Advanced Statistical Mechanics

UG/PG: PG	**Department: Physics**
Course Code: PHT721	**Course Name: Advanced Statistical Mechanics**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Basic ideas of probability theory, probability distribution functions, moments and cumulants, characteristic functions, the central limit theorem and the law of large numbers. [8 Lectures]

The Chapman-Kolmogorov equation, Markov chains, random walks, the Ehrenfest urn and the Wright-Fisher model, the master equation, methods of solution of the master equation, birth-death processes, the Moran model and models of competition. [20 Lectures]

The Fokker-Planck equation, relation to Schrödinger's equation, Barrier crossing, activation and mean-first-passage times, Langevin equation and its generalisations; methods of solution, Brownian motion in physical systems. [14 Lectures]

Books recommended:

1. A Modern Course in Statistical Physics: Reichl, L.E. (Wiley).
2. Elements of Nonequillibrium Statistical Mechanics: V. Balakrishnan (Ane Books).
3. Theory of simple liquids by J.-P. Hansen and I. R. McDonald (Academic press).
4. Statistical Mechanics by Kerson Huang (Wiley).
5. Diffusion and reaction in Fractals and Disordered Systems by D. ben-Avraham and S. Halvin (Cambridge).
6. Stochastic processes in Physics and Chemistry by N. G. Van Kampen (NHPL).

Advanced Techniques for Materials Characterization

UG/PG: PG	Department: Physics
Course Code: PHT722	Course Name: Advanced Techniques for Materials Characterization
Credits: 3	L-T-P: 3-0-0
Course Type: Core	
Pre-requisite course: Basic course on solid state physics/materials science	

Introduction to surfaces, interfaces and bulk of solid materials, classification, distinction and overview of surface and bulk characterization techniques, ultra-high vacuum: vacuum pumps and gauges. [7 Lectures]

Techniques for atomic structure and surface morphology determination: working principle and data analysis for X-ray Diffraction (XRD), transmission electron microscopy (TEM), low energy electron diffraction (LEED), scanning tunneling microscopy (STM) and atomic force microscopy (AFM). [12 Lectures]

Techniques for compositional analysis: working principle and data analysis for the techniques- electron probe micro analyzer (EPMA) and energy dispersive analysis (EDAX), X-ray fluorescence (XRF), X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), depth profiling by ion beam sputtering and secondary ion mass spectrometry (SIMS), Rutherford Back Scattering Spectrometry (RBS), elastic recoil detection analysis (ERDA), Nuclear Reaction Analysis (NRA). . [15 Lectures]

Thermal analysis and other techniques: working principle and data analysis for the techniques- differential scanning calorimetry (DSC), differential thermal analysis (DTA) and thermo-gravimetric analysis (TGA), Meesurements using Hall Effect, Four probe resistivity measurements set-up. [8 Lectures]

Books Recommended:

1. Surface Analysis Methods in Materials Science: D. J. O. Conner (Springer Verlag).
2. Surface and Interfaces of Solids: H. Lueth (Springer).
3. Advanced Techniques for Materials Characterization: A. K. Tyagi, M. Roy, S. K. Kulshrestha, S. Banerjee (Materials Science Foundations-Trans Tech Publications).
4. Vacuum Science and Technology: V. V. Rao, T. B. Ghosh, K. L. Chopra (Allied Publishers).
5. Instrumental Methods of Chemical Analyses: G.W. Ewing (McGraw Hill).
6. Characterization of Solid Surface: P.F. Kane (Plenum).

Basics of Astronomy & Astrophysics

UG/PG: PG	**Department: Physics**
Course Code: PHT723	**Course Name: Basics of Astronomy & Astrophysics**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Core	
Pre-requisite course:	

Coordinate systems for celestial objects and their interrelations, cardinal points in the sky, time measurements in astronomy, proper and peculiar motion of stars, astronomical observations and instruments, parallaxes, photometry, magnitude system, distance modulus, color indices.

[15 Lectures]

Stellar spectra and structure, ionization equation and elemental abundances, H-R diagram, stellar evolution, nucleosynthesis and formation of elements, variable stars, compact stars, star clusters and binary stars.

[12 Lectures]

Galaxies & their evolution and origin, classification of galaxies, Hubble law, active galaxies and quasars, big bang model (vs. steady state), early universe and CMBR, present epoch and future evolution of the universe.

