: X-ray emission from plasmas, absorption filters and their selection, time-resolved x-ray detectors, pinhole imaging camera, estimate of plasma electron temperature. Plasma Spectroscopy: Radiative processes in plasmas, Collisional processes in plasmas, statistical plasma models, plasma optical spectroscopy, and evaluation of plasma parameters.

Recommended Books:

1. Industrial Plasma Engineering, by J. Reece Roth, Institute of Physics
Publishing Bristol (2000).

2. Principles of Plasma Diagnostics, by I. H. Hutchinson, Cambridge University Press New York (1999).
3. Handbook of Radiation Effects, by A. H. Siedle and L. Adams, Oxford University Press (2002).
4. Principles of Plasma Processing, F. F. Chen and J. P. Chang, Kluwer Academic/Plenum Publishers New York (2003). 92
5. Principles of Plasma Spectroscopy, by Hans R. Griem, Cambridge University Press (1997).
6. Fundamentals of Plasma Physics, by J. A. Bittencourt. Pergamon Press Oxford (1995).
7. Plasma Diagnostics, by Orlando Auciello and Daniel L. Flamm, Academic Press Boston (1989).
8. Tokamaks, by John Wesson, Clarendon Press Oxford (2004).

PHY- 6123 Quantum Optics-II

Course Title: Quantum Optics-II

Course Code: PHY-6123

Credit Hours: 3+0

Pre-requisites:

Course Contents: Beam Splitters and interferometers: Experiment with single photon, Quantum Mechanics of Beam splitters, Interferometry with a single photon, Interactionfree measurement, ntereferometry with coherent states of light.Nonclassical Light: Quadrature squeezing, Generation of quadrature squeezed light, Detection of quadrature squeezed light, Amplitude (or number) squeezed states, Photon antibunching, Schrodinger cat states, Two-mode squeezed vacuum states. Atomic Coherence and Interference: Coherent trapping-dark states, Electromagnetically induced transparency, Lasing without inversion, Refractive index enhancement via quantum coherence. Cavity Quantum Electrodynamics: Rydberg atoms, Rydberg atoms interaction with a cavity field, Experimental realization of the Jaynes-Cummings model-micromaser, Generation of number state in high-Q cavity, creating entanglement in cavity Quantum electrodynamics. Quantum theory of damping: General reservoir theory, Atomic decay by thermal and squeezed reservoirs, Field damping. Optical Test of Quantum Mechanics: Photon sources-spontaneous parametric down conversion, The Houng-Ou-Mandal Interferometer, The quantum eraser, Induced coherence, Superluminal tunneling of photons, Optical test of local realistic theories and Bell’s theorem.

Recommended Text/References:

1. Introductory Quantum Optics, Christopher C. Gerry and Peter L. Knight, Cambridge University Press (2005)

2. Quantum Optics, Marlan O. Scully and M. Suhail Zubairy, Cambridge University Press (1997).

3. Fundamentals of Quantum Optics and Quantum Information, Peter Lambropoulos and David Petrosyan, Springer-Verlag Berlin Heidelberg (2007) 93

PHY- 6124 Atomic Physics

Course : Atomic Physics

Course Code: PHY-6124

Credit Hours: 3+0

Pre-requisites:

Course Contents: One-electron atoms: Energy levels and wave functions of hydrogen atom. Fine and Hyperfine Structure. Extension to other single valence electron Atoms Two-electron atoms. Helium atom. Independent particle model. Energy level structure, Configuration interaction, Doubly excited states and inner-shell excitations. Many electron atoms. Auto ionization. Fano's description for an isolated auto ionizing resonance. Multi-channel Quantum Defect Theory. Multi-channel Quantum Defect Theory (Cooke and Cromer approach). Interaction between two closed channels, one open and one closed channels. Photoionization cross sections. Angular Momentum. Angular Momentum Coupling Schemes (LS, LK, jK and jj), Spherical Tensor Operators. Angular Momentum Algebra (3j, 6j and 9j symbols), Wigner Eckart Theorem. Atoms in External fields: Hydrogen Atom in electric field (spherical and parabolic states, energy levels, field ionization). Non hydrogenic atoms (Quantum defects and energy levels, avoided crossings and "classical' ionization. Landau Zener Effect and pulsed field ionization). Magnetic Fields (Classical Methods of Coherent Spectroscopy: RF resonance spectroscopy, level crossing spectroscopy, Anti-crossing spectroscopy, Quantum Beats and wave packets). Atoms in Intense radiation fields. Multiphoton Absorption, Above threshold Ionization; High Harmonic Generation. Laser Cooling and Trapping. Doppler Cooling; Optical molasses and traps; Sub Doppler Cooling