[15 Lectures]

Books recommended:

1. An Introduction to Modern Astrophysics : B. W. Carrol & D. A. Ostlie (Addison Wesley)
2. Textbook of Astronomy & Astrophysics with Elements of Cosmology : V. B. Bhatia (Narosa)
3. Introduction to Astronomy & Cosmology: Ian Morrison (Wiley)

Experimental Techniques in High Energy Physics

UG/PG: PG	**Department: Physics**
Course Code:PHT724	**Course Name: Experimental Techniques in High Energy Physics**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Relativistic kinematics required to understand the experimental data in high energy physics (HEP), derivation of kinematic variables and their transformations, decay kinematics, rapidity, pseudo-rapidity, space like and time like, examples where relativistic kinematics play important role for understanding of data. [8 Lectures]

General concept of building a HEP experiment, interaction of high-energy particles with matter, specific applications related to the experimental high energy physics (EHEP), overview on various particle detectors used in EHEP: gaseous detectors, semiconductor detectors: silicon microstrip detectors, scintillators and cerenkov detectors, calorimeter and preshower detectors, basic principle of electromagnetic and hadronic shower generation. [14 Lectures]

Detector simulation and data analysis, need of simulation, various techniques in Monte Carlo simulations and data analysis in HEP, general approach of data preselection and cleanup, calibration, track reconstruction, reconstruction of events, error analysis in EHEP, statistical and systematical error analysis. [10 Lectures]

Important highlights on physics analysis techniques: particle identification, Dalitz plot distributions, missing mass and invariant mass, overview on present and future HEP experiments, Large Hadron Collider experiments, SuperLHC, Belle experiment at KEK, Japan, SuperKEKB, neutrino experiments, future collider experiment, ILC, applications of EHEP data analysis. [10 Lectures]

Books Recommended:

1. Relativistic Kinematics- A guide to the kinematic problems of High Energy Physics: R. Hagedorn (N.Y. W. A. Benjamin).
2. Techniques for Nuclear and Particle Physics experiments: W.R. Leo (Springer).
3. Radiation Detection and Measurement: Glenn F. Knoll (Wiley).
4. Evaluation of Silicon sensor technology in particle physics: Frank Hartmann (Springer).
5. The Experimental Foundations of Particle Physics: R. N. Cahn, G. Goldhaber (Cambridge University Press).
6. Experimental Techniques in High Energy Nuclear and Particle physics: T. Ferbel (World Scientific).
7. Introduction to Experimental Particle Physics: R.C. Fernow (Cambridge University Press, New York).
8. Data Reduction and Error analysis for the physical sciences: P. Bevington and D. K.Robinson (McGraw-Hill Higher Education).
9. Data Analysis Techniques for High Energy Physics: R. Frunwirth, M. Regler, R. K. Bock and H. Grote (Cambridge University Press).

General Theory of Relativity

UG/PG: PG	**Department: Physics**
Course Code: PHT725	**Course Name: General Theory of Relativity**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course: Classical Mechanics, Mathematical Methods	

Review of special theory of relativity, Riemannian geometry, manifolds, tensor calculus, Lie derivative, Christoffel symbols and covariant derivative, geodesics, Riemann curvature tensor, general properties of Riemann tensor, Ricci tensor and scalar, Weyl tensor. [8 Lectures]

Equivalence principle, principle of general covariance, gravity as a curvature of spacetime, geodesics as trajectories under the influence of gravitational field, non-local lift experiment, geodesic deviation, Einstein's field equation. [8 Lectures]

Schwarzchild solutions of Einstein's field equation, construction of metric and its symmetries, motion of a particle in Schwarzchild metric, experimental tests of general relativity, precession of the perihelion, bending of light, gravitational redshift, singularities, horizons, black holes. [6 Lectures]

Gravitational radiation, weak-field approximation, gauge transformations, plane gravitational waves, generation of gravitational waves, quadrupole radiation, detection of gravitational waves. [6 Lectures]

Books recommended:

1. Introducing Einstein's Relativity: Ray D'Inverno (Oxford University Press).
2. General Relativity: R. M. Wald (University of Chicago Press).
3. Gravitation and Cosmology: S. Weinberg (Wiley India PVT. LTD).
4. Gravity: An introduction to Einstein's General Relativity; J. B. Hartle (Pearson India Education).
5. Classical Theory of Fields: L. D. Landau and E. M. Lifshitz (CBSPD).
6. A First Course in General Relativity: Bernard Schutz (Cambridge University Press).