Recommended Textbooks:

1. Atomic Physics by C.J. Foot, 1st Edition (Oxford University Press) 2005.

2. Atomic and Molecular Spectroscopy, by S. Svanberg. 4th Ed. (Springer) 2004

3. Spectra of Atoms and Molecules, by P.F. Bernath, 2nd Ed. (Oxford), 2005

4. Physics of Atoms and Molecules, by Bransden and Joachain, (Longman), 1985

5. Atomic Spectroscopy, by Heckmann and Trabert (Springer), 1995

6. Laser Spectroscopy, by W. Demtroeder (Springer), 2004
7. Rydberg Atoms by T.F. Gallagher, (Cambridge Uni. Press), 1994 94
8. Highly Excited Atoms, by J.P. Connerade, (Cambridge Uni. Press), 1998

PHY- 6125 Quantum Information Theory-II

Course Title: Quantum Information Theory-II

Course Code: PHY-6125

Credit Hours: 3+0

Pre-requisites:

Course Contents: Quantum noise and quantum operation: Classical noise and Markov processes, quantum operations, environment and quantum operations, operator sum representation, axiomatic approach to quantum operations Strokes parameterization. Examples of quantum noise and quantum operations: Bit-flip and phase flip channels, depolarizing channel, amplitude damping channel, phase damping channel. Schumacher's noiseless channel coding theorem, Holevo bound. Distance measures for quantum information: Distance measures for classical information, Trace distance, fidelity. Quantum Measurement: Distinguishing quantum states, Generalized measurements, Projective measurements, POVM. Quantification of entanglement as a resource, entanglement of formation, concurrence, Wootter's criteria.

Reference Books:

1. Elements of Information Theory, T.M. Cover and J.A. Thomas, John and
Wiley Sons (1991)
2. Quantum Computation and Quantum Information, M.A. Nielson and I.I
Chuang, Cambridge University Press (2000)
3. Introduction to Quantum Information Science, Vlatko Vedral, Oxford
University Press (2006)

PHY- 6126 Accelerator Techniques for Materials

Course Title: Accelerator Techniques for Materials

Course Code: PHY-6126

Credit Hours: (2+1)

Pre-requisites:

Course Contents: Theory: 2 credit hours Introduction to Ion-Solid Interactions: Type of ion solid interactions; Low and High energy ions; Nuclear Energy loss and electronic energy; Defects production using ion beam techniques; The applications of introduced defects on material properties. Accelerators and Applications: Introduction to Electrostatic Accelerators;

Relevant detectors and nstrumentation; Accelerators for industrial and medical applications; Ion Implantation and ion beam analysis techniques: Rutherford Backscattering Spectroscopy (RBS), Proton Induced X-Ray Emission (PIXE), Elastic Recoil n Detection analysis (ERD). Rutherford and Non-Rutherford Backscattering Spectroscopy: Introduction, Applications, Kinematics [Kinematic factors, Rutherford scattering cross section, RBS system, mass resolution, energy resolution, depth resolution basic concepts, Energy loss, Analysis of thin and thick target samples, measurement of film thickness, depth profiling of impurities in the deposited films and of implanted species. Elastic Recoil Detection analysis (ERDA) and Nuclear reaction analysis (NRA): Introduction, Kinematics, Applications, Depth profiling of light elements in heavy materials, Techniques for profiling H; Using standard for concentration measurement and methods to improve the experimental statistics. Proton Induced X-Ray Emission (PIXE): Proton Induced X-Ray Emission: Principle, Application, Analysis of spectrum, Quantitative Spectrum fitting, experimental setup, use of external beam, Nuclear microprobe, Analysis of single Aerosol Particle.