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Introduction to Monte Carlo Simulations

UG/PG: PG	**Department: Physics**
Course Code: PHT726	**Course Name: Introduction to Monte Carlo Simulations**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Fundamentals of Monte Carlo approach to simulate the particle interactions with detector materials, random number generation, landau distribution of energy deposited, convolution with Poisson distribution, advantages of Monte Carlo method, basic Geant4 concepts, important features of Geant4, installation.

[10 Lectures]

User classes: mandatory classes and action classes, detector construction, physics processes: electromagnetic, hadronic and decays, generation of primary particles through gun, action classes: run, event and tracking of particles in the experiment, Geant4 examples: basic, extended and advanced examples, design of simple geometry e.g. calorimeter to the real life experiment e.g. hadron therapy.

[15 Lectures]

Hands on sessions on how to design the experiment, compile and run in geant4 simulation environment, analysis of simulated data from Geant4 using ROOT software: 1D, 2D and 3D histogram plotting, curve fitting, storing data in Tree and Ntuples, applications: computed tomography, 3D image reconstruction in medical physics, design optimization of any complex detector geometry in high energy physics experiments, radiation effects analysis in space science.

[17 Lectures]

Books Recommended:

1. Monte Carlo simulations, Geant4 User Guide: http://www.cern.ch/geant4
2. Data Analysis Software, ROOT User Guide: https://root.cern.ch/
3. Advanced Monte Carlo for Radiation Physics, Particle Transport Simulation and Applications: I. Kawrakow, in A. Kling et al (edts.) (Springer).
4. Techniques for Nuclear and Particle Physics Experiment: W. R. Leo (Springer).
5. Radiation Detection and Measurement: Glenn F. Knoll (Wiley).
6. Handbook of Radiotherapy Physics, Theory and Practice: P Mayles, A Nahum, J.C Rosenwald (Taylor & Francis).

Introductory Quantum Field Theory

UG/PG: PG	**Department: Physics**
Course Code: PHT727	**Course Name: Introductory Quantum Field Theory**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course: Special Relativity, Quantum Mechanics, Advanced Quantum Mechanics	

Bosonic Fields: Classical field theory; relativistic fields; identical bosons and quantum fields; Klein-Gordon propagator and relativistic causality; quantum electromagnetic fields and photons. [8 Lecture]

Fermionic fields: Lorentz symmetry and spinor fields; Dirac equation and its solutions; second quantization of fermions and particle-hole formalism; quantum Dirac field; Weyl and Majorana spinor fields.

[8 Lecture]

Symmetries in QFT: Continuous symmetries and conserved currents; spontaneous symmetry breaking and Goldstone bosons; local (gauge) symmetry and QED; Higgs mechanism and superconductivity; non-abelian gauge symmetries and the Yang-Mills theory; discrete symmetries. [10 Lecture]

Interacting Fields and Feynman Rules: Perturbation theory; correlation functions and Feynman diagrams; S-matrix and cross-sections, decay rates; Mandelstam Variables; Feynman rules for fermions; Feynman rules for QED.

[8 Lecture]

Quantum Electrodynamics: Some elementary processes; radiative corrections; infrared and ultraviolet divergencies; renormalization of fields and of the electric charge; Ward identities.

[8 Lecture]

Books recommended*:*

1. An Introduction to Quantum Field Theory: Michael Peskin and Daniel Schroeder (Perseus Books)
2. Quantum Field Theory: Franz Mandl and Graham Shaw (Wiley)
3. A First Book Of Quantum Field Theory: Amitabha Lahiri & Palash Baran Pal (Narosa)
4. Relativistic Quantum Mechanics and Field Theory: Franz Gross (Wiley-VCH)
5. Quantum Electrodynamics: Vladimir Naumovich Gribov and Julia Nyiri (Cambridge Monograph Series)

Laser Physics

UG/PG: PG	**Department: Physics**
Course Code: PHT728	**Course Name: Laser Physics**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Laser fundamentals, stimulated absorption, stimulated emission, spontaneous emission, Einstein coefficients, absorption and gain coefficient, radiative lifetime, spontaneous transition probabilities, saturation of absorption, gain saturation, widths and profiles of spectral lines, line broadening mechanism, natural line width, Doppler width, collisional broadening of spectral lines. [12 Lectures]