Experiments: 1 credit hour

Experiments will be conducted at 5-UDH tandem Accelerator Lab in Experimental Physics Labs (EPD). The proposed list of experiments for the basic understanding and learning of ion beam analysis techniques is as follows: 1. Ion implantation and sample preparation for Rutherford Backscattering Spectroscopy 2. Channels to energy calibration and measurements of deposited film thickness 3. Concentration determination of incorporated impurities and implanted species in the substrate 4. Hydrogen depth profiling 5. Particle Induced X-ray Emission 6. Gamma ray spectroscopy using NaI detector

Reference Books:

1. Ion Beams for Materials Analysis, by J. R. Bird and J. S. Williams Academic Press, Sydney, 1989.

2. Characterization of Materials Vol. I, II by Elton N. Kaufmann, Publisher John Wiley & Sons, 2003.

3. Backscattering Spectrometry by Wei-Kam Chu, Academic Press, New York,1978.

4. Particle Induced X-Ray Emission Spectrometry (PIXE), by Seven A. E Johansson, Publisher John Wiley & Sons, 1995.

5. Electrostatic Accelerators Fundamentals and Applications, by Kai Siegbahn, Publisher Springer, Heidelberg, 2005.

6. Introduction to Solid State Physics by Charles Kittle, 7th Edition, Publisher John Wiley & Sons, Singapore, New York, 2003. 96.

PHY-6127 Computational Physics

Course Title: Computational Physics

Course Code: PHY-6127

Credit Hours: 3+0

Prerequisites: NIL

Course Contents: Linear algebra: Exact methods, iterative methods, eigen-values and eigenvectors; Stochastic Methods: equi-distribution, transformation of probability densities, rejection methods, multivariate distributions; random sequences, Markov chains, Gaussian Markov sequence, Winer-Levy process, Quantum mechanical simulations; Deterministic and Stochastic Optimization, Simulated annealing, Genetic Algorithms; Initial and Boundary value problems; Partial differential equations.

Recommended Texts:

1. R. H. Landau, M. J. Páez, C. C. Bordeiano, *Computational Physics*, Problem Solving with Computers, 2nd Edition, Wiley, 2007.
2. N. J. Giordano, H. Nakanishi, *Computational Physics*, 2nd edition, Prentics Hall, 2006.
3. Franz J. Vesley, *Computational Physics-An Introduction,* Kluwer Acad. Pub., 2001.
4. T. Pang, *An Introduction to Computational Physics*, 2nd Edition, Cambridge University Press, 2006.

PHY-6128 Physics Simulations

Course Title: Physics Simulations

Course Code: PHY-6128

Credit Hours: 3+0

Prerequisites: Computational Physics

Course Contents: Classification: discrete and continuous models; Mathematical modeling: equation ordered models, deterministic and stochastic models, ODE & PDE based models, Applications to various systems; Simulation Techniques: Digital Simulations; GUIs, Languages, Mathematica and Matlab, simulation process; Deterministic simulation; grids and discretization, numerical approximations; Stochastic Simulation; random processes and random number generators, Monte Carlo methods, discrete events, Metroplis and Gibbs sampling, sensitivity analysis, applications.

Recommended Texts:

1. H. Gould, J. Tobochnik, W. Christian, *An Introduction to Computer Simulation Methods*: Applications to Physical Systems, 3rd Edition, 2007.

2. R. Y. Rubinstein, D. P. Kroese, *Simulation and the Monte Carlo Method*, 2nd Edition, John Wiley, 2008.
3. S. M. Ross, *Simulation*, 4th Edition, Elsevier Academic Press, 2006.
4. R. L. Zimmerman, F. I. Olness, *Mathematica for Physics*, 2nd Edition, Addison Wesley, 2002.

PHY-6129 Fourier Optics

Course Title: Fourier Optics

Course Code: PHY-6129

Credit Hours: 3+0

Prerequisites: NIL

Course Contents: Analysis of two-dimensional signals and systems: Fourier analysis in two dimensions, local spatial frequency localization, linear systems, two-dimensional sampling theory. Diffraction theory: Kirchhoff formulation, Rayleigh-Sommerfeld formulation, generalization to non -monochromatic waves, diffraction at boundaries. Fresnel and Fraunhofer diffraction, frequency analysis of optical imaging systems. in-coherent and coherent optical information processing systems, VanderLugt filter; application to character recognition, holography; applications to interferometry, optical elements, data storage and others.

Recommended Texts:

1. Joseph W. Goodman, *Introduction to Fourier Optics*, McGraw-Hill, New York, 1996.
2. K. Eizuka, *Engineering Optics*, Springer-Verlag, Berlin, 1983.

PHY-6130 Non-linear Dynamics in Physics

Course Title: Non-linear Dynamics in Physics

Course Code: PHY-6130

Credit Hours: 3+0

Prerequisites: Computational Physics

Course Contents: Dynamical systems, phase space, Poincare section, spectral analysis, Basin of attraction, bifurcation diagrams; the Logistic map, period doubling, Lyapunov exponents, entropy; Characterization of chaotic attractors; prediction of chaotic states, method of analogues, linear approximation method, modification of chaotic states; spatio-temporal chaos, intermittency; Quantum maps, chaos in non-equilibrium statistical mechanics, driven systems; inter-mode traces in the propagator for particle in the box.

Recommended Texts:

1. G. L. Baker and J. P. Gollub, Chaotic Dynamics: An Introduction, Cambridge Univ. Press, 1996.
2. S. Strogatz, Nonlinear Dynamics & Chaos: With Applications to Physics, Biology, Chemistry, & Engineering, Perseus Books Group, 2001.
3. V. B. Sheorey, Nonlinear Dynamics and Computational Physics, Narosa Pub. House, London, 1999.
4. S. Wagon, Mathematica in Action, Freeman & Co., NY, 1999.

PHY-6131 Fiber Optics

Course Title: Fiber Optics

Course Code: PHY-6131

Credit Hours: 3+0

Prerequisites: LASER, AQM

Course Contents: Optical fibers; attenuation and dispersion performance characteristics, optical fibre as communication channels; Maxwell's equations and propagation of light in planer waveguides, model waveguide and material dispersion, fibers transmission characteristics; Electro-optic components, PIN and avalanche photodiodes, semiconductor lasers.

Recommended Texts:

1. J. M. Senior, *Optical Fibre Communications: Principles and Practice*, Prentice Hall, 1992.
2. G. Keiser, *Optical Fibre Communications*, McGraw Hill, NY, 1991.
3. L. Kazovsky, S. Benedetto, A. Willner, *Optical Fibre Communication Systems*, Artech House, Bosten, 1998.

PHY-6132 Radiation Physics-I

Course Title: Radiation Physics-I

Course Code: PHY-6132

Credit Hours: 3+0

Prerequisites: NIL

Course Contents: Radiation Sources, interaction of radiations with matter, introduction to nuclear track detectors, track formation mechanisms; radiation damage in solids; track formation models; bulk track and electrochemical etching; track etching geometry; thermal fading of latent damage trails; use of track detectors in particle identification; an overview of properties, origin and transport of radon; radon monitoring devices based on SSNTDs; neutron and radon dosimeter with track detectors; methods of track image enhancement; spark counters; electrical breakdown devices; scintillator-filled etch pit counting; automatic and semi-automatic image analysis; fission track dating.

Recommended Texts:

1. S. A. Durrani and R. K. Bull, *Solid State Nuclear Track Detection Principles, Methods and Applications,* Pergamon, 1987.
2. R. L. Fleischer et al., *Nuclear Tracks in Solids*, Univ. California Press, 1974.

PHY-6133 Radiation Physics-II

Course Title: Radiation Physics-II

Course Code: PHY-6133

Credit Hours: 3+0

Prerequisites: Radiation Physics-I

Course Contents: Production of X -rays, Industrial Radiography, non-destructive testing systems; Radiographic equivalence; exposure factors; x-ray safety, radiation hazard; shielding in radiation installations, basic principles of protection; medical surveillance; radiation dosimetry; exposure; absorbed dose; exposure measurement; absorbed dose measurement; Bragg-Gray principle; Kerma; Film badge dosimeter; thermoluminiscent dosimeter; chemical dosimetry; dose calculations; dose from surface contamination; internally deposited radioisotopes; total dose; dose commitment; external radiation protection; time distance and shielding; internal radiation protection; health physics instrumentation; evaluation of protective measures; disposal of solid liquid and airborne radioactive waste.