Basic principles of laser, amplification, laser oscillation, population inversion, pumping mechanism, optical and electrical pumping, optical resonators, optimization of losses, resonance frequencies, laser modes, rate equations, steady state output, transient laser behavior, single-mode operation techniques, short pulse operation, Q-switching, mode locking, chirped pulse amplification, high power lasers. [14 Lectures]

Practical lasers, solid state lasers, ruby laser, semiconductor laser, Nd: YAG laser; gas lasers, He-Ne laser, excimer laser, CO_2 laser; liquid lasers, organic dye laser; properties of lasers, directionality, beam divergence, intensity, brightness; scientific and industrial applications, optical communication, holography, laser induced fusion.

[16 Lectures]

Books recommended:

1. Lasers: Fundamentals and Applications: K. Thyagarajan and A. Ghatak (Macmillian Publishers India Ltd, Second edition).
2. Introduction to Laser Physics: K.Shimoda (Springer-Verlag).
3. Principles of Lasers: O. Svelto (plenum Press).
4. Introduction to Lasers and their Applications: D.C. OShea, W.R. Callen & W.T. Rhodes (Addison-Wesley).
5. Laser Spectroscopy: A Basic Concepts and Instrumentation; W Demtrder, (SpringerVerlag).
6. Atomic and Laser Spectroscopy, A. Corney (Clarendon Press).
7. Laser Systems and Applications: V.K. Jain (Narosa Publishing House).

Materials Science and Engineering

UG/PG: PG	**Department: Physics**
Course Code: PHT729	**Course Name: Materials Science and Engineering**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Defects-types of defects, motion and properties of dislocation, diffusion in solids- Fick's laws of diffusion, solutions to Fick's second law, atomic theory of diffusion, mechanism of diffusion. [8 Lectures]

Phase transformations in solids- solid solutions, phase rule, binary phase diagrams, binary isomorphous systems, binary eutectic systems, types of transformations, homogeneous and heterogeneous transformation, thermodynamics of transformation, nucleation and growth kinetics, overall kinetics, recovery, recrystallization and grain growth. [12 Lectures]

Properties of materials- mechanical properties of materials-elastic and plastic deformation, hardness, dislocations and strengthening mechanisms, failure-fatigue and creep, corrosion and degradation of materials- corrosion rates, forms of corrosion, passivity, corrosion prevention, oxidation.

[12 Lectures]

Special materials and their properties- ceramics-crystal structures, silicate ceramics, polymers- types of polymers, glass transition, polymerization, composites- particle and fiber reinforced composites, ferrous and non ferrous alloys. [10 Lectures]

Books recommended:

1. Materials Science and Engineering, An Introduction by W.D.Callister, Wiley Publications.
2. Materials Science and Engineering by V.Raghvan, PHI
3. Solid State Phase Transformations by V.Raghvan, PHI
4. Essential Materials- Science and Engineering by Askeland and Phule, CENGAGE Learning

Nanostructured Materials and Applications

UG/PG: PG	**Department: Physics**
Course Code: PHT730	**Course Name: Nanostructured Materials and Applications**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Overview of nanostructures, top-down and bottom-up approaches, size dependant properties of nanomaterials, zero, one and two dimensional nanostructures, physics of thin film deposition, superlattice structures, structural, optical, electrical, dielectric and magnetic properties of nanomaterials. [16 Lectures]

Synthesis of semiconductor and metal nanocrystals, carbon nanotubes, nanocomposites, nanocrystalline thin films, tuning the properties of nanomaterials, ion beam modification of nanostructures, analysis of nanostructured materials using XRD, Raman, TEM, SPM and SEM. [16 Lectures]

Applications of nanotechnology in energy, space, optics, medicine and electronics. Environmental, health and safety issues. [10 Lectures]

Books recommended:

1. Introduction of Nanotechnology: Charles P. Poole, Jr. and Frank J. Owens (Wiley Interscience 2003).
2. Nanostructures and Nanomaterials Synthesis, Properties and Applications: G. Cao (Imperial College Press-2006).
3. Nanotechnology: Editor-G. Timp (Springer-1999).
4. Nanotechnology: Basic Science & Emerging Technology: M. Wilson, K. Kannangara, G. Smith, M. Simmons and B. Raguse (Overseas Press-2005).