Recommended Texts:

1. C.A. Jacobi and D.Q. Paris *Textbook of Radiologic Technology*, 6th ed., Mosby Co., St. Louis Missouri, 1997.
2. S. C. Bushong, *Radiologic Science for Technologists: Physics, Biology and Protection,* Mosby Co., St. Louis Missouri, 2004.
3. H. Cember, *Introduction to Health Physics*, 3rd ed., McGraw-Hill Inc, 1996.

PHY-6134 Bio-Photonics

Course Title: Bio-Photonics

Course Code: PHY-6134

Credit Hours: 3+0

Prerequisites: Laser, AQM

Course Contents: Optical properties of tissues with strong multiple scattering, propagation of polarized light in tissue. Light scattering methods and instruments for medical diagnosis. Time and frequency domain spectroscopy and tomography of tissues, Interferometric and speckle-interferometric methods, Optical coherence tomography, polarization-sensitive optical coherence tomography

Recommended Texts:

1. V. Tuchin, *Tissue Optics*, SPIE, Washington, 1999.
2. M. Niemz, *Laser-Tissue Interaction*, Springer-Verlag, Berlin, 2003.

PHY-6135 Neutron Physics

Course Title: Neutron Physics

Course Code: PHY-6135

Credit Hours: 3+0

Prerequisites: Radiation Physics-I & II

Course Contents: Neutron cross sections, experimental measurements, data libraries; Neutron sources, nuclear reactions, energetics, (α,n) and (γ, n) sources, research reactors, experimental facilities; Neutron detection, boron, lithium and helium counters; Neutron fields, neutron transport and diffusion equations, solution for standard geometries; Neutron slowing down, Nuclear resonances, spatial distributions of thermal and fast neutrons; time dependent neutron diffusion, multiplying systems, flux and spectra; slowing down parameters.

Recommended Text:

1. K. H. Beckurtz and K. Wirtz, *Neutron Physics*, Springer, 1964.
2. J. N. Marion and J. L. Fowler, *Fast Neutron Physics*, Interscience, 1963.
3. G. C. Phillips, J. B. Marrion and J. R. Risser, *Progress in Fast Neutron Physics*, Chicago University Press,1963.

PHY-6136 Environmental Physics

Course Title: Environmental Physics

Course Code: PHY-6136

Credit Hours: 3+0

Prerequisites: Statistical Mechanics

Course Contents: Structure an composition of the Atmosphere: layers, ideal gas model, temperature structure; the hydrosphere: properties, hydrologic cycle, humidity, cloud formation and rain; Winds: the Beaufort Scale, origin of winds, forces, cyclones, gradients and patterns; the Ground: soil and its properties, water flow, temperature profiles; Energy & the Environment: resources, energy production, nuclear power, renewable energy resources, energy conservation; Sound and Noise: the decibel, noise and its measurement, design of partitions; Solar Radiation and Atmosphere: the Sun, Solar energy, cycles, solar spectra, radiative energy transport, radiation balance, the Ozone layer, role of CO_2, H_2O and the Greenhouse Effect; Nuclear Pollution: biological effects, radiation protection standards, and regulatory practices, environmental radioactivity; Other Pollutants: sources, acid rains, toxic elements, agricultural chemicals, chlorofluorocarbons (CFCs), toxic gases, marine pollutants, transport of pollutants.

Recommended Texts:

1. N. Mason, and P. Hughes, *Introduction to Environmental Physics: Planet Earth, Life and Climate*, Taylor and Francis, 2001.
2. E. Boeker, and R. v. Groundelle, *Environmental Physics*, 2nd ed., Wiley, 1999.
3. J. Blunden and A. Reddish, *Energy Resources and Environment*, Hodder and Soughton, 1996.
4. L. E. Kinsler, A. R. Frey, A. B. Coppens and J. V. Sanders, *Fundamentals of Acoustics*, 3rd edition, Wiley, 2000.
5. M. Eisenbud, *Environmental Radioactivity*, McGraw-Hill, 1987.

PHY-6137 Non-Linear Optics

Course Title: Non-Linear Optics

Course Code: PHY-6137

Credit Hours: 3+0

Prerequisites: Fourier Optics, Fiber Optics

Course Contents: Electric field and polarization, wave propagation in non-linear anisotropic media, Pockels effect and related phenomenon, second harmonic generation, parametric effects, Raman and Brillouin effect, optical Kerr effect, four wave mixing, propagation of light pulses, Solitons, non-linear effects in glass fibres.