Nanotechnology for energy applications

UG/PG: PG	**Department: Physics**
Course Code: PHT731	**Course Name: Nanotechnology for energy applications**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Energy challenge in the 21st century, introduction of nanotechnology, synthesis and characterization of nanomaterials, nanomaterials and nano systems for energy applications, energy storage and energy harvesting technologies. [12 Lectures]

Renewable and non-renewable energy sources development and implementation of renewable energy technologies, energy transport, conversion and storage, challenges in photovoltaics, limits in conversion efficiency, solar cells and its merits/demerits, thermoelectric materials, thermoelectric properties on nanoscale, thermoelectric nanocomposites [12 Lectures]

Micro-fuel cell technologies, fuel cells, polymer membranes for fuel cells, PEM fuel cell. Acid/ alkaline fuel cells, design of fuel cells [6 Lectures]

Methods for separation of hydrogen, membranes for gas separation, hydrogen storage methods, metal hydrides, hydrogen storage in carbon nanotubes, use of nanoscale catalysts to save energy, nanomaterials based rechargeable batteries [12 Lectures]

Books recommended:

1. Nanotechnology for the energy challenge: Javier Garcia-Martinez (WILEY- VCH)
2. Nanoscale applications for information & energy systems: David J. Lockwood, A Korkin (Springer).
3. Energy efficiency and renewable energy through nanotechnology: Ling Zang (Springer).
4. Renewable energy resources: John Twidell, Anthony D. Weir (Taylor and Francis).
5. Physics of solar cells: Peter Würfel, John (Wiley & Sons).
6. Fuel cell technology handbook :Hoogers (CRC Press).
7. Hydrogen fuel: production, transport and storage, Gupta (CRC Press).

Optoelectronic Materials and Devices

UG/PG: PG	**Department: Physics**
Course Code: PHT732	**Course Name: Optoelectronic Materials and Devices**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Materials for optoelectronics: structural properties of crystalline, polycrystalline, amorphous materials, liquid crystals, organic molecules, organic films, organic solids, electronic properties of semiconductors: band structures, doping and carrier transport, excited states of aggregated films, optical properties of semiconductors: interband and intraband transitions, charge injection and radiative/non-radiative recombination, exitonic effects. [12 Lectures]

Light detection and imaging: solar cell, photoconductive detectors, phototransistor, metal-semiconductor detector, charge coupled devices, laser diode, organic lasers, and temperature dependence of laser output. [08 Lectures]

Light emitting diode: operation and advanced structures, organic light emitting diodes (OLED), fabrication techniques, performance, way to perceive colors, conventional, transparent, inverted and flexible OLEDs, OLED based flexible display technology. [08 Lectures]

Electro-optic modulators, interferometric modulators, directional couplers, liquid crystal display, organic thin films transistors (OTFT): fabrication techniques, performance, applications, single molecule switch and memory element, organic nanotube transistors, OTFT based display technology, fabrication and processing of devices: bulk crystal growth and epitaxial crystal growth, lithography and etching. [14 Lectures]

Books Recommended:

1. Optoelectronics: An introduction to Materials and Devices, Jasprit Singh, McGraw Hill Inc, 1996.
2. Optoelectronics and photonics: principles and practices, S. O. Kasap, Prentice Hall 2001.
3. Semiconductor Optoelectronic Devices, Pallab Bhattacharya, Prentice-Hall. 1995.
4. Organic Electronics: Materials, Processing, Devices and Applications, F. So, CRC Press, 2010.
5. Physics of Organic Semiconductors, W. Brutting, Wiley-VCH, 2005.
6. Organic Spintronics, Z. V. Vardeny, CRC Press, 2010.