Recommended Texts:

1. E. G. Sauter, *Nonlinear Optics*, John Wiley & Sons, NY, 1996.
2. Y. R. Shen, *The Principles of Non-linear Optics*, Wiley NY, 1984.

3. N. Blooembergen, *Nonlinear Optics*, Addison Wesley, Reading, MA, 1996.
4. R. W. Boyed, *Nonlinear Optics*, Academic Press, CA, 2000.

PHY-6138 Atomic and Molecular Physics

Course Title: Atomic and Molecular Physics

Course Code: PHY-6138

Credit Hours: 3+0

Prerequisites: AQM

Course Contents: Hydrogen atom review: degeneracy, spin-orbit coupling and fine structure, hyperfine interactions, spectral consequences of fine structure. Electron-electron interactions: coupled angular momentum, Pauli Exclusion Principle, exchange interaction, helium energy levels, coulomb/exchange integrals, degeneracy, alkali metal energy levels. Atom - field Interactions: dipole transitions, normal and anomalous Zeeman Effect, Lande g-factor, spectral consequences of applied fields, Stark effect. Atom - atom Interactions: Van der Waals bonding, covalency, new degrees of freedom rotations and vibrations, molecular electronic spectra, experimental probes Raman and infrared spectroscopy, selection rules.

Recommended Text:

1. W. Demtroder, *Atoms, Molecules and Photons*, Springer Berlin, 2010
2. D. Budker, D. Kimball, D. DeMille, *Atomic Physics: An exploration through problems and solutions*, Oxford University Press, Oxford, 2008
3. G.W.F. Drake, *Handbook of Atomic, Molecular and Optical Physics*, Springer, Berlin, 2006
4. M. Born, *Atomic Physics*, 8th Edition, Dover Publications, New York, 1989.

PHY-6139 Laser Physics

Course Title: Laser Physics

Course Code: PHY-6139

Credit Hours: 3+0

Prerequisites: AQM

Course Contents: Principles of lasers; population inversion, pumping processes, steady-state laser pumping, rate equations in steady-state and transient systems, laser gain saturation analysis. Optical resonators, resonator g-parameters, stability diagram, unstable and stable systems, laser modes, single mode operation. Broadening mechanisms, Qswitching, methods of Q-switching, laser beam properties. Mode locking, amplitude and frequency modulation mode locking, spatial hole burning, spectral hole burning and Lamb dip, amplification of short optical pulses, ultrashort light pulses. Some laser systems and their applications.

Recommended Texts:

1. C. Rulliere, Femtosecond laser pulses, Springer Science, New York, 2005
2. O. Svelto, Principles of Lasers, 4th
3. W. T. Silfvast, Laser Fundamentals, Cambridge University Press, Cambridge, 2000 Edition, Springer Science, New York, 1998
4. P. E. Milonni and J. H. Eberly, Lasers, John-Wiley, New York, 1988.
5. J. T. Verdeyen, Laser Electronics, Printice Hall,
6. A. E. Seigman, Lasers, University Science Books, California, 1986.

PHY-6140 Advanced Fiber Optics

Course Title: Advanced Fiber Optics

Course Code: PHY-6140

Credit Hours: 3+0

Prerequisites: Fourier Optics, Fiber Optics

Course Contents: Fiber modes analysis using Maxwell equations and Bessel functions, single mode fibers, performance limiting factors, fiber attenuation, fiber dispersion, polarization mode dispersion, pulse compression, optical connections, optical time domain reflectometer (OTDR), fiber transmitters, erbium-doped fiber amplifiers, Raman amplifiers, optical detection techniques, and their performance, quantum limit of photo-detection, coherent detection, modern techniques for optical modulation, nonlinear Schrödinger equation, pulse propagation using Gaussian pulse, chirped-Gaussian pulse and super-Gaussian pulse, hyperbolic-secant based optical pulse solitons, bright and dark solitons.

Recommended Texts:

1. J. M. Senior, *Optical Fiber Communications:* Principle and Practice, 3rd ed., Prentice Hall, New Jersey, 2009.

2. G. Keiser, *Optical Fiber Communications*, 5th ed. McGraw Hill, New York,, 2013.
3. G. P. Agrawal, *Nonlinear Fiber Optics,* 5th ed., Academic Press, New York, 2012.
4. Y. S. Kivshar and G. P. Agrawal, *Optical Solitons: From Fibers to Photonic Crystals,* Academic Press, New York, 2003.