Physics at Low Dimensions

UG/PG: PG	**Department: Physics**
Course Code:PHT733	**Course Name: Physics at Low Dimensions**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course: Basic course in Solid State Physics	

Brief overview of band structure and density of states function for 0D, 1D and 2D systems, schematics of making things smaller, limits to smallness, quantum nature of matter, realization of low-dimensional electron systems. [06 Lectures]

Band gap engineering and semiconductor heterostructures, infinite and finite square well potentials, the occupation of subbands, quantum wells in heterostructures, electronic transitions in a quantum well, multiple quantum wells, triangular potential well and its wave functions, two-dimensional electron gas (2DEG), Shubnikov de Haas oscillations, 2DEG at the high magnetic field and low temperature, edge states. [14 Lectures]

Quantum wires and nanowires, growth and fabrication of semiconductor quantum wires/nanowire, electronic transport in 1D structures, novel properties and applications of nanowires, interference of electronic waves, ballistic transport, resonant scattering, impurity scattering, Anderson localization, Anderson transition, scaling theory, various quantum transport phenomena, quantized conductance, coulomb blockade. [14 Lectures]

Device application of low dimensional systems: double heterostructure laser, high electron mobility transistors, 2D materials: graphene, topological insulators, WS_2 and their properties. [08 Lectures]

Books recommended:

1. The Physics of Low-dimensional Semiconductors, J. H. Davies, Cambridge University Press, 1998.
2. Transport in Nanostructures, D. K. Ferry, S. M. Goodnick, and J. Bird, Cambridge University Press, 2009.
3. Introduction to Mesoscopic Physics: Yoseph Imry, Oxford Univ. Press, 2008.
4. Electronic Transport in Mesoscopic Systems: Supriyo Datta, Cambridge Univ. Press, 1997.

Plasma Physics

UG/PG: PG	**Department: Physics**
Course Code:PHT734	**Course Name: Plasma Physics**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Basic properties, occurrence of plasma, criteria for plasma behavior, plasma oscillations, quasineutrality, Debye shielding, plasma parameters, brief discussion of methods of plasma production, dc discharge, rf discharge, photo ionization, tunnel ionization, plasma diagnostics, Langmuir probe. [10 Lectures]

Charged particle motion and drifts, guiding center motion of charged particles, motion in uniform electric and magnetic fields, motion in non-uniform magnetic field, principle of magnetic mirror, loss cone, motion in non-uniform electric field for small Larmor radius, time varying electric field, time varying magnetic field, adiabatic invariance of magnetic moment, plasma as fluids, equation of motion, convective derivative, waves in plasma, Langmuir waves, ion acoustic waves, electromagnetic waves. [16 Lectures]

Collision and diffusion parameters, plasma resistivity, solution of diffusion equation, equilibrium and stability, concept of magnetic pressure, classification of instabilities, two stream instability, Weibel instability, controlled fusion, fusion reactions, Lawson criterion, principle of MHD power generation, plasma processing of materials, electromagnetic wave propagation in ionosphere, plasma accelerators. [16 Lectures]

Books recommended:

1. Introduction to Plasma Physics and Controlled Fusion: F.F. Chen (Plenum Press).
2. Methods in Non-linear Plasma theory: R.C. Davidson (Academic Press).
3. Plasma Physics in Theory and Applications: W.B. Kunkel (McGraw Hill).
4. Fundamentals of Plasma Physics: J.A. Bittencourt (Pergamons Press).
5. Principles of Plasma Physics: N.A. Krall and A.S. Trivelpiece (McGraw Hill).
6. Plasma: The first state of matter: V. Krishan (Cambridge University Press).
7. Basic Plasma Physics: B. Ghosh (Narosa Publishing House).

Quantum Field Theory: Advanced Topics

UG/PG: PG	**Department: Physics**
Course Code: PHT735	**Course Name: Quantum Field Theory: Advanced Topics**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course: Introductory Quantum Field Theory	

Functional Methods: Path integrals in quantum mechanics; "path" integrals for classical fields and functional quantization; functional quantization of QED; QFT and statistical mechanics; quantum symmetries and conservation laws.

[12 Lecture]

Renormalization Theory: Systematics of renormalization; `integration out' and the Wilsonian renormalization; `running' of the coupling constants and the renormalization group.

[12 Lecture]

Non-Abelian Gauge Theories: Non-Abelian gauge symmetries and the Yang-Mills theory; interactions of gauge bosons and Feynman rules; Fadde'ev-Popov ghosts and BRST; renormalization of the YM theories and the asymptotic freedom; chiral gauge symmetries; the standard model; confinement and other non-perturbative effects.