PHY-6141 Simulations in Statistical Physics

Course Title: Simulations in Statistical Physics

Course Code: PHY-6141

Credit Hours: 3+0

Prerequisites: Statistical Physics, Physics Simulation

Course Contents: Introduction, basic notations, phase transition, ergodicity and broken symmetry, fluctuations, Ising model, probability, non-equilibrium and dynamics; Sampling and Monte Carlo methods, percolations, random walks; Importance sampling Monte Carlo, spin -flip sampling, discrete variable models, spin-exchange sampling, micro-canonical methods, ensambles, statics and dynamics of polymer models; Lattice systems, cluster flipping methods, specialized techniques, classical spin models, systems with quenched randomness, free energy and entropy sampling, Off-lattice models, fluids, short- and long-range forces, adsorbed monolayers, complex fluids, polymers, configurational bias and smart Monte Carlo methods.

Recommended Texts:

1. D. P. Landau, Kurt Binder, *A Guide to Monte Carlo Simulations in Statistical Physics*, Cambridge, 2000.
2. M. E. J. Newman, G. T. Barkema, *Monte Carlo Methods in Statistical Physics*, Oxford Univ. Press, 1999.

PHY-6142 Photodynamic Therapy

Course Title: Photodynamic Therapy

Course Code: PHY-6142

Credit Hours: 3+0

Prerequisites: Bio Photonics, Laser

Course Contents: Principles of PDT, Mechanisms of PDT, Cell structure and functions: Transport across the membrane, Cell signaling, molecular pathways in cell death, Cellular and molecular biology of cancer, cytoprotective mechanisms in PDT, molecular mechanisms regulating protoporphyrin synthesis and PDT efficacy, Molecular and cellular mechanisms of the immune response induced by the PDT, cellular and molecular mechanisms of photodynamic injury of nerve cells, sensitizers for PDT and imaging, photophysics and photochemistry in PDT, combining PDT with antiangiogenic therapy, technologies and biophysical techniques for PDT, nano particles in PDT and factors in the establishment and spread of PDT.

Recommended Text:

1. M. P. Goldman, *Photodynamic Therapy*, Saunders, Elsevier, 2nd Edition, 2008.

2. A. B. Uzdensky, *Photodynamic therapy at the cellular level*, Research Signpost, 2007.
3. H. Masuhara, S. Kawata and F. Tokunaga, *Nano biophotonics Science and Technology*, Elsevier, Amsterdam, 2007.
4. R. D Bookers, E. Boysen, *Nanotechnology*, Wiley Publishing, Indiana, 2005.
5. D. M. Terrian, *Cancer cell signaling Methods and Protocols*, Humana Press. New York, 2003.
6. W. M. Saltzman, *Drug Delivery*: *Engineering Principal for drug therapy*. Oxford University Press, Oxford, 2001.

PHY-6143 Polarization Imaging

Course Title: Polarization Imaging

Course Code: PHY-6143

Credit Hours: 3+0

Prerequisites: Bio Photonics, Laser

Course Contents: Polarization Ellipse, Stokes polarization parameters, Mueller matrices for polarization components, Methods of measuring stokes parameters, Measurement of characteristics of polarization, Elements, Mathematics of Mueller matrices, Jones matrices, Poincare sphere, Fresnel Arago interference laws, optical activity and Faraday rotation, Stokes Polarimeter, Mueller Matrix Polarimeter, Ellipsometry, General Imaging Systems, Polarisation based imaging systems, Scope and application of polarization imaging techniques.

Recommended Text:

1. D. Goldstein, *Polarized Light*, Crc Pr I Llc; 3rd edition 2010.
2. E. Wolf, *Introduction to the theory of coherence and polarization of Light*, Cambridge University Press, 2007
3. V. V. Tuchin, L. Wang and D. A. Zimnyakoy, *Optical Polarization in Biomedical Applications*, Springer, New York, 2006.
4. R.M.A. Azzam and N.M. Bashara, *Ellipsometry and Polarized Light*, North Holland, 1988.