[18 Lecture]

Books recommended:

1. Field Theory - A Modern Primer: by P. Ramond (Westview)
2. Quantum Field Theory: L.H. Ryder (Cambridge University Press)
3. Quantum Field Theory - A Modern Introduction: M. Kaku (Oxford University Press)
4. Introduction to Gauge Field Theory: D. Bailin and A. Love (Taylor & Francis)
5. Renormalization Methods - A Guide for Beginners: W.D. McComb (Oxford University Press)

Semiconductor Physics and Devices

UG/PG: PG	Department: Physics
Course Code: PHT736	Course Name: Semiconductor Physics and Devices
Credits: 3	L-T-P: 3-0-0
Course Type: Elective	
Pre-requisite course:	

Bipolar junction transistors, transistor as an amplifier and switch, field effect transistors, MOSFET devices, metal-semiconductors FET, hetero structure FET.

[13 Lectures]

Photonic devices, crystalline and amorphous solar cells, photo detectors, LEDs, semiconductor lasers, solid state microwave devices, techniques to measure properties of semiconductors, four probe method, hall effect, spreading resistance for diffusion measurements, measurement of mobility of carriers, semiconductor device.

[20 Lectures]

An overview of IC fabrication technology, epitaxial growth, diffusion, oxidation, wafer doping and etching, photolithographic processing, ion implantation, ultra purification.

[9 Lectures]

Books recommended:

1. Physics of Semiconductor Devices: M. Schur (Prentice Hall of India).
2. Physics of Semiconductor Devices: S.M. Sze (John Wiley and Sons).
3. Solid State Electronic Devices: B. G. Streetman and Banerjee (Prentice Hall of India).
4. Semiconductor Physics and Devices: S.S. Islam (Oxford University Press).
5. Principles of Semiconductor Devices: Sima Dimitrijev (Oxford University Press).

Soft materials

UG/PG: PG	**Department: Physics**
Course Code: PHT737	**Course Name: Soft materials**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Introduction to soft materials and soft matter, generic aspects of soft materials, classification in terms of their thermal, mechanical and often unusual physical properties. examples of soft systems: polymers, foams, granular media, colloids, liquid crystals, micelles, vesicles and biological membranes. [12 Lectures]

From hard to soft building blocks, synthesis of hard and soft colloids, hard systems, softer systems and their characterization, dispersion forces, polymers in solution, gels, emulsions and foams. [10 Lectures]

Shape and directional interaction, crystal structure, effect on maximum packing density, anisotropic and directionally interacting colloids, complex shape particles, deforming and stretching, soft lithography and micro molding [10 Lectures]

Building blocks for self-assembled soft materials, learning from small molecules, block copolymers, phase diagram, crystallization, micellization, experimental methods for study of block copolymers [10 Lectures]

Books recommended:

1. Fundamentals of soft matter science: Linda S. Hirst (CRC).
2. Soft materials: structure and dynamics: John R. Dutcher, A. G. Marangoni (CRC).
3. Introduction to soft matter: Ian W. Hamle (Wiley).
4. Polymer surfaces and interfaces: M Stamm (Springer).
5. Soft condensed matter: R.A.L. Jones (Oxford).

Solar Energy and Applications

UG/PG: PG	**Department: Physics**
Course Code: PHT738	**Course Name: Solar Energy and Applications**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Solar energy: origin, solar constant, spectral distribution of solar radiation, absorption of solar radiation in the atmosphere, global and diffused radiation, seasonal and daily variation of solar radiation, measurement of solar radiation, photo thermal conversion, types of solar energy collectors, concentrating/non-concentrating solar collectors, collector efficiency and its dependence on various parameters, solar fuels: electrolysis of water, photoelectrochemical splitting of water. [14 Lectures]

Fundamentals of solar cells: photo voltaic effect, p-n junction photodiodes, depletion region, electron and holes transports, absorption of photons, excitons and photoemission of electrons, band engineering, charge carrier generation, recombination and other losses, I-V characteristics, silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells. [12 Lectures]

Device physics, device structures, device construction, output power, metal-semiconductor heterojunctions, efficiency, fill factor and optimization for maximum power, surface structures for maximum light absorption, operating temperature vs conversion efficiency, solar cell properties and design, materials for solar cells, organic solar cells, organic-inorganic hybrid solar cells, advanced concepts in photovoltaic research, nanotechnology applications, quantum dots, solution based processes solar cell production. [16 Lectures]

Books Recommended:

1. Solar Cell Device Physics: Fonash.
2. Solar Engineering of Thermal Process: Duffie and Backman (John Wiley).
3. Solar Energy: S.P. Sukhatme, (Tata McGraw Hill).
4. Principles of Solar Engineering, D. Yogi Goswami, Taylor and Francis.
5. Applied Photovoltaics, Stuart Wenham, Martin Green, and Muriel Watt, Earthscan.
6. Semiconductor Devices, Physics, and Technology, Second Edition, S. M., Sze, New York, NY: Wiley.
7. Solid State Electronic Devices, New Edition, Ben. G. Streetman, S. K. Banerjee, PHI Leaning Pvt. Ltd.
8. Fundamentals of Renewable Energy Processes, Aldo Vieira da Rosa, Elsevier Academic Press

Spintronics: Physics and Technology

UG/PG: PG	**Department: Physics**
Course Code:PHT739	**Course Name: Spintronics: Physics and Technology**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course: basic course in Solid State Physics	

History and overview of spin electronics, classes of magnetic materials, quantum mechanics of spin, spin-orbit interaction, exchange bias, spin relaxation mechanisms, pure spin and charge currents, spin-Hall effect and inverse spin-Hall effect, spin Seebeck effect, magneto caloric effect, the spin galvanic effect, basic electron transport, spin-dependent electron transport, spin-dependent tunneling, the basic theory of Andreev reflection, ferromagnet/ superconductor/ ferromagnet double junctions. [14 Lectures]

Spin-transfer torque and its magnetic dynamics, current-driven switching of magnetization and domain wall motion, domain wall scattering and current-induced switching in ferromagnetic wires, spin injection, spin accumulation, spin current, spin Hall effect, spin electronic devices, spin LEDs: fundamental and applications, spin photo electronic devices, electron spin filtering. [14 Lectures]

Materials for spin electronics, nanostructures for spin electronics, micro and nanofabrication techniques, semiclassical transport models, basics of spin valve and magnetic tunnel junctions, tunnel magneto resistance, quantum mechanical model of coherent tunnelling and giant TMR, read heads, MRAMS, spin transistors, spintronic biosensors, and quantum computing with spins. [14 Lectures]

Books Recommended:

1. Introduction to Spintronics, S. Bandyopadhyay, M. Cathay, CRC Press, 2008.
2. Magnetoelectronics, M. Johnson, Academic Press 2004.
3. Concepts in Spin Electronics, S. Maekawa, Oxford University Press, 2006.
4. Spintronic materials and technology, Y.B. Xu and S. M. Thompson, Taylor & Francis, 2006.
5. Magnetic Recording Technology, C.D. Mee and E.D. Daniel, McGraw-Hill Professional (1996).

Vacuum Science and Thin Film Technology

UG/PG: PG	**Department: Physics**
Course Code: PHT740	**Course Name: Vacuum Science and Thin Film Technology**
Credits: 3	**L-T-P: 3-0-0**
Course Type: Elective	
Pre-requisite course:	

Basics of vacuum science, creation of vacuum using rotary, diffusion, getter ion, turbo molecular, and cryo pumps, measurement of vacuum using Penning, Pirani, ionization gauges, B-A gauge, designing a typical vacuum system, vacuum leak detection, helium leak detector, residual gas analyzer. [10 Lectures]

Methods of producing thin films using PVD, CVD methods, growth of thin films, RF/DC sputtering, PLD, electron beam / thermal evaporation, spin /dip coating, epitaxial films, film thickness measurement. [10 Lectures]

Adhesion and stress measurements, electrical properties, resistivity variation, reflection, refraction, ellipsometry, reflecting and anti reflecting films. [8 Lectures]

Thin film analysis (with applications of techniques in solving research problems): ion beam sputtering, selective surfaces, depth profiling, study of inter diffusion in thin films using XPS, AES, SIMS and RBS, diffraction studies on thin films using LEED, thin film morphological studies by SEM, STM and AFM. [14 Lectures]

Books recommended:

1. Handbook of Thin Film Technology: Maissel and Glange (McGraw Hill).
2. Vacuum Technology: A. Roth (North Holland).
3. Thin Film Phenomena. K. L. Chopra (McGraw-Hill)
4. Ultra High Vacuum Technology: D. K. Avasthi.
5. Thin Film Solar Cells: S.R. Das and S.P. Singh.
6. Fundamentals of Vacuum Techniques: Pipko, Pliskosky et al. (Mir Publishers).